COLOR ATLAS OF PORCELAIN LAMINATE VENEERS

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Highdent laboratory

مرکز تخصصی پروتزهای دندانی

های دنت

طراحی و ساخت انواع پروتزهای دندانی بویژه ایمپلنت

برگزار کننده دوره های آموزشی تخصصی وجامع دندانسازی و...

با ما همراه باشید...

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DEDICATION

Dr. Fay B. Goldstep, my wife, whose encouragement and understanding, both personal and professional, were invaluable, and to Judy, to whom "the book" meant that Daddy was working and unavailable for play. My parents, Bella and Wilhelm, for always being there when I needed them. June Patterson, who has been with me since my first day of practice. And Dr. Ludwig Friedman, my godfather and first dentist; he taught me that being a dentist is enjoyable, and that dental work does not have to hurt.

George A. Freedman, D.D.S.

I consider it an enormous privilege to once again thank Judi, my wife, for the loving support she has given this project and the cheerful manner in which she accepted the many sacrifices it entailed. This book would simply not exist except for her help and it is dedicated to her.

Gerald McLaughlin, D.D.S.

ACKNOWLEDGEMENTS

The vast amount of work involved in a project such as this text always includes the help of a number of people, not all of whom can be mentioned in this short space.

Certainly it is appropriate to recognize many of the people who worked so diligently over the years to develop the new technology of porcelain bonding and to bring it to the attention of the world. When writing a text such as this one, it is easy to give the impression that the authors did all the work single-handedly. Nothing could be further from the truth. The concept and methods of porcelain bonding had many parents, all of whom should be justly proud for their various roles. Some people like Charles Pincus, Michael Buonocore, Ron Goldstein, and Ron Jordan were amoung the pioneers of the esthetic field. We also need to acknowledge some of the other many innovators in the field, such as Thomas Greggs, Alain Rochette, John Calamia, and Harold Horn, all of whom made significant contributions to the concept of porcelain bonding.

Then, too, there are the visionaries and teachers, such as John Morrison, Glynn Thomas, Robert Nixon, Robert Ibsen, Adrian Jurim, and Roger Sigler who have done so much to increase awareness of this exciting creation. All these people, and many more, have contributed meaningfully to the nearly explosive acceptance of porcelain bonding. Without the efforts and creativity of these people and many others like them, there would be no need for a book such as this.

There are others , too, who were of particular help to us in the gargantaun task of assembling the current state of knowledge of this exciting modality into a single text. For these people we owe a special debt of gratitude. One of these individuals is Dr. Greg Hacke, our editor at IEA Publishers.

We especially would like to thank Omer Reed for his thoughts. His words are particularly appropriate to the situation of the Cosmetic Dentist in his everyday practice. Our thanks also go to Michael B. Miller for his section on composite veneers in chapter 2.

For the many hours needed to assemble the section describing the refractory laboratory procedure, we are indebted to Andre Dagenais, R.D.T., and Carl L. Lee-Young. Similarly, we must extend a special note of appreciation to Thomas Greggs, the developer of the platinum foil technique, for his contribution to chapter 11. And once again we are indebted to Leon Silverstone, one of the pioneers in the field of enamel bonding, for the use of his priceless SEM photographs.

No less important is John Morrison's contribution, not only for bringing the technique to England, but also for his laminates and inlays that he provided for the text. His early work in the development of the techniques will prove a service for years to come. We also wish to thank Roberta Baird, M.S. W., for sharing her thoughts about the concepts in chapter 1.

CONTRIBUTORS

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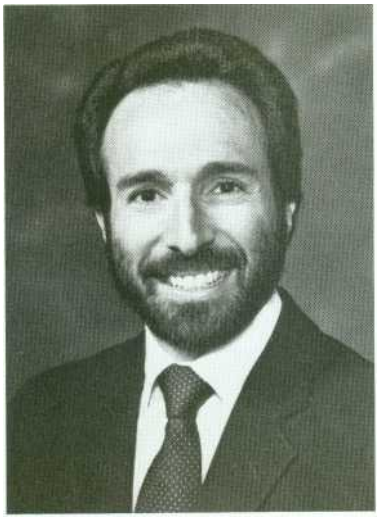

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FOREWORD

In this time of change, a pivotal period when our society is shifting from the industrial to the information/service-driven economy, it is exciting to realize that a parallel revolution is taking place in the profession of dentistry. This paradigm shift is driven by an extensive reduction in disease, an increase in dental manpower, and a discovery that over half our population, considered by the profession to be the "unmet need market," has less disease in intensity and frequency than those who are presently coming to see us. There is still another revolution that is simultaneously taking place in materials, techniques, and philosophy in dentistry.

The revolution in materials technology, as evidenced by the Duret micro-milling machine and other emerging systems, is leading to a dental office of the future that will no longer use the traditional plaster techniques. A patient can, without an impression or temporary, have the finest and most accurate veneer, inlay, crown or bridge placed during the first visit, creating a more profitable win-win situation for both the doctor and the patient.

The "New Dentist" of the 90's and the turn of the century will either be serving the commercial forces that presently exist in the health care system, or he will be "private care," providing unique, interdependent, and service-oriented procedures to people. The new technology for veneering or laminating of labial and buccal surfaces for cosmetic and functional reasons allows the profession to offer a new level of service and to open up an entirely new population of potential patients in the realm of cosmetic dentistry. This new technological development in the field of cosmetic dentistry comes along just in time to meet the felt needs and wants of a market that is in the midst of a parallel revolution in which "free time" is any time and the affluent consumer perceives an attractive smile no longer as a luxury, but rather a necessary part of the prevailing lifestyle.

A full crown may unnecessarily destroy the incisal guidance, the contact, morphology, food-flow pattern, and phonetics that already exist in the patient's mouth. The new laminate technology now gives the dentist a viable alternative to offer to his patients. The best dentistry is no dentistry, and people gladly remunerate us for being well and for staying well, and being assured that they are functionally sound. In this light then, it is possible to conceive that the less we do, the more we are rewarded for our services; especially if we understand the concept of "values driven co-development" of the fee in our marketing *efforts.*

The emerging laminate technology dovetails perfectly with the needs and wants of this new affluent consumer of dental services. Laminates is a topic that should be high on the list of new skills that every dentist should be learning if he is to be a successful and prosperous part of the new dental market of the 90's and beyond. In the following chapters, Drs. Freedman and McLaughlin appropriately and effectively present those necessary skills for the 90's and beyond.

Omer K. Reed, D.D.S.

INTRODUCTION

In ancient times, people sought dental care almost exclusively for esthetic reasons. In some cultures, teeth were hollowed out with primitive drills for the purpose of implanting precious stones. In other times, teeth were filed down to points or sharpened to imitate the dentition of animals. Sometimes they were (and still are in some cultures) knocked out entirely.

Through several thousand years, dentistry changed but little. In this century, however, science and technology have provided the necessary basics that have propelled dentistry into fields unimaginable only a short time ago.

We have become proficient at saving, filling, and straightening teeth, and especially at educating the public about the importance of good dental care. As a result, more and more people have come to regard teeth as an essential necessity of life. Now that we can maintain teeth in relatively good health for an entire lifetime, much of the attention has again turned to their appearance.

Thus we have come full turn. Man, initially concerned with nothing more than dental esthetics, has gone the full cycle through health and function, and is now back to his initial concern.

Dentistry is fortunate that at this particular time of interest in cosmetic dentistry there are many materials and procedures available to patients-and more are being developed all the time.

The objectives of Cosmetic Dentistry must be to provide the maximum improvements in esthetics with the minimum trauma to the dentition. There are a number of procedures that begin to approximate the ideal parameters of Cosmetic Dentistry, most notably that of porcelain veneers.

Porcelain veneers are a recent and very exciting development in the dental armamentarium. They enable the dentist to change the appearance, size, color, spacing, and, to a minor extent, the positioning of the teeth. Many veneering procedures can be accomplished with little or no preparation of the natural dentition, and commonly, anesthesia is not required.

This text is intended to provide the practicing dentist and the laboratory technician with a concise view of the state of the art in the design, manufacture, and clinical application of porcelain veneers. It is important for the reader to understand that this technique is in its infancy; many changes in the years to come will evolve and improve it, including innovations that will radically alter some of the concepts in this text. There is, however, a need within the profession for information about porcelain veneers at this time.

This book represents the clinical experiences of the authors, and it is our sincere desire that both dentists and technicians will use it as a basis on which they can expand their knowledge in order to provide better and more conservative treatment.

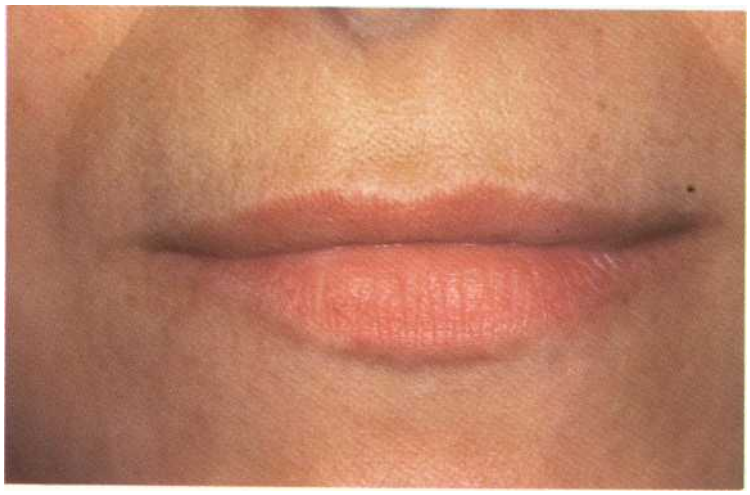
CONTENTS

Chapter I THE DEMAND FOR COSMETIC DENTISTRY

APPEARANCE AND SELF IMAGE

We live and work in a visual society, and easily the most visible and most readily observed part of the body is the face. We tend to focus our eyes on others' faces more often than any other anatomical feature. The facial expression is the most common aspect of nonverbal communication, and any deformity or unappealing feature that greets the observer's eye is bound to influence, and perhaps bias, the messages that are received.

When conversing, people tend to maintain eye contact for between 30 to 60 percent of the time'. If there is concern about the appearance of one's face (and of particular interest in this text is the display of the teeth), then it places the person with the concerns at a disadvantage. A person who is self-conscious about his teeth will try to avoid eye contact when at all possible. By not looking directly at his conversational partner, he tends to assume that the partner will also not look directly at him. Unfortunately, this stratagem is rarely successful. Failure to establish eye contact when conversing unintentionally communicates doubt, discomfort, and guilt. Customs officers often assess a person's lack of eye contact as an indicator of prevarication. An additional problem that may be created is that the observer begins to react to the overt body language and the undesirable messages that are being transmitted rather than to the person's true and often completely innocuous nature.



The significance of the teeth to smiling and to the face in general should not be underestimated. Teeth contribute an important part to what we term "appearance". A person's appearance and, more importantly, his perception of his appearance have a vast influence on his self image, which is proportionally related his confidence (Figs. 1-1, 1-2, 1-3).

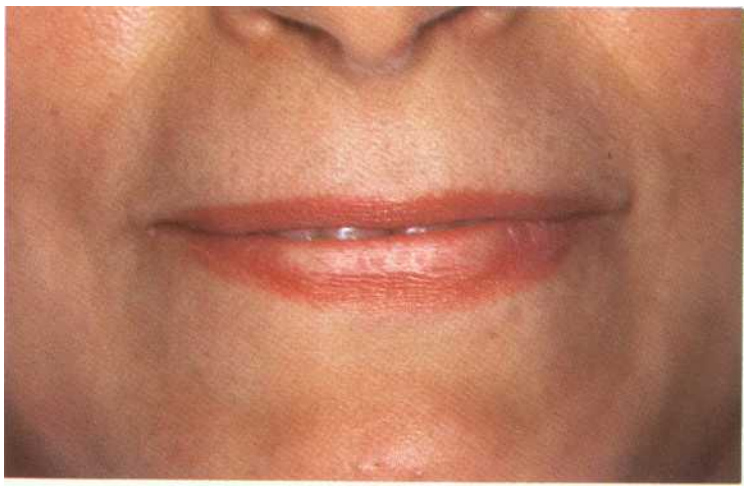
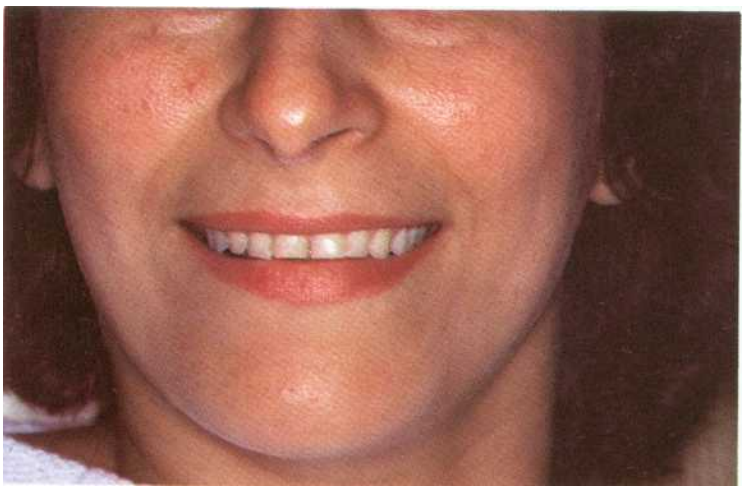


Fig. 1-2



Mg. 1-3

Confidence, in turn, enhances personal relationships. People look up to and like to have dealings with others who have faith in themselves. This self-assurance is readily recognizable in the conversational manner of a person. Those who master the art of personal relationships are more likely to succeed in today's highly interactive society.

Unattractive teeth are particularly detrimental to an individual's chances of success because they tend to negatively alter perceptions about cleanliness, health, sincerity, and truthfulness.

Which segments of the population are more likely to be concerned with esthetics and self-image?

Single men and women are possibly the most conscious of their appearance. It is this group that consumes the largest share of clothing and cosmetic products. In trying to make themselves attractive to the opposite sex, they have become sensitized to esthetics. Nearly every advertisement in print and on television utilizes models with perfect dentition. Rather than a remote possibility for some, this state is now a basic necessity. In the authors' experience, it is singles who most commonly seek cosmetic treatment.

Careers are understandably important to both men and women today. Many jobs involve extensive personal contact with both employers and employees. In the process of positioning one's self for advancement, grooming and appearance are so highly valued that career people regularly attend lectures that discuss everything from hair styling to shoe shining. Certainly, in light of the above discussion of interpersonal communication, teeth form a very great part of a person's presentability.

As industries are shifting more to service and service-related areas, corporations are recognizing that each employee represents the company to customers and the public. Since corporate self-image is just as important as personal self-image, a company will naturally tend to hire, retain, and promote persons who meet their esthetic requirements, which include neatness, cleanliness, and general appearance. A corporation does not wish to be represented by an employee whose unesthetic smile might harm his self image, which may possibly impair his communicational or negotiating abilities.

The middle-aged and the elderly are often a forgotten group in cosmetic dentistry, but this trend may change. People expect to keep their teeth longer and now expect to keep them better looking as well. The staining and the craze lines that often appear in the forties and fifties are no longer solved by extractions and dentures. This group consists of persons at the height of their careers and in excellent physical shape, and they do not want any reminders that time is progressing relentlessly. Menopause and mid-life crisis are other underlying conditions that may induce this age group to seek extensive cosmetic restructuring of their teeth.

It is occasionally noted with patients who have undergone rejuvenating plastic surgery that their teeth are the oldest appearing facial features. Plastic surgeons must make their patients aware that along with soft tissue procedures, dental cosmetic treatment may be indicated.

Adolescence is a very trying time both emotionally and physically. It is also a period during which peer pressure and the need to be accepted are the strongest. The slightest physical deviation can undermine the confidence of a youngster and possibly affect his continued normal development. Adolescents are constantly preening in front of mirrors, and thus have all the more time to become self-conscious about dental defects. What better way to eliminate these deleterious effects than through a non-invasive, reversible cosmetic procedure.

The above are just a few highlighted examples. Everyone is, to a greater or lesser extent, concerned with self-image and can therefore benefit from an improved dental appearance.

THE RELATIONSHIP BETWEEN APPEARANCE AND SUCCESS

When someone unknown to us is described as a successful person, we immediately form a mental picture. In our minds we have actually created our own ideal of success. While the imagined person will vary greatly from one mind to the next, certain qualities will be present in all cases: the successful person will be confident, well dressed, well groomed, and will invariably be smiling.

Our imagination often guides our expectation, and consciously or subconsciously we attempt to emulate an appearance of success in our own actions. We, too, wish to be smiling, confident, respected, and sure of ourselves.

Will an individual with dental esthetic problems appear to be successful?

If on smiling and conversing the dental problems are visible, then this will create a picture of uncleanliness and/or poor attention to grooming. Such an individual would not be perceived as the responsible type of person to whom one could entrust an important task. After all, it may be felt that if he is inattentive to personal detail, he is just as likely to be careless at work.

This entire case against the person with unesthetic teeth has been made without regard to his personality, integrity, qualifications, and experience. Yet the judgment has been made at the first contact, often the meeting that sets the tone for an entire relationship.

The prejudice that has been created does not distinguish between decayed teeth, lost or broken teeth, or teeth stained extrinsically or intrinsically (Figs. 1-4, 1-5).

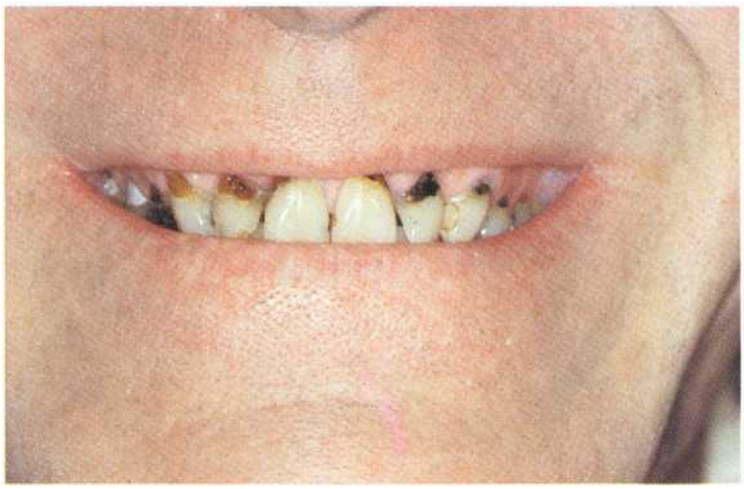


Fig. 1-4

Fig. 1-5

The cause of the esthetic liability is rarely determined. Whether the factors are neglect, medication, or genetic, seems to have no bearing on the negative impact that poor dental appearance creates in the mind of the observer.

Persons with the esthetic problems described above will often resort to compensatory behavior. This line of action only serves to aggravate the situation.

Some people never smile at all, or at best exhibit a very tight grin. This is not commonly taken as an indication of an outgoing personality, and the person is assumed to be smug, conceited, self-centered, antagonistic, and incapable of being friendly. It is unlikely that this individual will be easily accepted either socially or professionally.

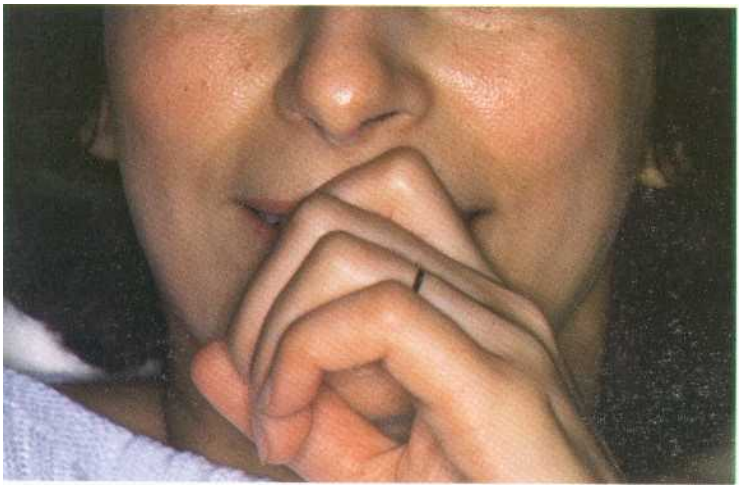


Fig. 1-6

Yet another compensatory mechanism is the avoided look. The dentally-compromised person looks down or away from a conversational partner. This is interpreted by the observer as shiftiness, uncertainty, or vacillation, and usually the dental imperfection is not at all hidden.

As an individual begins any of these behavior patterns, his partner will lean in or come closer to re-establish greater eye contact. The partner cannot understand why the dentally unesthetic person is setting up these barriers and he tries to undo them. As there is greater eye-to-eye or eye-to-lip contact, the defensive person becomes ever more insecure and attempts further avoidance.

At any given time, our body language is sending messages to those around us. If these messages are strong and confident ones, we will appear to be successful. As the feedback from others confirms and reinforces these feelings, these perceptions become self-fulfilling. If we do not appear successful due to an unesthetic dentition, and if we radiate messages of antagonism, insecurity, and defensiveness, it is likely that similar feelings will be reflected from those with whom we associate.

It is wrong to assume that a good appearance will guarantee success, but it is a safe bet that a poor appearance will hinder success greatly.

REFERENCES

1. Nierenberg, G.I., Calero, H.H.: How to Read a Person Like a Book, New York, 1971, Simon and Schuster.

Others may attempt to compensate by covering their mouths with their hands. Besides making their conversation difficult to understand, this gesture implies self-doubt. While this maneuver may effectively hide the dental problems most of the time, it is unlikely to lead to a successful outcome. Combined unintelligibility and the appearance of insecurity tend to show an individual in a rather poor light.

Chapter 2 THE HISTORICAL DEVELOPMENT OF PORCELAIN LAMINATE VENEERS

When most dentists think of esthetic dentistry, they commonly think as far back as Dr. Buonocore's article in 1955 [1] and no further. This was the beginning of the modern era of resin dentistry, but certainly not the first time that cosmetic laminates were used.

Throughout history, people have attempted to modify their teeth in various ways to correspond with the prevailing values of fashion and taste. But in the early part of this century, a particularly difficult problem arose.

With the advent of photography and motion pictures, a very accurate and lifelike facsimile of an individual could be reproduced. Any disfiguring mark was also reproduced with discomfiting accuracy. Unlike paintings, in which the artist could obligingly touch up the offending areas, film was cruelly truthful.

In many still photographs of the nineteenth century, the grain of the film covers facial blemishes to an extent, but, significantly, very few of the subjects are smiling. The dental blemishes are thus covered by the lips. It is probably not an accident that many of our forebears seem so serious and strict; in many instances they were just hiding unsightly teeth.

When the earliest motion pictures were produced, the film was so jumpy that it was impossible to see fine facial features, and close up sequences were rare. Then, in the late 1920s, the talkies arrived. Combined with improved filming and projecting techniques, which made minor details more readily visible, Hollywood's film makers experienced a dental dilemma.

It became necessary for movie stars to have glamorous smiles. The audience expected nothing less than perfection from their heros and heroines, and teeth were part of the package. Needless to say, not all of those who were, or wanted to be, stars had perfect dentition. Thus necessity led to invention.

Dr. Charles Pincus was a Beverly Hills practitioner, and part of his patient load came from the people in the movie industry. Among these were makeup personnel from various studios. When they brought their stars' dental problems to Pincus, he began experimenting with certain techniques to improve their appearance.

The only important considerations for Pincus at that time were esthetics, and to a lesser extent, comfort. The dental work had to look good for close-up camera work, to be comfortable in the mouth for extended periods, and to be placed so that it would not interfere with speech.

Ultimately, Pincus developed a porcelain facing that fulfilled these conditions'. He baked a thin layer of porcelain onto platinum foil and designed the appliance so it would not interfere with normal oral function. As you would expect, it was not worn in the mouth continuously. The stars could not eat with their facings and wore them for performing only. They were not bonded onto the teeth (suitable technology not yet having been invented); in fact, they were glued temporarily into place with denture powder.

Thus was born the "Hollywood Smile". Through the years, this has become the generally accepted lay standard of dental cosmetic excellence. As the world's exposure to films increased, dentists were besieged with patients desiring the movie stars' smile. These people did not realize that much of the dental perfection that they saw was as much of an illusion as the rest of the film. They also could not possibly know the limited function of these esthetic prostheses.

Dentists have spent the intervening years trying to catch up to their patients' expectations. Various materials were used in the technique of Pincus, and they all shared the same major limitation. Without any means of secure attachment to teeth, they were of little practical use. This changed dramatically in 1955 with the discovery of bonding. Finally, dental materials could be securely attached to tooth structure, but the materials available then did not fulfill the needs of esthetic dentistry. The first attempts at esthetic bonding made use of dental acrylic, and were unsuccessful due to the unpleasant taste of the residual monomer, and the stains and mouth odors that the acrylic material retained. It was hardly an esthetic solution.

Then, in 1972, Dr. Alain Rochette published a paper detailing an innovative combination of acid-etched bonding of enamel with a porcelain restoration. The porcelain itself was not etched, but was pre-treated with a coupling agent to promote chemical adhesion of an unfilled resin luting agent. First in French, and later in English,4 he described the successful placement of a custom-fabricated porcelain prosthesis to repair a fractured incisal angle.

Unfortunately, although Dr. Rochette reported excellent results over a three year observation period, it seems that his creation was too far ahead of its time, and nothing more was heard of the technique for many years. Instead, the emphasis was placed on improving the plastic dental materials used for direct application to the etched enamel. Acrylics and unfilled resins were followed by filled resins and then macrofill composite resins. Each material represented an improvement over the previous generation of materials, but each in turn was abandoned because none fulfilled the major requirement of esthetic restoration: creation and maintenance of an improved appearance.

For all these attempts, the dream of restoring a dentally compromised patient's esthetic appearance without resorting to full coverage was just that-a dream. Dentistry had not yet developed a cosmetic and functional device that could be placed on the dentition permanently.

PREFORMED PLASTIC LAMINATES

In the 1970's, a dental cosmetic technique using preformed factory processed plastic laminates was presented to the dental profession[5,6] (Mastique, Caulk-Dentsply, Milford, Delaware). This technique held the promise of a simple, durable treatment whereby unesthetic teeth could be cosmetically treated without resorting to full crown coverage.

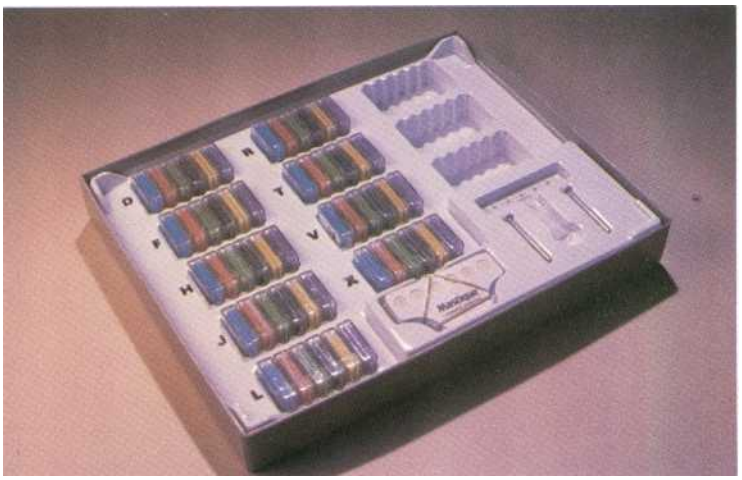


Fig. 2-1

The technique consisted of matching preformed plastic laminates to the teeth to be veneered and then of modifying them chairside until a fairly close adaptation was achieved.

Fig. 2-2

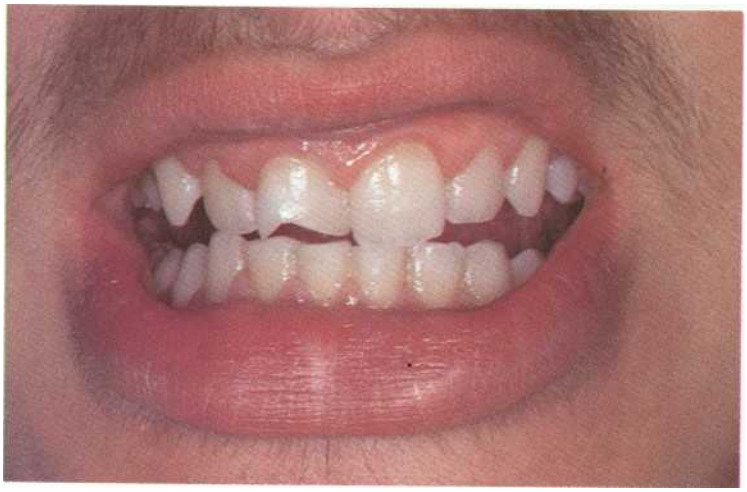


Fig. 2-3

Then, through the use of a composite bonding agent, the laminate was bonded to the etched tooth surface. By the judicious use of various shades of composite, the underlying deformities could be masked, and an esthetic result was obtained (Figs. 2-3, 2-4).

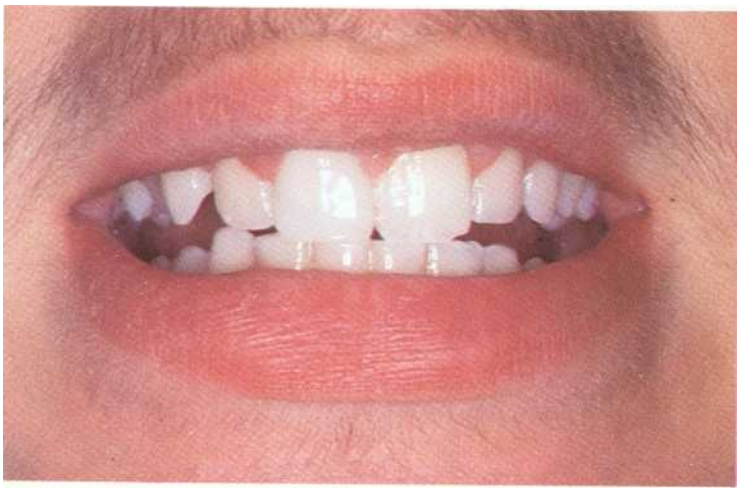


Fig. 2-4

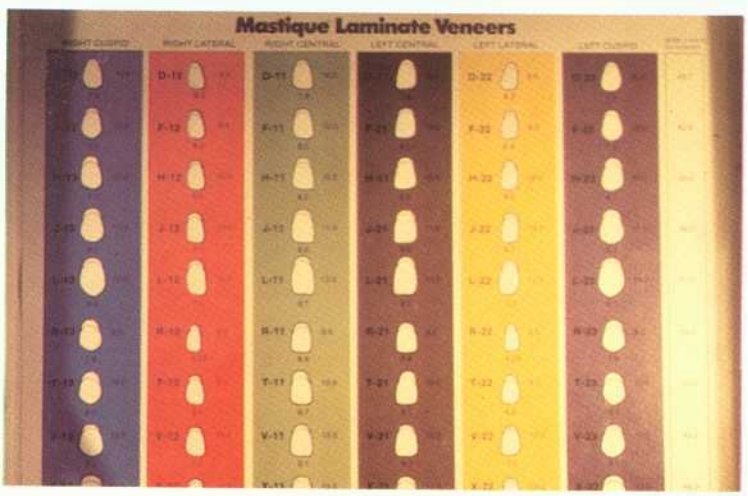


Fig. 2-5

The Mastique laminate was relatively easy to place on teeth but the kit provided only a moderate selection of different shapes and sizes. Once an appropriate veneer was chosen, the dentist was required to shape it to fit on the selected tooth. Thus while the bonding was simple, the procedure still remained technique sensitive, and, correspondingly, various levels of success were reported .

Subsequently, as dentists realized the difficulties in adapting plastic laminates, laboratories began fabricating them using a heat molding technique. This again enhanced the use of these veneers for a time. But the increased use of plastic laminates brought to the fore certain inherent problems with this treatment modality. The most serious drawback was an inadequate bond formed between the composite bonding agent and the plastic laminate7. This gave rise to delamination, chipping, and marginal percolation.

Fig. 2-6

The entire laminate would often just pop off the tooth, as it did for this patient's lateral incisor. Some of these failures were due to a weak bond, and some to the memory that the plastic exhibited. When the laminate was in any way stressed into place during the bonding procedure, it tended to spring back to its original shape at some time after.

Fig. 2-7

Any pressure at the marginal areas chipped off sizable segments of the plastic veneer, leaving portions of the underlying composite exposed. The subsequent differential staining was one of the major causes of cosmetic failure.

Fig. 2-8

Fig. 2-9

The laminated plastic veneers had to be protected from occlusal forces. Where any biting or clenching stresses were applied, if the veneer did not debond, it would wear very quickly.

The earlier plastic veneers were bonded with self-curing resins. These materials contained amines, which caused discoloration and darkening over time. Such was the situation with the two-year-old plastic veneers over the maxillary lateral incisors shown here.

Fig. 2-10

The weak marginal area also permitted the percolation of oral fluids under the veneer, in between it and the composite. After a number of years, it was quite common to see pooled areas of stain showing through the plastic.

Fig. 2-11

The longevity of these laminates can now be evaluated. While some have lasted five years or more, very often the esthetic benefits were gone in two. The plastic veneers done for this patient are typical. The first two photographs were taken about two hours apart, demonstrating that the improvement is both dramatic and immediate. The third photograph, however, which was taken about two years later, shows the disappointing longevity of the preformed plastic laminate system (Figs. 2-11, 2-12, 2-13).

Fig. 2-13

Plastic laminate veneers were a suitable technique in their own time and, perhaps,had their introduction not coincided with the advent of light-cured microfill composite freehand veneers, they might have gained a greater acceptance and use by the profession. Their greatest contribution to dentistry was that they made the profession aware of the esthetic possibilities of veneering.

DIRECT RESIN VENEERS

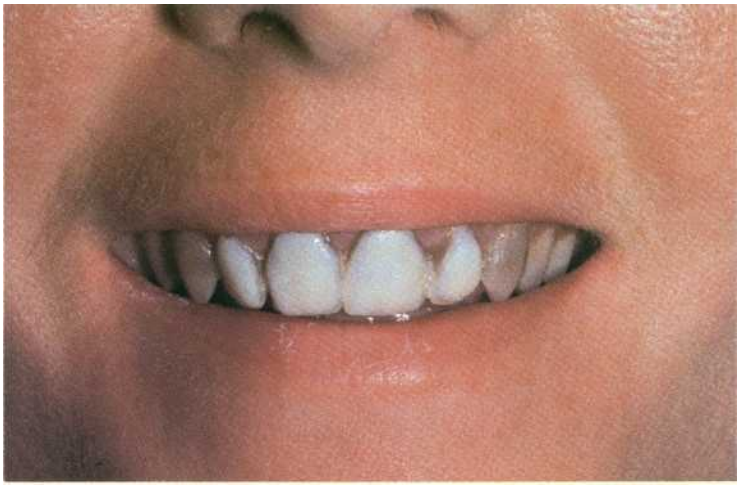
Michael B Miller, D.D.S.

Direct resin veneers have be.en the glamour procedure in Cosmetic Dentistry and are most responsible for its explosive growth. They permit "instant", one-appointment enhancement of our patients' smiles and allow us to control the entire fabrication process, rather than depending on the laboratory. This control, however, places more artistic responsibilities on our shoulders. The dentist must be willing to learn layering, sculpting, and finishing techniques, or these veneers will be frustrating to him and a disaster for his patient.

Direct veneers may be done without any tooth preparation, although the results generally will not be as esthetic as a veneer done after enamel reduction. Even though these veneers are slowly being replaced by porcelain veneers as the optimal esthetic option, freehand veneers still have their place in the Cosmetic repertoire.

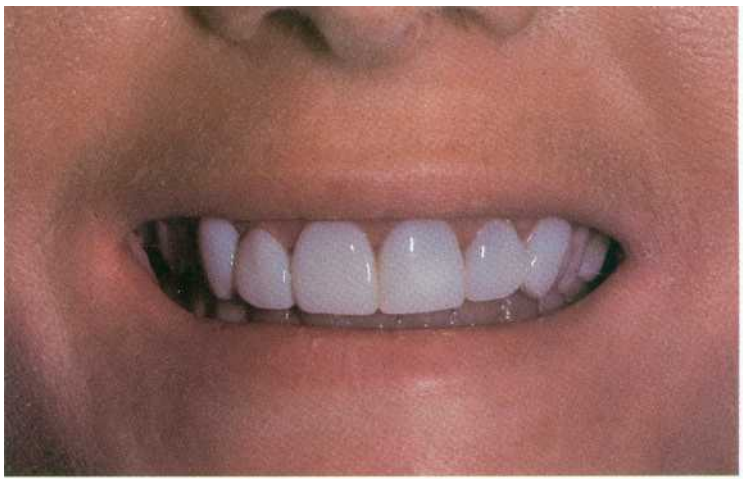
While many materials are used for direct veneering, microfills are the most responsible for the acceptance of this modality. Because of their translucent and polishable nature, microfills can be made to mimic enamel almost as well as porcelain. However, microfill restorations are susceptible to chipping, and the patient must accept the fact that these veneers do require periodic maintenance. To minimize this tendency, direct resin veneers often utilize several layers of various materials, each with its own individual strength.

Since direct veneers are done without laboratory support, there is neither a lab fee nor the chance that the technician will not follow the dentist's instructions. Considering the lesser cost of this procedure, direct veneers give rise to a lower fee than porcelain. The costs of porcelain veneers unfortunately can be prohibitive to some people, especially younger patients. In this instance, direct veneers may serve as an entry-level procedure, and may be remade in porcelain at some point in the future when necessary and affordable.



This female patient had been "bonded" by another dentist. In fact, there was merely a layer of opaque on her teeth. She could not afford optimal dentistry.

Fig. 2-14



The opaque was removed. Direct veneers were sculpted onto the teeth, this time including the cuspids, using only one shade of an opaque microfill. This allowed the dark teeth to be covered to the patient's satisfaction without requiring much time spent with opaquers and tints, which procedures would have resulted in a substantial increase of the fee involved.

Fig. 2-15

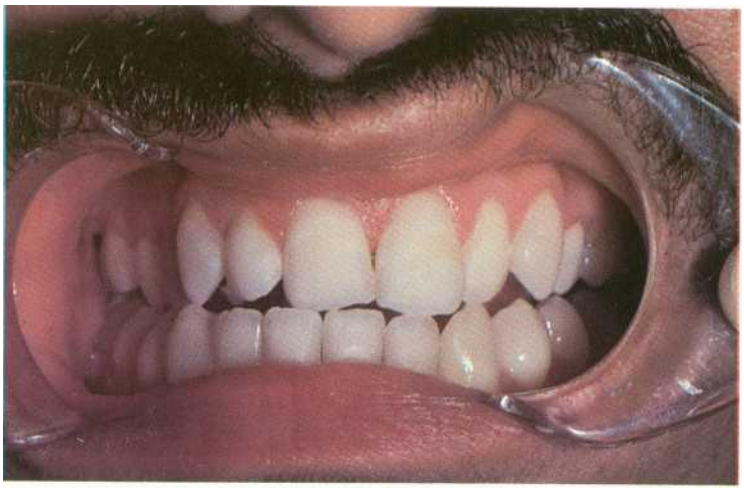


Fig. 2-16

The male in this picture had a number of problems: a Class III occlusion, rotated teeth, and (in his own perception) teeth that were too dark. Orthognathic surgery and orthodontics were prescribed prior to cosmetic restorative treatment. The patient declined this treatment plan. He wanted only "straight white teeth".

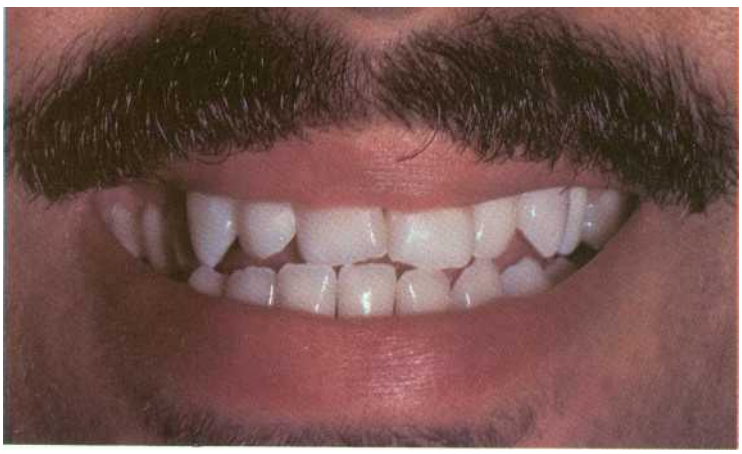


Fig. 2-17

Initially, the patient was subjected to vital bleaching, but the color improvement was inadequate.

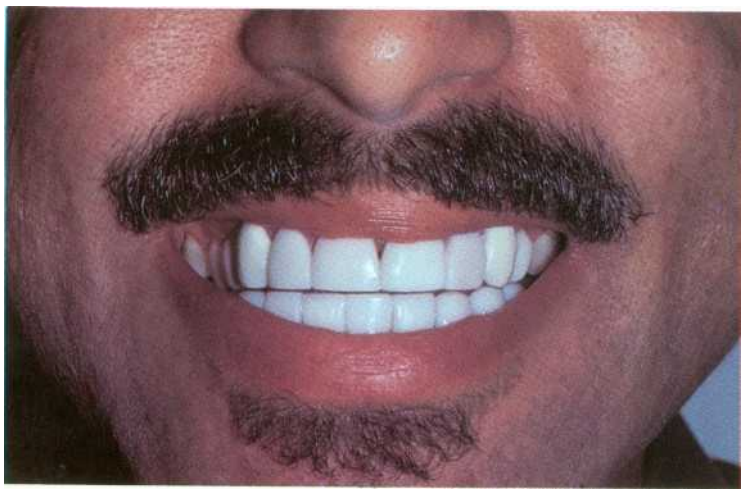


Fig. 2-18

The maxillary and mandibular anteriors were then veneered to give the patient the appearance he desired. Bonded veneers were chosen instead of porcelain because the patient wanted such a radical change. In the event that the patient is not satisfied after the procedure, or if he ever decides to have his malocclusion corrected, it will be relatively easy to remove the bonded veneers and to replace them with porcelain.

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Chapter 3 FUSION: THE BONDING THAT MADE IT ALL POSSIBLE

There are three basic ways of attaching porcelain laminates to the surface of teeth. These use either chemical attachment, micromechanical attachment, or some combination of the two.

CHEMICAL ATTACHMENT

Chemical attachment, usually known as cementing, has been a workhorse for dentistry, dating back to the earliest times. It is the attachment method which we use to affix crowns, bridges, inlays, and other appliances. To use this technique a dental cement such as zinc oxyphosphate, or polycarboxylate is mixed and spread in a thin layer between the tooth and the appliance being attached. Chemical bonds form between the cement and both substrates, and ultimately it is these bonds that hold our appliances in place.

Unfortunately, the current strengths of cementing in the mouth are are quite low. It is for this reason that the dentist must always design restorations in such a way that the demands on the cement are minimal. It is this the reason, for instance, that near parallel walls are desirable for crown preparations.

Dental cements are always used in thin films. The reason for this is that the cements generally display far greater adhesive strength than cohesive strength. In fact, for most dental cements the theoretically ideal film thickness is two molecules thick, even though from a practical standpoint this is virtually unobtainable.

One group of dental cements which are particularly interesting to us here are the lightly filled composite resins. These exhibit good adhesive strength, but really excel in the areas of cohesive strength and low solubility. They are severely limited in dental utility due to the pulpal irritation which they cause when placed on freshly cut dentin, but they may be used safely on enamel. Unfortunately, they do not form strong water resistant bonds with either unetched enamel or porcelain.

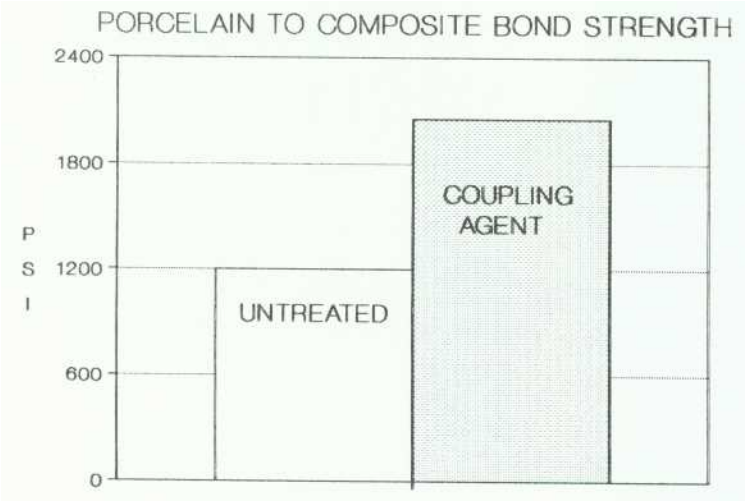

Fig. 3-1

There is yet another group of materials that is becoming increasingly important in dentistry. Known as "coupling agents", these materials nearly function as true dental cements. These materials generally have tremendous adhesive strength but such low cohesive strength as to be totally useless as cements by themselves. In combination with other materials, however, they can serve the same purpose as true cements.

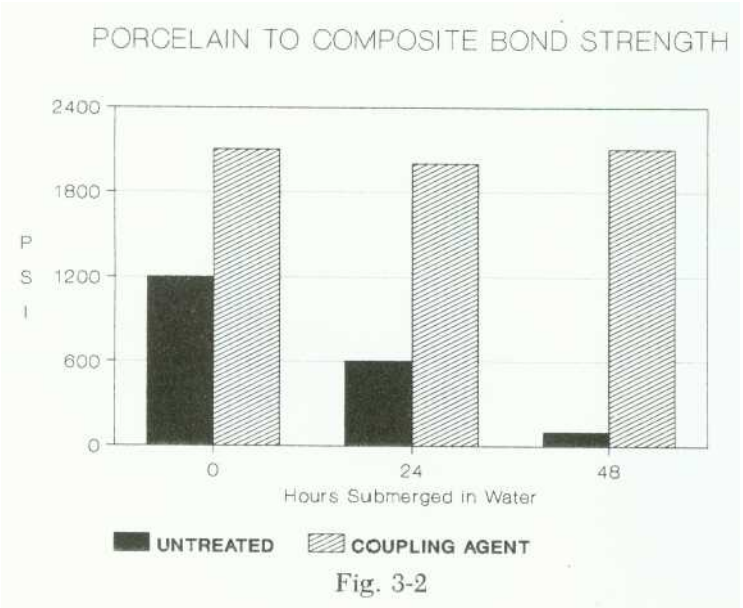

Fig. 3-2

A typical example of a coupling agent used in dentistry can be found in attaching BIS-gma resins to porcelain. Porcelain represents a particularly difficult surface for cementation if the cement bonds are to be submerged in water. Bond strengths of 1200 psi in the tensile direction are not unusual when attaching resins to porcelain in a dry environment, but after only 48 hours of submersion the two surfaces nearly fall apart'. Certain intermediary treatments of the surfaces can make an extraordinary difference. For instance, when the porcelain has been coated with a monomolecular layer of an organofunctional silane before being covered by the resin, the bond strength becomes formidable.

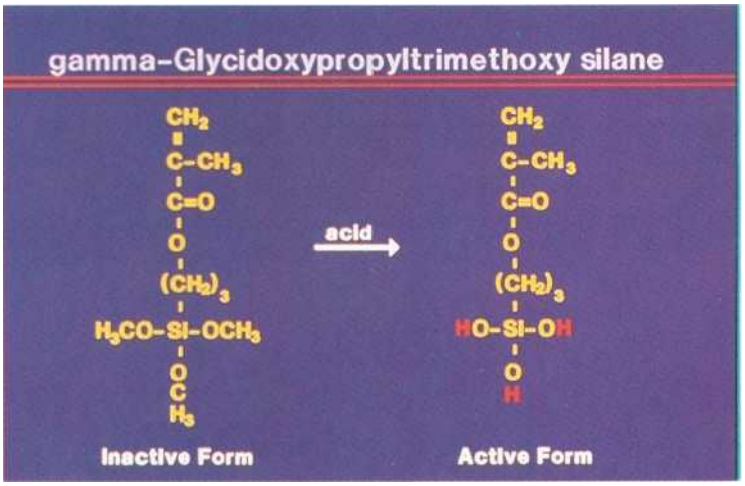

Fig. 3-3

An organo-functional silane is composed of long-chain silicon molecules having a reactive organic group at one end and a reactive inorganic group on the other.

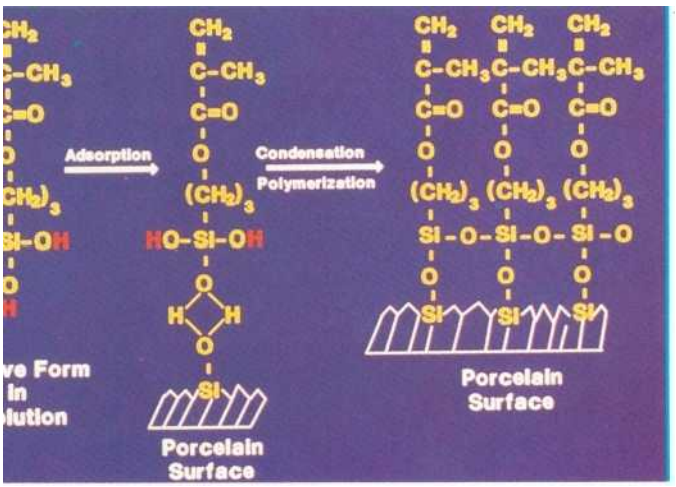

Fig. 3-4

when me porcelam ls coaieu with mane, the inorganic end of the silane molecule firmly attaches to the inorganic porcelain. The net result is that the normally inert and unreactive inorganic porcelain surface becomes coated by a sheath of highly reactive organic groups. This new surface can then tightly adhere to the organic components of the dental resin, allowing the resin to act as a true cement with the silane coated porcelain, but without the restrictions of needing a thin film thickness.

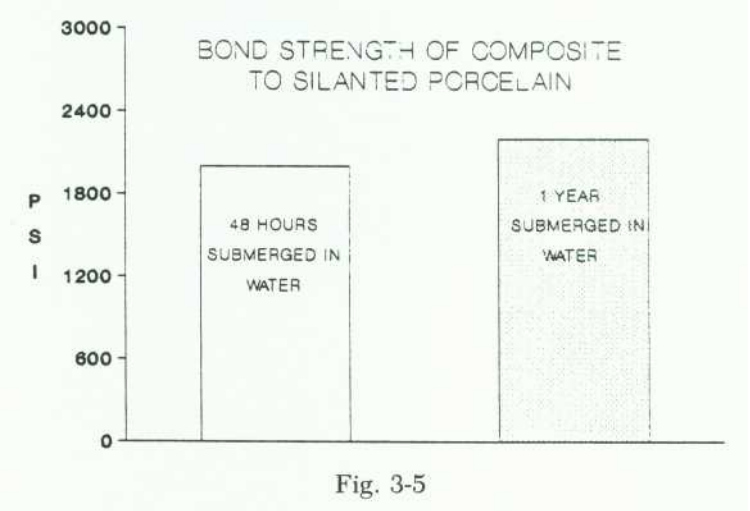

Fig. 3-5

Even more important for porcelain laminates, the chemical bonds which form between the porcelain and composite are not only stronger, but also water resistant. While most adhesive bonds tend to diminish in strength after exposure to the oral environment, substantial evidence shows that the silane/porcelain bond actually becomes stronger after submersion and thermal cycling[2,3].

MICROMECHANICAL ATTACHMENT

The basic technique of micromechanical attachment has changed little since it was first described in 1955 3. Working in New York, Michael Buonocore noticed that the application of a weak acid to the surface of enamel results in an irregular and pitted surface. Buonocore then flowed dental material onto this roughened surface to create a mechanical attachment between the material and the tooth. From this simple beginning has sprung "The Bonding Revolution".

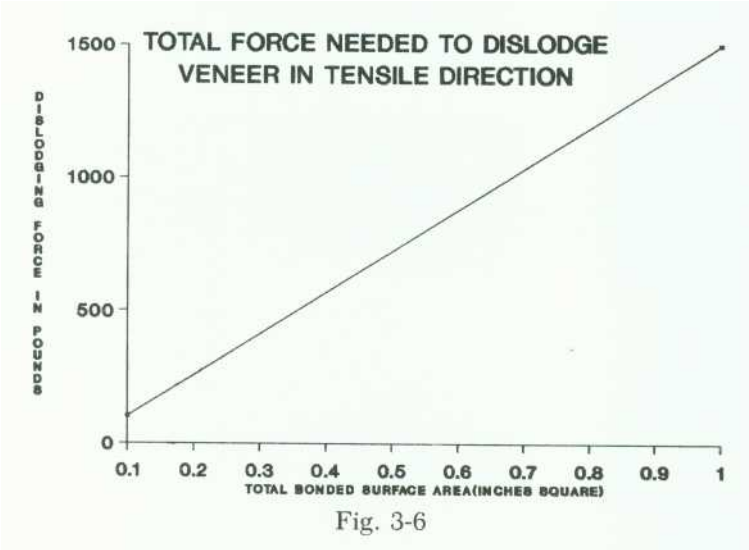

Fig. 3-6

By 1983, the combination of etching and pre-treatment with a coupling agent had been incorporated into the porcelain laminate veneer techniques6.7.8 Simple bonding was used on the enamel surface, but the inner surface of the porcelain veneer was etched with hydrofluoric acid, and then treated with a silane before being bonded into place. This simple change in technique resulted in a great increase in the bond strength of composite to porcelain. This seemingly important improvement in the bonding technique, however, resulted in no increase in the total bond strength because, like any chain, the connection between the veneer and the tooth breaks at its weakest point.

COMBINED ATTACHMENT

The processes of micromechanical retention and chemical retention are not mutually exclusive. In fact, they are potentially augmentive. Since chemical retention is directly dependent upon the total surface area, the higher the surface area, the greater the potential bond strength. Etching the enamel increases the enamel surface area nearly a hundredfold'. Thus, etching before cementing can greatly enhance the bond strength .

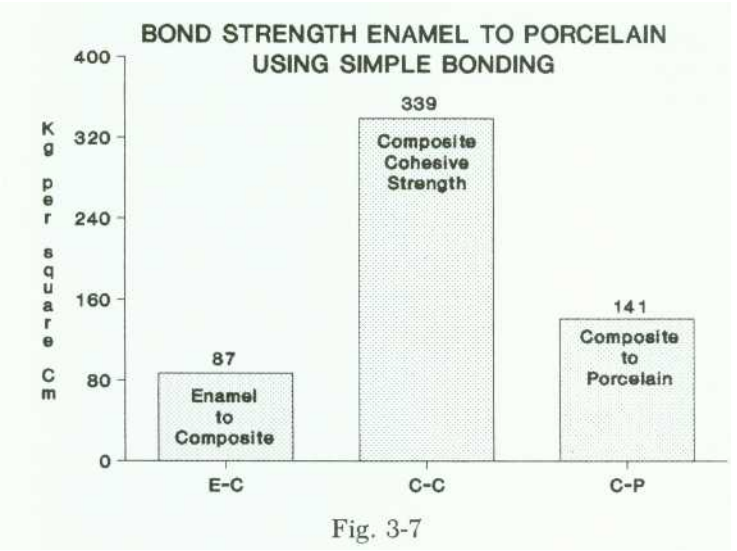

Fig. 3-7

This figure illustrates the relative strength of the various components of the connection between the tooth and the laminate when simple bonding is used. Even without silanization of the porcelain, the bond strength of composite to etched porcelain exceeds the strength of the bond between etched enamel and composite.

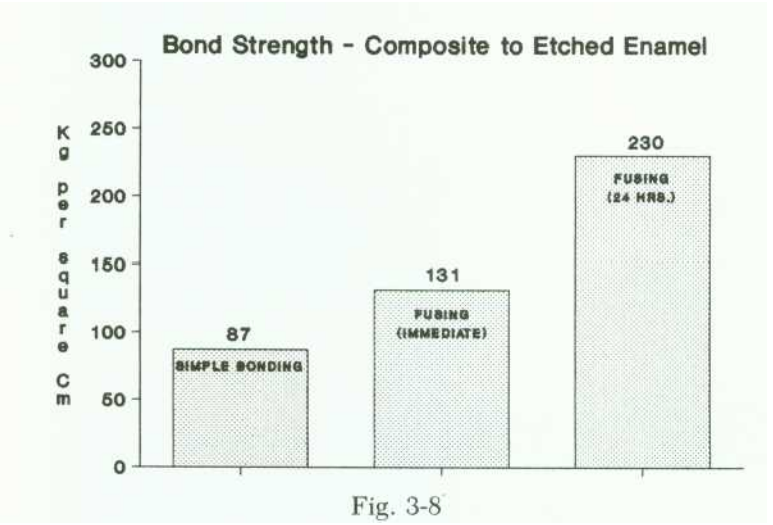

Fig. 3-8

In 1983 coupling agents were discovered which were effective on etched enamel. The first of these consisted of phosphate esters of BIS-gma. The presumed point of attachment of the enamel coupling agent and the enamel is a phosphate/calcium bond. Although the exact mechanism has not been fully elucidated, one study showed an increase in bond strength of 86 percent when etched enamel was pre-treated with a coupling agent before being coated with composite resin9. Later studies with improved coupling agents have shown an immediate improvement of 50 percent, with a 24 hour improvement of 170 percent. Now, composite to enamel bonds of 3,000 psi are not uncommon

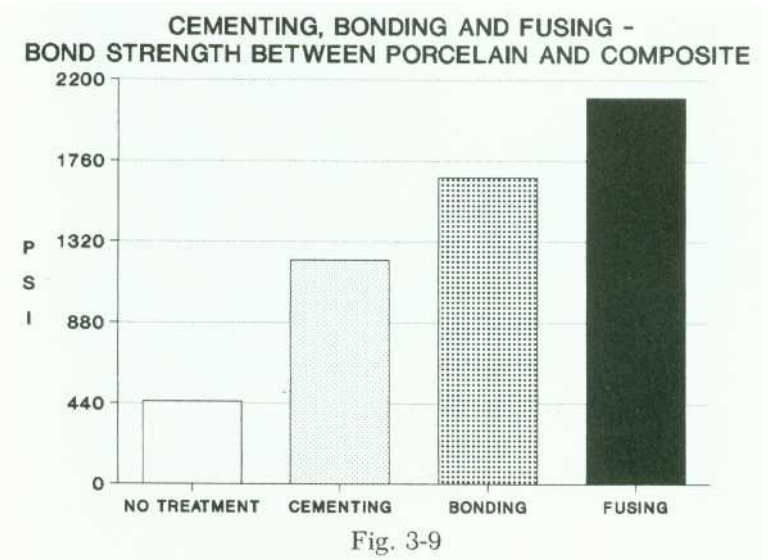

Fig. 3-9

Finally, all the components necessary for a new and improved retention system had been discovered. All that remained was to put them together in a coherent system. In 1983, in a paper on porcelain veneers, a new term entered the dental vocabulary: enamel fusion. McLaughlin introduced this term to describe the combination of both micromechanical and chemical attachment on all interfaces of a restoration to a toothl°. By definition, each surface being fused first would be etched and then cemented. The use of enamel fusion requires either using materials which are capable of both cementation and bonding, or alternatively, using "coupling agents" as intermediaries.

By using the fusion process, the total bond strength of porcelain to tooth is increased by 66 percent over simple bonding. When using this process, the dentist is able to adhere porcelain veneers on to the tooth surface with greater tenacity than has ever before been possible. In fact, one report indicated that the strength of the attachment between a porcelain laminate and enamel after the fusing process exceeds the strength of the bond between the enamel and the underlying dentin.

In summary, then, present day fusing is made possible by two things: the mechanical gripping afforded by etching, and the chemical attachment afforded by coupling agents. To better understand exactly what is happening in the fusing process, it is helpful to examine each of the components separately. First we will look at what happens to the tooth.

When a mild acid is placed on the surface of a tooth, a roughened, pitted surface results due to one of the morphological characteristics of human enamel. Microscopically the enamel is composed of bundles of prisms or rods which radiate in a direction from the center of the tooth toward the periphery. Surrounding each of these prisms and serving as "mortar" for them is the substance known as interprismatic enamel. It is because of the difference in resistance to acidic attack between the enamel prisms and the interprismatic enamel that the acid wash creates a retentive surface. In some areas of the enamel, the centers of the prisms erode more rapidly than the interprismatic enamel. In other areas, the reverse will happen, and the interprismatic enamel erodes more thoroughly than the prisms themselves. As a result, four major etching patterns of the enamel are reported in the literature.

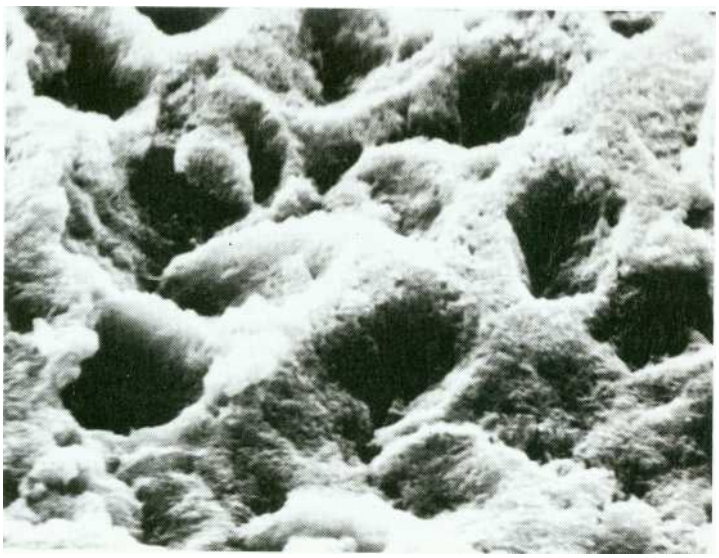

Fig. 3-10

The Type I etching pattern is created when the prism shows less resistance to the acid than the interprismatic enamel. This pattern appears as a series of relatively symmetrical "holes" or "pores" in the enamel, extending to a depth of approximately 20 microns.

The average width of the craters found in the Type I etching pattern is about five microns. It is partly for this reason that many luting agents utilize a filler particle size of no greater than five microns. A generally held belief is that by restricting the particle size to five microns or less it is possible for the filler particles to enter into the lumen of the etched enamel. This characteristic of luting composite is of dubious value, however, since even if penetration of a five micron filler particle may be possible and reasonable with a Type I etching pattern, it is probably of no significance whatever in Types II, III or IV.

The Type II etching pattern is created when the interprismatic substance erodes more rapidly than the enamel prisms themselves. The resulting surface has been described as looking like a view of treetops when seen from above. The invaginations eroded into the enamel are obviously much narrower than that of the Type I etching pattern, but this surface is still suitable for fusing.

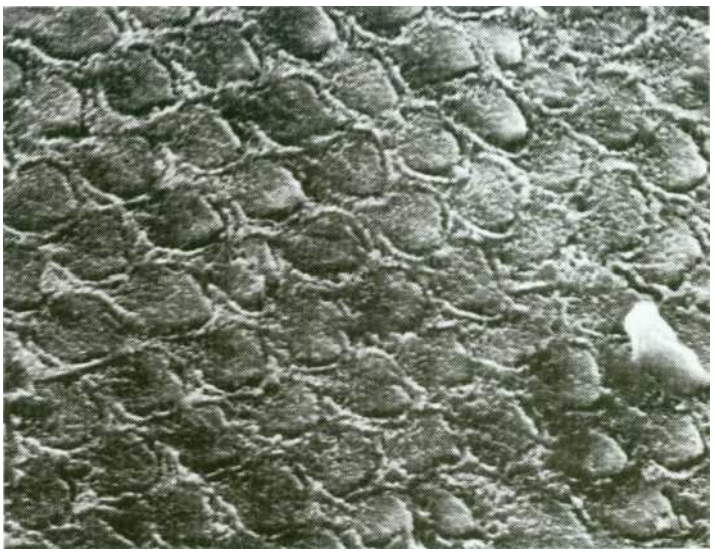

Fig. 3-11

It is interesting to note that even though Types I and II etching patterns are exact reverses of each other, they will often occur in adjacent areas of the same tooth, sometimes even in adjacent prisms.

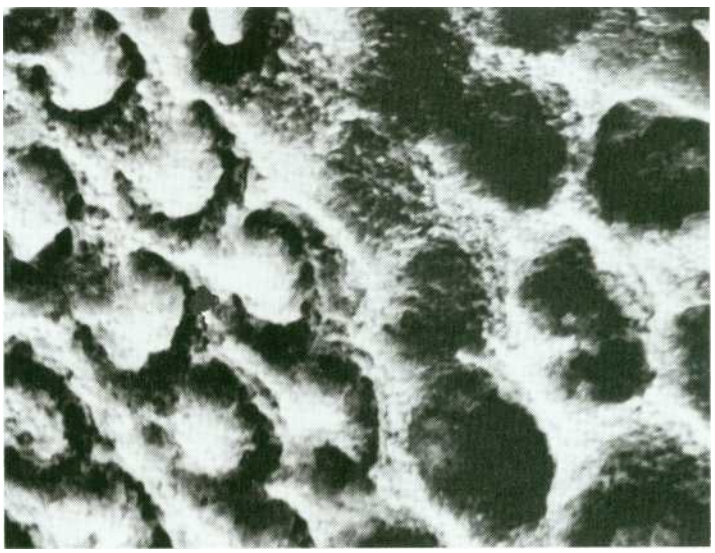

Fig. 3-12

While Type I and II etching patterns are suitable for mechanical retention, Type III is not. In a typical Type III etching pattern, no rod structures are evident. This etching pattern results when the enamel consists of a homogeneous mass rather than the familiar rod and interprismatic enamel structure.

It was recognized early that deciduous teeth frequently exhibit a stratum of homogeneous enamel in their outermost layer. It is because of this homogeneity that an application of acid results in a simple reduction of enamel bulk rather than the differential etch required for mechanical retention. As such, the Type III etching pattern can be troublesome for fusing. To make matters worse, prismless enamel is not confined to deciduous teeth as had once been believed. An increasing number of reports indicate that the cervical two-thirds of premolar and molar crowns is often completely devoid of rod patterns after etching[11,12,13].

Fortunately, the prismless enamel layer is usually confined to the outer 13 to 20 microns of the enamel. It is therefore possible to erode past this prismless layer using the etchant.

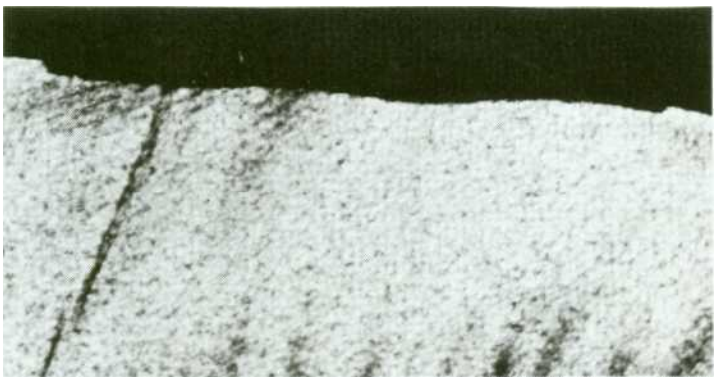

Fig. 3-13

An application of 30 percent orthophosphoric acid for 60 seconds on enamel usually results in a loss of about 10 microns in surface contour and about 20 micron depth of histologic change. Since the prismless enamel usually extends no deeper than 20 microns, it is obviously possible to easily erode past this layer with the application of 30 percent orthophosphoric acid. Beneath the prismless layer, the underlying structure usually exhibits one of the other three etching patterns. Thus the presence of prismless enamel dictates that the etching time for proper fusing be considerably longer than that required by normal enamel.

The fourth etching pattern (Type IV), is a combination of Type I and II. It exhibits what at first appears to be a random irregularity in the surface of the enamel. Some dentists believe that the irregularity and apparent randomness of the perforations enlarged into the enamel create the ultimate surface for composite fusing. (Figures 3-10 through 3-14 courtesy Dr. Leon Silverstone)

Over the first 48 hours, many forces combine to hold the composite in contact with the enamel. These include not only mechanical gripping, but also chemical, and Van der Walls forces. After 48 hours in the mouth, however, the chemical, electronic, and Van der Walls forces diminish to such an extent that they are insignificant. These three forces are effective only when the enamel and composite resin are in extremely intimate contact. Since water has a much greater affinity for both the enamel and composite resin than they have for each other, water from the patients saliva gradually insinuates itself between these two layers, "prying" them apart. After 48 hours, the mechanical retention is all that remains for standard bonding.

Still, this bonding is quite strong. The currently accepted value for the bond strength of composite to etched enamel in both tensile and shear directions is between 980 and 1400 psi [14,15]. This is extremely high for simple mechanical gripping for these materials. The obvious explanation for this surprisingly high bond strength is that the mechanical bonding is not "simple" at all. During the etching process, the enamel "pores" become enlarged. These pores not only penetrate vertically into the tooth's surface, but also interconnect (Bergman and Hardwick hypothesize that they are pathways used for transport of ions and tissue fluids) [16,17]. The increase in size of these interconnecting pores allows the relatively large resin molecules to penetrate through the subsurface of enamel and to interconnect with other resin tags. This results in a very high degree of resin interlocking around the enamel crystalite itself.

In order to consistently create these exceptional bond strengths, meticulous attention to detail is required prior to fusing. While enamel is an excellent substrate for fusing, in its natural state there are several mechanical impediments to forming a strong mechanical attachment.

Proteins from saliva continually adsorb to the surface of teeth, even in high abrasion areas. As a result, the enamel is normally covered by a thin organic layer called pellicle[18]. This pellicle then serves as a point of attachment for plaque. The plaque products, along with solid food constituents and fluids form a continuous plaque/pellicle complex. This layer serves as an effective barrier to etching by mild acids. In 1973 Mura and his co-workers showed that the etchant alone was not sufficient to do the job". This was further demonstrated by Gwinnett[20] in 1976 when he showed that enamel which was etched without a mechanical pre-cleaning was often contaminated by remnants of the pellicle as well as by microorganisms.

The obvious conclusion is that in order to maximize the effectiveness of the etchant, the enamel must be pre-treated with a thorough prophylaxis. The usual cleaning agent is unfluoridated, unflavored pummice, despite the fact that there is support in the literature that standard prophylaxis paste, even with fluoride, is equal in effectiveness. Much has been written about

the potential advantages of using either a rubber cup or a bristle brush to clean the enamel [22,23,24,25] but there appears to be no qualitative differences between a thorough prophylaxis performed with either instrument. Thus the choice seems to be simply a matter of operator preference. There also has been some interest in the possibility of using a diamond bur to lightly "dust over" the enamel, both cleaning the enamel and removing the outermost layer of its surface, and some of the literature supports this method [26.27].

If a diamond instrument is used, however, caution must be exercised. Remember that the porcelain laminate has been constructed to carefully fit the tooth; the dimensions should not be randomly altered after the impression has been taken, or placement could be complicated. Prudence also is particularly indicated in the case of some of the less conservative tooth preparations (Type IV,V). If the dentist has already eliminated all the enamel that can be safely removed, then good judgment would dictate that the use of a diamond bur be avoided during the attachment phase.

The method used for cleaning the enamel is not critical. What is absolutely vital, however, is that complete cleaning be achieved on all surfaces to be bonded. This also includes the interproximal areas, as well as any areas on the lingual of the tooth that are going to be covered by porcelain. Also, it is good practice to clean and etch slightly beyond the actual area to be covered by porcelain whenever possible. This will allow for minor discrepancies in placement and for a smoother transition from tooth to porcelain.

The result is that there is nearly always a need to clean the enamel interproximally. This can be achieved using polishing strips or a Prophy Jet (Dentsply, York, Pennsylvania). The Prophy jet uses a stream of sodium bicarbonate and water under pressure much like a miniature sandblaster.

Fig. 3-15

ETCHING

Many etching materials are now on the market. They are all composed of orthophosphoric acid of between 35 and 50 percent concentration. Some of them also have been combined with filler to make a gel. While they are all clinically effective, the gels and liquids require two slightly different techniques. In using the liquid, one must continually stir the liquid on the surface of the enamel. Be especially careful to avoid pressing against the enamel during this phase because even slight pressure can burnish the enamel rods and diminish ultimate bond strength. If a gel is used, the stirring is not necessary.

Until recently, the accepted time for a proper etch has been 60 to 90 seconds[28◦29]. Some interesting research, however, has made those times equivocal[30,31,32]. Further research in this area is needed to clearly determine the optimal etching period.

After the appropriate amount of time (usually around 60 seconds), the etchant is rinsed off. Since the gel is so much thicker, it naturally requires more time to remove. Rinse the liquid for at least 20 seconds, and the gel for at least one minute before proceeding. Though using a gel takes longer than a liquid, it stays where it is placed. This becomes important when there are any areas of exposed dentin or cementum. In such cases the gel can be carefully placed to avoid the dentin and cementum. The use of a syringe is often helpful for this process.

Fig. 3-16

Once etched and rinsed, the enamel should be completely dried with clean oil-free air. The enamel should have a "frosted" appearance, as shown here.

If it is still glossy, then repeat the etching step. If the acid has been allowed to stay on the enamel too long, the tooth will show an opaque, white, chalky appearance (as opposed to "frosted") due to the production of an insoluble precipitate. The precipitate stays behind after rinsing, clogging the roughness created by the etching. The result is a diminished bond strength. The solution: repolish the surface and re-etch.

After etching and drying, it is important to avoid contamination of the surface. Among the list of possible contaminants is oil from the fingers, talc from gloves and saliva. Even a few seconds of exposure to saliva is sufficient to diminish the bond strength dramatically. If the etched enamel becomes contaminated, it can be re-activated by a ten second exposure to the etchant. This short treatment with the etchant both cleans the etched surface and raise up its energy level so it will be chemically ready to react with the composite.

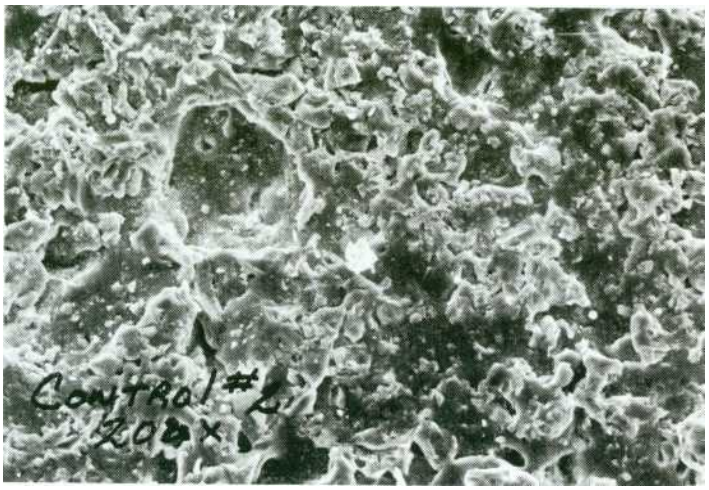

Fig. 3-17

By comparison to enamel, the porcelain/composite interface seems much simpler. Unetched, unglazed porcelain presents a microscopic surface that is somewhat porous. This figure shows unetched/unglazed dental porcelain at a magnification of 200X.

Fig. 3-18

Magnified to 2,400X, it has this appearance.

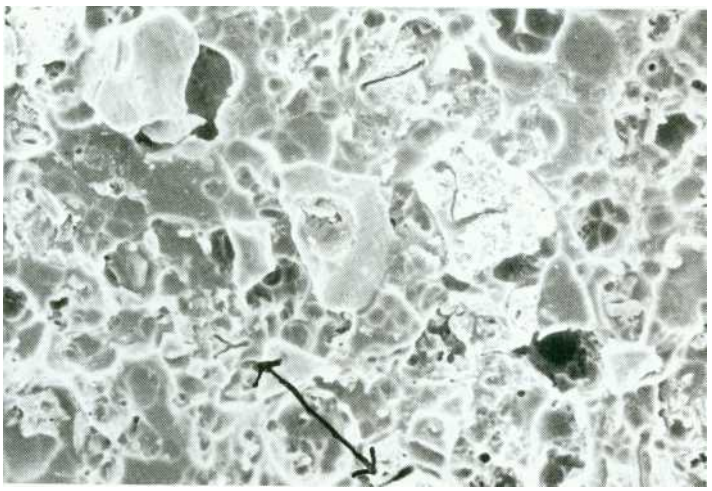

Fig. 3-19

The application of hydrofluoric acid to this surface not only widens the pores present on the surface, but also cleans away small bits of material from the openings. Here is a sample of dental porcelain that has been etched and magnified to 200X.

The "cleaning" effect of the acid is even more apparent in these two views taken at 2,400X (Figs. 3-20, and 3-21).

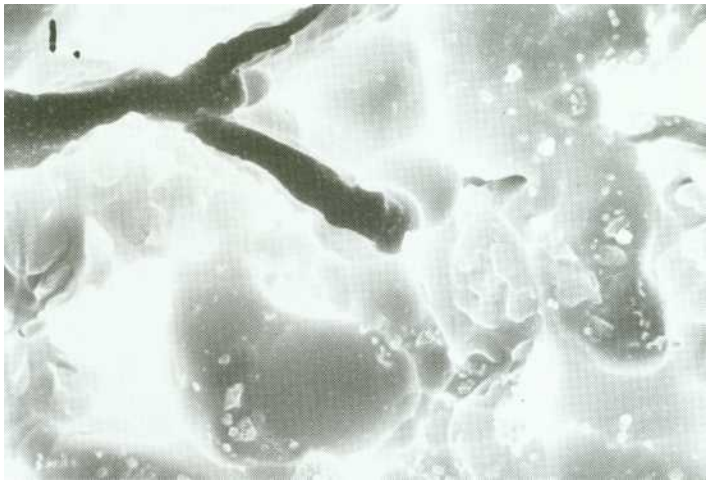

Fig. 3-20

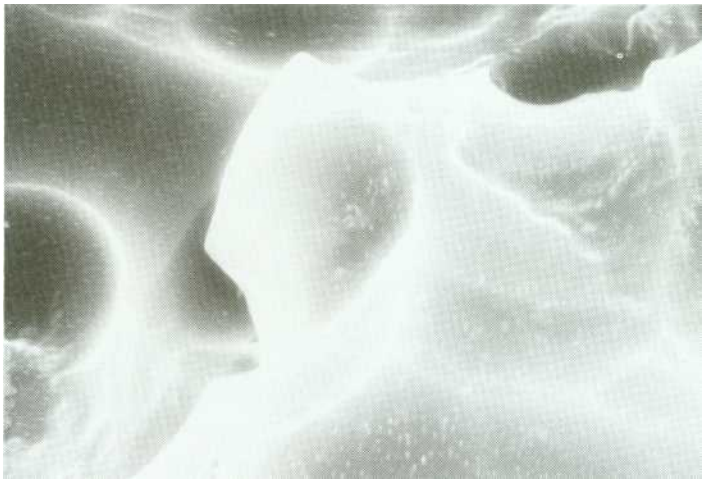

Fig. 3-21

One might think that the thin fragile projections of porcelain that cover the surface of the etched porcelain would not have sufficient strength to serve as an anchorage of attachment in fusing. It should be remembered, however, that each of these projections will be completely surrounded by resin.

As with enamel, there is an optimal period for etching the porcelain. After the optimal period, there is a decrease in the mass of the porcelain, but no improvement in the retentivity of the surface. The optimal time for etching is dependent upon the concentration and mixture of acid used as well as the formula of the porcelain.

Experience has shown that the optimal time for etching may even be partly dependent upon the exact conditions used to fire the porcelain. Fortunately, the bond strength to etched, silanated porcelain is so high that even a substantial variation from the ideal will still yield results beyond those required by the technique. Any bond strength between the composite and porcelain in excess of that between the composite and enamel is unused..

One porcelain manufacturer has specifically formulated a porcelain with components that etch out selectively in order to optimize the etching technique. Etching provides the mechanically retentive portion of the fusing technique on both the tooth and porcelain interfaces. The chemical attachment between the resin and both the etched enamel and etched porcelain is afforded through the use of coupling agents. In the case of the porcelain, the usual coupling agent is a silane. There are many brands of silane currently available in the dental marketplace. Most use either gamma-methacryloxipropyltrimethoxysilane or gamma-Glycidoxypropyltrimethoxysilane.

In the case of the etched enamel, the coupling agent is one of the group of "dentin/enarnel bonding agents". Most of the present formulations incorporate esters of BIS/gma. Examples of this group are Bondlite, Scotchbond, and Sinterbond. These presumably work by forming chemical bonds between the esters and the calcium or phosphate groups of the tooth structure. This group of coupling agents is extremely suitable for use with porcelain laminates.

On occasion, it becomes necessary to cover over exposed dentin. This could occur, for instance, during a maximum prep, or while covering over a cervical abrasion. While BIS/gma esters are useful for this purpose, several other materials also may be used. These include polyurethane based dentin adhesives, glass ionomer cements, "Bowen's formula" adhesives, GLUMA, and Scotchbond2. As always, deep areas of dentin exposure must be protected from composite resin. Calcium hydroxide is most often used for this purpose, since eugenol will inhibit setting of composite resin.

The polyurethane based group is exemplified by Dentin Adhesit and Restodent Dentin Bonding Agent. The polyurethanes are generally created as a condensation polymer between a polyol (from polyesters or polyethers) and a polyfunctional isocyanate. The working assumption is that the polyfunctional isocvanates are responsible for coupling to organic components of the tooth surface and composite resin. For maximum effectiveness, it is therefore necessary to have a dentinal smear layer. If one is not present during the adhesion process, then it should be created. Note that since the polyurethane based dentin adhesives require a dentinal smear layer for attachment, they are inappropriate for use on etched enamel.

"Bowen's formula" adhesives (also known as the oxylate group) have been reported to achieve 1600 psi bond strength to dentin. This is a formidable tenacity, but is achieved only after multiple procedures that take nearly five minutes to perform.

Scotchbond 2, consists of a light cured material ("Scotchbond 2") in conjunction with a primer ("Scotchprep") (3M, St. Paul, Minnesota). Neither the adhesive nor the primer individually create any adhesion to dentin, but when applied sequentially, the immediate bond strength is in the region of 1500 psi, with a 24 hr. strength of 2700 psi. This compares favorably with the strengths attainable by bonding to etched enamel (Fig. 3-23). One of the major attractions of Scotchbond 2 is its extreme simplicity and ease of use.

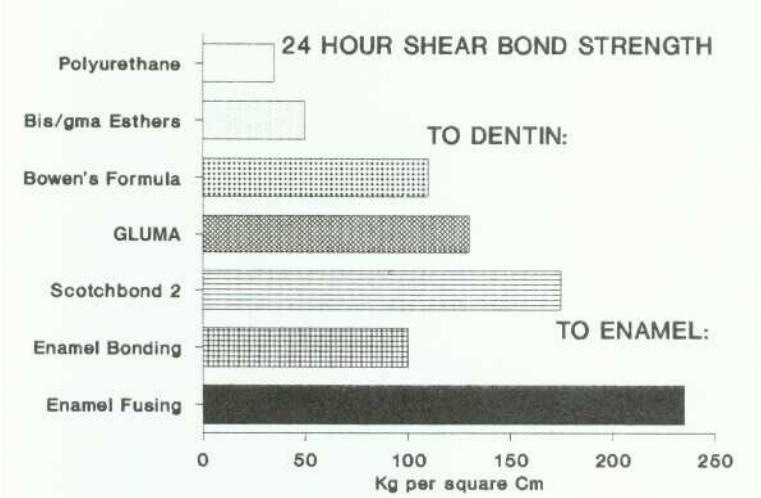

Fig. 3-22

GLUMA (Columbus Dental, St. Louis, Mo.) is another extremely interesting material for dentin bonding. The technique utilizes EDTA, glutaraldehyde, and 2-HEMA in successive applications. The bonding is usually explained by the glutaraldehyde action on collagen in the dentin and copolymerization of HEMA carbon bonds with the composite resin. One of the main attractions of GLUMA is the fact that the material and technique have been reviewed in the literature since 1984 with consistently impressive results. It was available in Europe for several years before first becoming available in the United States late in 1988. The clinical technique is simple and reliable.

For cervical abrasion, many operators find it useful to fill in the defect with glass ionomer cement prior to preparation for the laminate. Later, when the veneer is seated, the glass ionomer is treated as if it were enamel, with the exception of adjusting the etching time to 20 seconds. While glass ionomer does not produce as high bond strengths to dentin as Scotchbond2, GLUMA, or the oxylate systems, it does have the decided advantage of slowly leaching fluoride to the adjacent tooth structure.

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Chapter 4 PORCELAIN VENEERS: INDICATIONS AND CONTRAINDICATIONS

INDICATIONS

There are many indications for porcelain laminate veneers. Included among these indications are the following:

Fig. 4-1

Stained or darkened teeth. This discoloration arose from the high metallic content of the drinking water that this patient consumed throughout her childhood in the Azores Islands. Staining also can result from smoking, drinking tea and coffee, fluorosis, and inadequate oral hygiene.

Fig. 4-2

Hypocalcification. The so-called white "discoloration", these spots can be as perplexing to the patient and dentist as staining.

Fig. 4-3

Diastemas. These are frequently seen in patients whose jaw and teeth sizes do not match. The mandible may be too large, or the teeth may be too small, or possibly a combination of both. There may be anterior spacing due to early loss of the posterior teeth and the subsequent drifting.

Fig. 4-4

Peg laterals. These malformed incisors occur relatively frequently, often being seen in patients who have congenitally missing teeth and the related problems of diastemas. Peg laterals are hereditary, and if a patient is affected, it is likely that his siblings will require treatment also.

r ig. 4-5

Chipped teeth. This kind of breakdown may be attributable to external influences, such as sports or fights, or to intraoral forces, such as bruxing, grinding, and clenching.

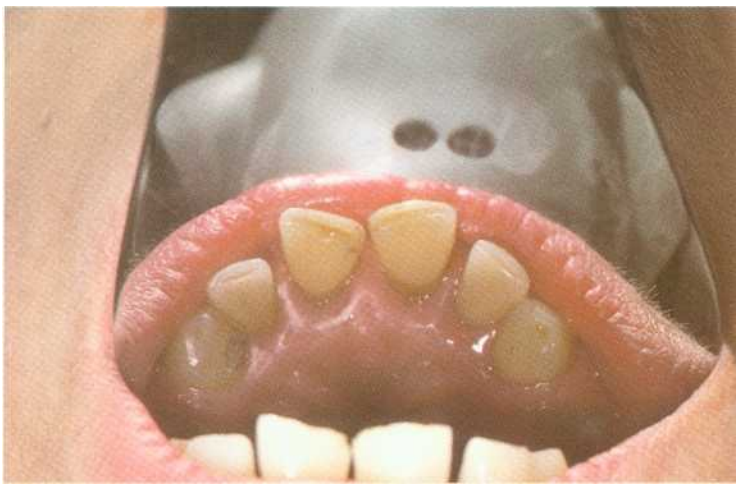


Fig. 4-6

Rotated teeth. These teeth erupt or grow incorrectly, often as a result of crowding during the mixed dentition period. Their cosmetic treatment will sometimes include the use of orthodontics.

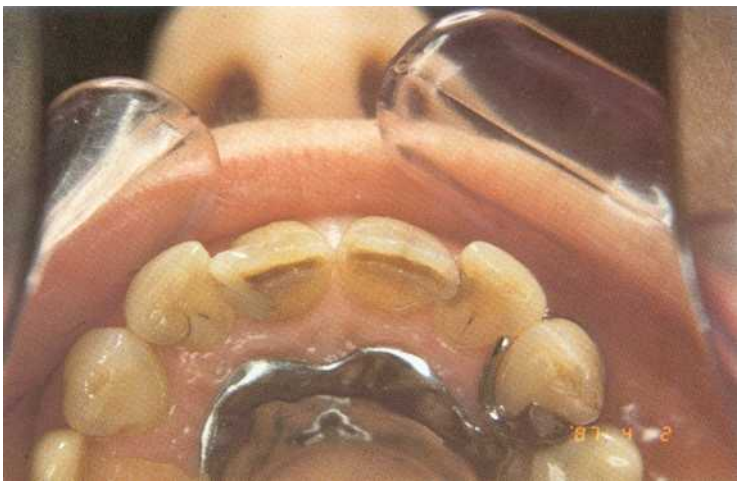


Fig. 4-7

Lingual position. These malpositioned teeth are most often corrected orthodontically, but can be treated with porcelain veneers as well.

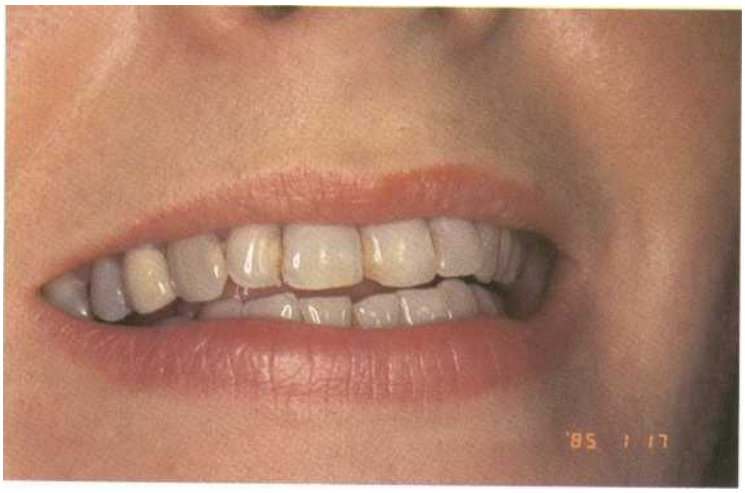


Fig. 4-8

Stained restorations. Composite restorations may be acceptable dentally, but not esthetically. For patients who smoke, or drink coffee or tea, replacing these with new composites is often at best a short term solution.

Fig. 4-9

Foreshortened teeth. Some patients have worn away some part of their incisors through clenching or grinding. Once the problem of decreased vertical dimension has been attended to, these anteriors can be esthetically restored.

Fig. 4-10

Malpositioned midlines. In cases where there is a moderate amount of midline displacement, especially when this is associated with diastemas, porcelain veneers may be a desirable treatment modality.

Toothbrush abrasion. The non-invasive nature of veneering, and the resistant surface presented after treatment, make porcelain veneers the restoration of choice.

Fig. 4-11

Worn acrylic veneers. There are many patients who have preformed plastic veneers bonded to their teeth. Unfortunately, preformed plastic laminates have a relatively short esthetic lifetime in the mouth. When the positive esthetic effect of the plastic veneer is lost, these patients become ideal candidates for porcelain laminates.

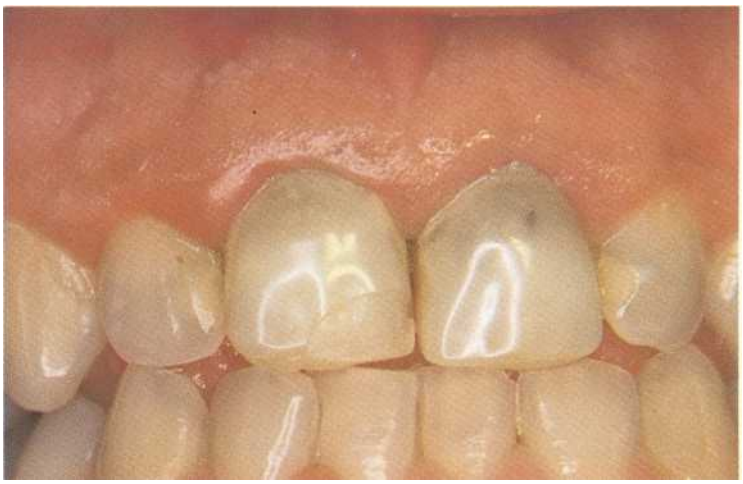


Fig. 4-12

Bonding to existing bridges. Silane fusion allows dentists to bond veneers to both porcelain fused to metal and acrylic veneer bridges. Porcelain laminates thus can be utilized to replace worn or chipped facings on existing bridges. At present, this use is considered a compromise to replacing the entire bridge and should not be considered a permanent solution.

Fig. 4-13

Fig. 4-14

Missing lateral incisors. This common problem is often solved by disguising the cuspid as a lateral incisor. Since the facial aspect of the premolars exhibit caniniform anatomy, the result can be esthetically dramatic.

CONTRAINDICATIONS

There are also a few contraindications for the use of porcelain laminates. These contraindications include the following:

Fig. 4-15

Insufficient fusible substrate. The technique used to attach porcelain veneers to teeth has always been most effective with etched enamel. Adequate attachment also has been effected over roughened composite. In the past, the bond strength to dentin has not been considered high enough to warrant the placement of a veneer in the absence of enamel. With the current emergence of the newer dentin bonding agents such as GLUMA (Columbus Dental, St. Louis, Mo.) and Scotchbond II (3M, St. Paul, Minnesota), this contraindication may already have been eliminated.

Labial version. Teeth that are positioned labially to the arch contour beyond the reasonable depth to which preparation can be taken traditionally have not been veneered. The anticipated bond strength to dentin has always remained below acceptable levels for this technique. As already indicated, it is hoped that with the new generations of dentin bonding agents this restriction will be lifted. Until such time, however, we would continue to recommend that whenever possible such cases should be treated orthodontically.

Fig. 4-16

Excessive interdental spacing. This type of situation does not allow full closure of the spaces without creating another esthetic problem-oversized looking teeth. Porcelain laminates can still be used to improve the esthetic situation, but the experienced Cosmetic Dentist will leave some interproximal space.

Fig. 4-17

Poor oral hygiene. The lack of home care is a contraindication to any type of major dental restorative work, including veneers.

Fig. 4-18

Mouthbreathing. When mouthbreathing is present, there is a relatively poor prognosis for the case due to both the eventual decay under the veneers and the potentially shortened lifespan of the materials themselves. The materials experience greater stresses when they are constantly wetted and then desiccated. The dentist, therefore, has a duty to inform certain patients with high lip lines that they do not present ideal oral conditions for porcelain veneers, and the long term prognosis must be guarded.

Some contact sports. Chipped anteriors are sometimes the result of playing various sports without a protective face or mouthguard. If the patient cannot be induced to change his habits, or to at least protect his teeth, veneers are not indicated.

Clenching or bruxing. Clenchers and bruxers are sometimes poor candidates for porcelain veneers for a perhaps surprising reason. Porcelain veneers that extend over onto surfaces which come into contact with the opposing dentition may fracture, but it is more likely that they will wear down any opposing natural teeth creating accelerated wear.

Extreme midline deviation. In those few cases where one of the upper central incisors actually straddles the midline, laminate veneering is not a good solution to the problem. Since veneering cannot create an embrasure or interdental space in the middle of a tooth, it is not reasonable to undertake laminate treatment where esthetic results are unlikely to be achieved.

THE SMILE ANALYSIS

Obviously, the first step in the fabrication of porcelain veneers must be to establish the need for this kind of restorative work and the conditions upon which ultimate success (or failure) will be predicated. If all that is being considered is a single tooth, there is no need for a complete smile analysis. In such cases, the porcelain laminate must be designed to fit harmoniously with the existing dentition. When restoration of a larger section of the dentition is considered, however, the initial evaluation should be the smile analysis. This should be done to help both the dentist and patient examine the general problems that exist and the potential for their solution.

Perhaps in the field of cosmetics more than in any other area of dentistry, it is easy for the dentist to misinterpret the desires of the patient. The patient has little or no knowledge of dentistry and is thus often unable to clearly define his dental goals, or sometimes even what is currently disturbing him. Therefore, the authors suggest regular use of a short but comprehensive questionnaire to help identify and isolate both the problems and the most acceptable treatment goals.

Our questionnaire has been designed with two convergent areas: patient and dentist objective considerations, and patient and dentist subjective considerations. In the former, the dentist is more important because he is the one trained to observe and analyze oral conditions. In the latter, the patient's concerns are paramount because he will be wearing the final product.

OBJECTIVE EVALUATION

The objective evaluation is begun by comparing the shape and the size of the teeth in relation to the shape and the size of the head. Current esthetic standards lead us to expect a visual correspondence between these two structures. For example, today's cosmetic standards lead us to expect long, narrow teeth to occur more frequently in dolicocephalic patients (and, conversely, we would also expect that someone with a wide, round face is likely to possess wider, less angular teeth). This perceived cosmetic relationship is particularly important for case planning when multiple spaces are present, since in such cases the dentist cannot use any existing anterior teeth to estimate the required dimensions.

There is a readily available method of quantifying this analysis in a reproducible manner, which is in turn easy to transmit to a laboratory. A number of years ago, the Dentsply Company created the Trubyte Tooth Indicator (L.D. Caulk Co., Milford, Delaware). While this system was intended to help select properly proportioned anterior teeth for dentures, it can guide the choice of both shape and size in the veneer reconstruction of a smile. An added benefit of utilizing this system is that laboratory technicians, already familiar with denture tooth selection, can readily comprehend and duplicate the type of appearance requested by the dentist.

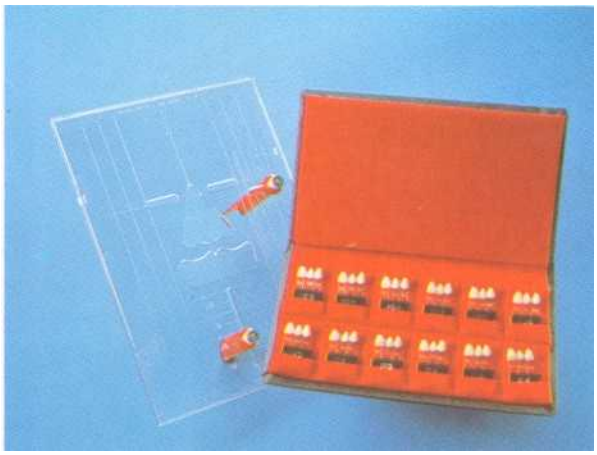


Fig. 4-19

It is important to remember that this system is but a guide. The dentist must always exercise artistic control in order to achieve the maximum improvement in esthetics.This system classifies faces into four basic typical forms: Square, Square Tapering, Tapering, and Ovoid (See Fig. 4-20).

There is a further modification of the first four categories by an additional Ovoid influence (See Fig. 4-21). A basic assumption behind the tooth indicator is that if the face and teeth are in harmony, then a more pleasing esthetic condition results. There is no intention here to indicate that the teeth are, or even should be, always related to the proportions of the face. However, if the result of this type of evaluation leads to a more pleasing visual impact, then it cannot be ignored in dental cosmetics.

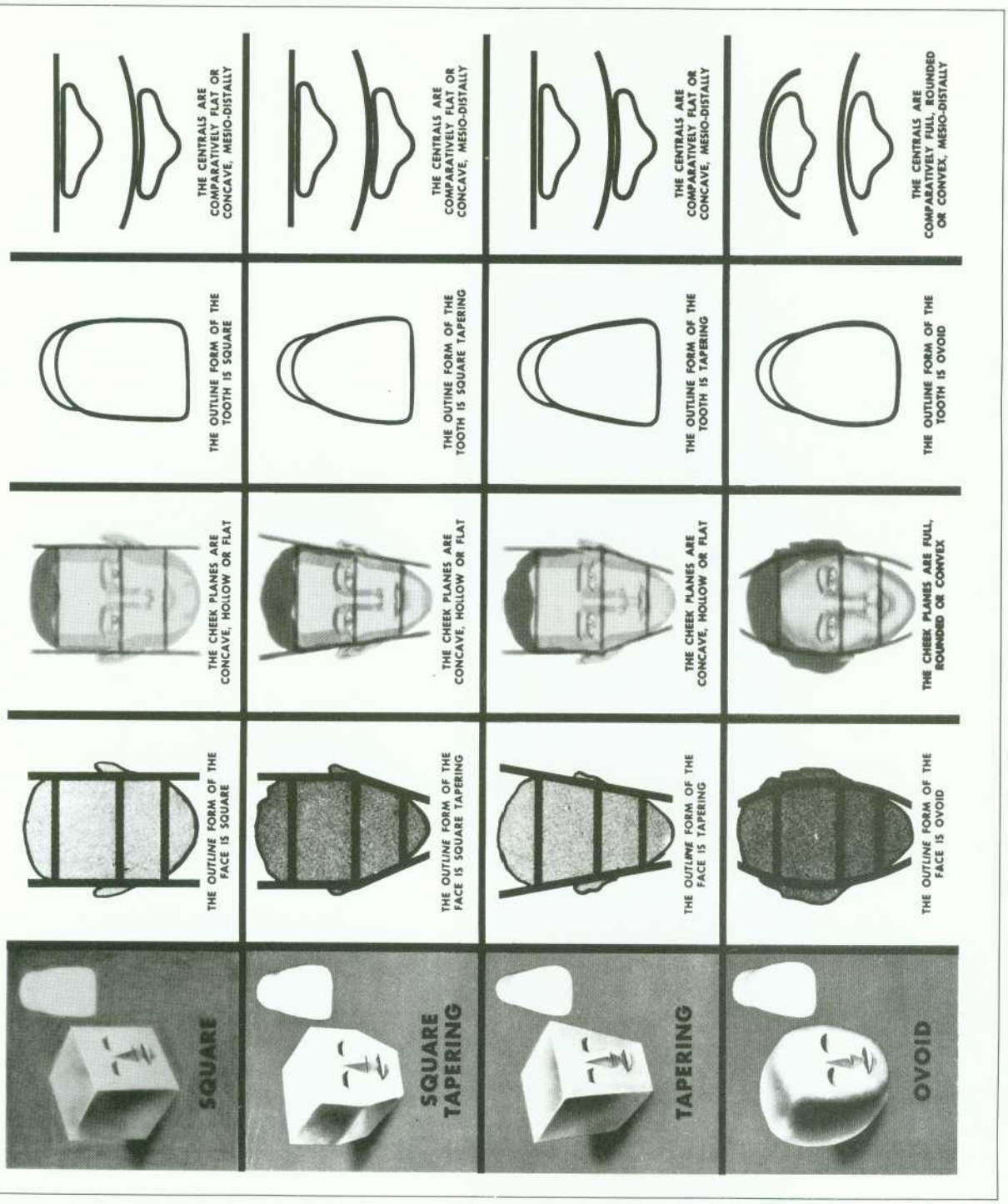


Fig. 4-20. The four Basic Face Forms. (Reprinted with permission, Dentsply International, Inc.)

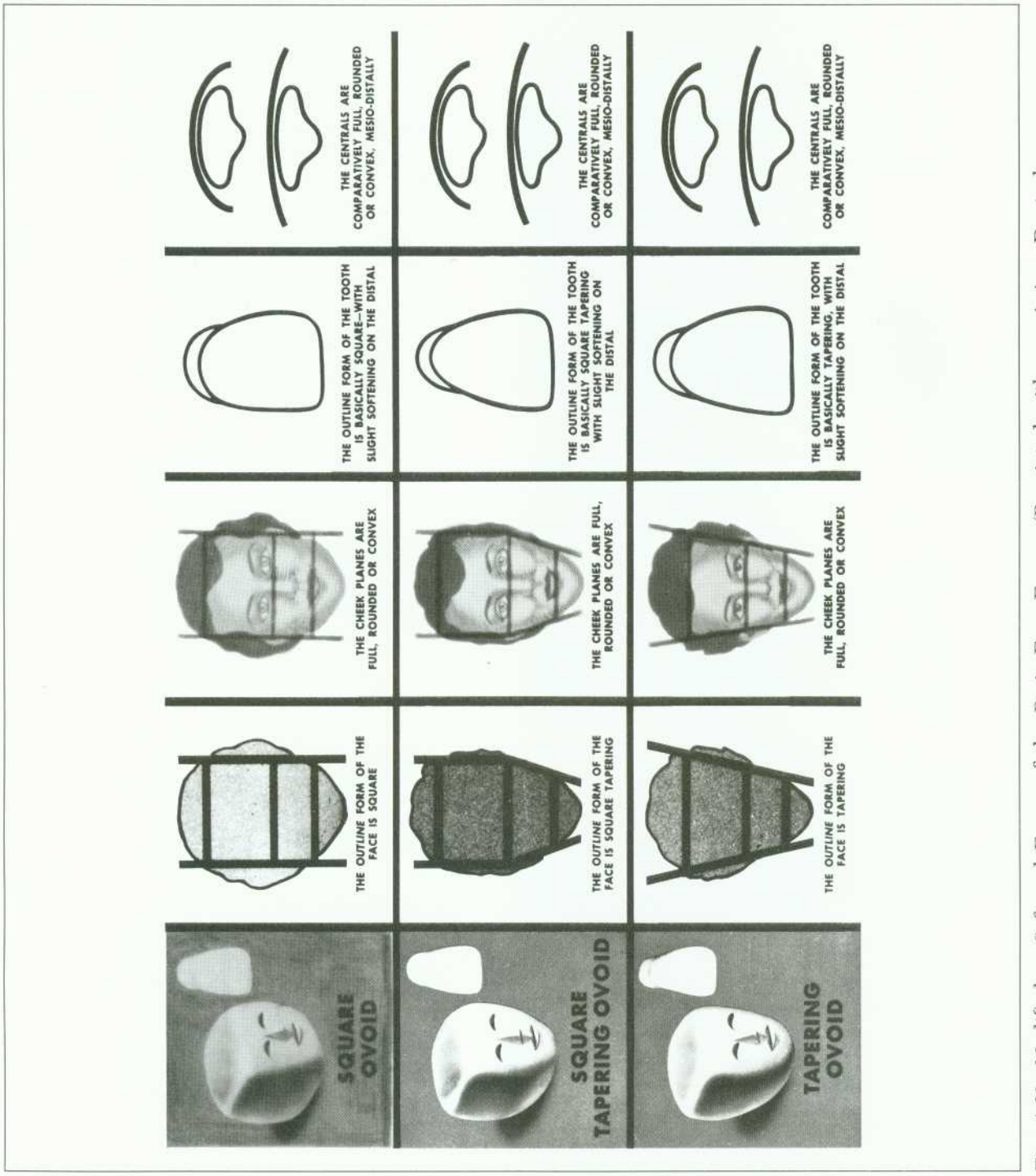


Fig. 4-21. Modified or Softened Forms of the Basic Face Forms. (Reprinted with permission, Dentsply International, Inc.)

r ig. 4-22

The plastic plate is placed in front of a patient's face, with the nose poking through the specially provided triangular space . The eyes are lined up in the special slits provided, and the mouth is centered. Then, looking from straight ahead, the dentist can determine the shape of the face. It is helpful at this time to utilize the vertical guidelines in the plastic face plate. Because these lines clearly delimit various portions of the face, they are particularly useful in trying to decide borderline cases. In short, the face plate helps to focus the dentist's attention on the details he is seeking and tends to eliminate most of the extraneous input that might make this evaluation more difficult.

The shape of the face also tends to influence the ideal relative convexity (or concavity) of the maxillary central and laterals. This is an area often overlooked by both dentists and technicians, and while such an oversight is not a glaring error, it certainly can have enough of an effect on porcelain veneers to make them appear less lifelike.

The facial shape should be entered on the Smile Analysis Form. Combined with later data on the mesio-distal and vertical space available, the shape will assist in the generation of the specific personalized "mold" to be fabricated.

Fig. 4-23

The number of teeth exposed to view on smiling will indicate how far distally the dentist should be placing veneers. While it is generally accepted that in order to adequately improve the smile, at least the anterior six maxillary teeth should have veneers, this is plainly not enough for someone who shows the second bicuspid. All the maxillary teeth that are apparent on a regular smile should be treated. While this may sound like a make-work suggestion, the dentist must consider the final result. A patient who has had his six anteriors covered with porcelain veneers may find that his untreated first bicuspids, now particularly unesthetic in comparison with the treated teeth, stand out much more than previously when he smiles.

In a case where one of the bicuspids is lingual to the arch, for instance, placing a veneer on the adjacent cuspid will increase the apparent malposition of the bicuspid. Therefore, if possible the bicuspid should be covered as well.

Fig. 4--24

For patients seeking partial or incomplete treatment, this problem must be pointed out, or they will be very disappointed in the results. In fact, the dentist should allow the patient, with the help of a mirror, to actually select just how far back the veneers will be done. It is likely that the patient will opt for more teeth than the dentist might have chosen.

The next point of observation is the maxillary high lip line. A full or even a lower than normal lip is of no great importance, but a raised high lip line may lead to many difficulties. In these cases the location and the finishing of the gingival margins of the veneers is even more critical than usual. The slightest imperfection or incomplete masking will be readily visible, especially to the patient's eye. Sometimes the only method available to correct an irregular set of gingival margins is with surgery.

With normal lips, these areas are usually hidden, excepting those instances where extreme muscular movements occur. In the high lip line patients, the gingival margin of the upper anteriors is often the visual focusing point. In any case, it is vital that this observation be made before starting the case. A mistake in planning at this point cannot be compensated for after the case is fused in place.

Fig. 4-25

Another major concern in these patients is the shape and the size of the interproximal spaces. These are the hardest areas to finish veneers in such a way that they both cover the underlying tooth completely and are esthetic and anatomically correct in their own right. A mistake often made by those just beginning to work with porcelain veneers is to make the teeth quite square, and thereby close off much of the interproximal spaces. In a high lip line patient this can be disastrous; the teeth look enormous and unnatural, the so-called "horse-teeth".

Another consideration found with some high lip line patients is that there is often an associated tendency toward mouthbreathing.

Fig. 4-26

Misaligned teeth may or may not hinder the placement of veneers, depending on the direction and the degree of misalignment. A lateral incisor in slight linguo-version can easily be built out to the arch contour with a slightly thickened veneer assuming there is adequate mesio-distal clearance (Figs. 4-26, 4-27).

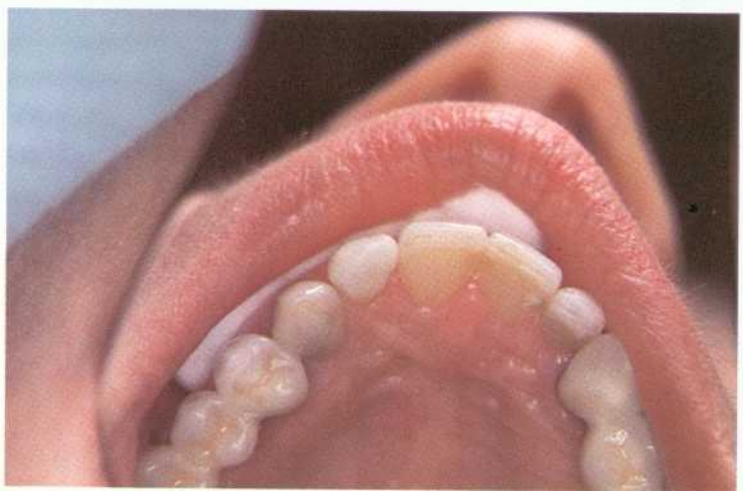


Fig. 4-27

But a mandibular cuspid in crossbite often limits treatment. If the tooth to be treated is in crossbite, orthodontics may be required prior to cosmetic restoration.

In certain orthodontically classified conditions, such as a bimaxillary protrusion, or a Class II malocclusion, where the maxillary anteriors are already positioned too far labially, adding the bulk (however minimal) of a porcelain veneer will cause a more accentuated esthetic problem. Obviously, this characteristic must be discovered and discussed with the patient at this time.

Fig. 4-28

Some patients' teeth may have wear facets or even chipping. While these conditions may be minor and not contribute greatly to the esthetic problem, they may be indicative of underlying situations that contraindicate the placement of veneers. Both wear facets and chipping can be the result of a loss of vertical dimension in the posterior region. If this loss cannot be corrected first, then it is unlikely that veneers will succeed in the long term, for they will be subject to the intense and continuous occlusal forces that broke the natural teeth initially.

Fig. 4-29

Any chipped or broken teeth should be noted at this time, as well as the reason for the breakage. If the cause for the destruction cannot be alleviated or at least modified, then there is little hope the porcelain laminates will survive.

Finally, the dentist must evaluate the color and staining of the teeth. This is important for the dentist to understand the difficulty of the ensuing project. The ideal situation for porcelain laminates occurs when the color does not have to be changed. The next most desirable category occurs when the colors of all the teeth have to be changed equally and not greatly. As the tint has to be lightened more, the work becomes more difficult. The hardest situation is one in which the teeth are various different dark shades and they all have to match in the final product.

When determining the final shade for the maxillary anteriors, the dentist should take into consideration the shade of the mandibular anteriors. If the difference in shade between the two arches is too great, the esthetic result will not be pleasing; a decision must be made either to veneer the lower anteriors as well, or to make a less dramatic alteration in the maxilla.

Natural characteristics of the patient's own dentition, such as translucency and shade gradation, should be incorporated into veneers whenever possible and desirable. Such qualities can greatly enhance the final appearance of a veneer. In order to insure harmony with the remaining unlaminated teeth, the dentist should make several observations about the natural teeth's shading. What is the degree of incisal graying (translucency)? Is the degree of coloration near the cervical a normal amount? Are there any unusual characterizations present, such as craze lines, hypoplastic areas, maverick colors, etc., which would be desirable in the final laminate? A conscientious dentist, working with a competent laboratory technician should have few problems including the above features. (see chapter 7)

Mesio-distal Space Analysis

Once the operator has established the facial factors that will govern the overall shape and size of the anterior teeth, it remains to be established that the required space is available and that the veneers can be placed in such a manner as to ensure an esthetic result.

The first guiding figure is the total suggested space for the six maxillary anteriors, determined by using the Trubyte Bioform System of Face and Tooth Form Harmony. This "ideal" width is compared to the space actually available in the mouth, using either the distals of the cuspids or the mesials of the first bicuspids as a reference point. These measurements will enable the dentist to determine the need for larger or smaller teeth.

Fig. 4-:30

Under certain circumstances, the operator can physically alter the size of the teeth (by making the veneers wider, for instance), while in other cases he has to rely on the technician's capacity for creating illusions in the porcelain laminates.

The second factor that is important in this analysis is the "ideal" width of the central incisor in proportion to the width and contour of the face. The dentist might need to increase the width of the central (and then the other interiors correspondingly), and this measurement will indicate just how wide the tooth can be made before it will look out of proportion with respect to the face. An analysis of this type will indicate, before treatment is begun, whether the diastemas should be closed completely.

It is very important in terms of cosmetic appearances to establish the correct location of the midline. The midline, between the two upper central incisors, has two reference points: the midline of the facial features (eyes, nose, lips), and the midline of the lower anteriors. When the maxillary midline is malpositioned, the entire face seems to be unbalanced. It is therefore, very important to respect the existing midline if it is in the proper location, and if it is not, to recreate an esthetic appearance by placing it correctly. The maxillary and mandibular midlines should be aligned, and both, in turn, must follow the facial lines.

A difficulty arises when the facial and mandibular dental midlines do not coincide. The dentist is faced with a dilemma; whichever alignment he chooses will leave a partially unesthetic appearance. The solution is not to place the maxillary midline in an intermediate position, as this would only compound the problem. The maxillary midline should always be aligned with the facial midline, as these are the two most readily visible landmarks.

Fig. 4-31

Placing the maxillary midline out of the facial midline will often give the patient an unidentifiable (by non-dentists) but nevertheless skewed appearance. In contrast, the malpositioned mandibular midline will be hidden by either the lower lips or the maxillary teeth most of the time. In this situation, obviously, a compromise solution must be employed.

It is sometimes preferable for the patient to have orthodontic treatment to align his teeth. Naturally, this solution requires time and the willingness of the patient to wear orthodontic appliances. Unfortunately, many patients seeking cosmetic treatment are also seeking to avoid intraoral appliances. Sometimes, however, acceptable esthetics simply cannot be obtained without some tooth movement, and the use of orthodontics and porcelain lamination act in symbiotic fashion to achieve the patient's desired esthetic results in a minimum amount of time.

Fig. 4-32

Symmetry in a smile goes beyond having the right number of teeth on each side of the midline. Generally, the corresponding teeth on either side of the arch are similar in size. Any divergence from this balance is observed as an unesthetic feature. Prior to treatment, the dentist must evaluate whether the contralateral teeth are dimensionally balanced. In the case that they are not, he must make sure that there is enough spacing available to restore this balance. If the mesio-distal spacing is unavailable, it should be created by a minimum amount of judicious preparation.

Rotated teeth present a problem in veneering only to the extent that they protrude from the arch contour and present mesio-distal size discrepancies when viewed from the labial. Any portion of the rotated tooth that is labial to the normal facial contour of the arch should be reduced; otherwise, the covering porcelain veneer will protrude in an unappealing manner. Care must be taken to ensure that this preparation does not remove excessive tooth structure; if the reduction involved is very deep into the dentin or the pulp, then obviously this treatment modality is not the one of choice.

If a lateral is rotated 90 degrees with no spaces present on the mesial or distal, then, by virtue of the dimensions bucco-lingually being less than those mesio-distally, there will be inadequate width to place a normal looking lateral veneer. If there is no space available in the arch, then either preparation of the adjacent teeth or illusion creating techniques must be employed to correct this feature (see chapter 9).

Another possible problem of rotation is a cuspid in a similar 90 degree position. Here the problem is reversed. The bucco-lingual dimensions of the cuspid are greater than the mesio-distal ones. Therefore, the veneered cuspid will appear too wide. This cannot be corrected by the reduction of the cuspid's dimensions because this kind of preparation would destroy the interdental contacts and upset the occlusal harmony of the entire mouth. Fortunately, by adjusting the labial prominence of the cuspid more mesially or distally, the apparent size can be controlled (see chapter 9).

Vertical Space Analysis

Once the dentist has analyzed the facial form and the mesio-distal influences that contribute to the porcelain veneer design, there remains one additional dimension that requires parameter definition before the procedure can be started.

The Bioform Tooth Form System gives a reading for the approximate vertical height of the central incisor. This figure, in millimeters, refers to the enamel portion of the crown from the incisal edge to the cervical dentino-enamel junction at the mid-point of the tooth. This dimension, along with the previously established central incisor width and facial outline form, gives a total picture of a tooth (and hence the entire anterior region) that is in esthetic harmony with the patient's face.

If there is adequate vertical space to allow the required length for the incisors, then the fabrication of the veneer is straightforward. Should the necessary space be lacking, the laboratory will have to resort to lengthening the teeth (or shortening them, as the case may be) through illusion (see chapter 9).

Many patients would like a younger appearance and this is often one of their main reasons for seeking Cosmetic Dental treatment. One important method for achieving this is to make the central incisors slightly longer than the maxillary lateral incisors.

Fig. 4-33

Fig. 4-34

Occlusal interference with the lower incisors could be very damaging. The porcelain of the veneers will abrade the enamel of the mandibular teeth if they are in excessive contact, particularly if the glaze has been removed from the porcelain during finishing procedures. The dentist also must evaluate the potential for excessive contact in extreme protrusive movements. While this is not a likely excursion for the patient, even a single occurrence could fracture a veneer that has too little vertical clearance and a weak incisal edge. Under usual circumstances there should be no hesitation in allowing normal occlusion on the porcelain, including porcelain that is brought over the incisal edge.

Subjective Evaluation

Once the dentist has had a chance to evaluate all of the above, he will want to find out what the patient's overriding concerns might be.

People are most concerned about the color of their teeth. Often even perfectly healthy, esthetic teeth are deprecated for not having the "Hollywood Look". Due to many years of reinforcement by television advertising, most patients think their teeth are too yellow. Therefore, the first question asked to the patient often should be "How do you feel about the color of your teeth?". The manner and content of the patient's answer will give the dentist important clues as to the potential for successful treatment. The less realistic a patient's self-evaluation, the more likely that he will be dissatisfied with treatment, no matter how good the result may be. The pickier he is with minor, non-contributory details, the harder he is going to be to please. The closer that he holds the mirror to his mouth before treatment, the closer his inspection after treatment.

The dentist must also determine whether the concern with the color (or appearance) of the teeth is the genuine problem. It may be the outward manifestation of some deeper psychological

Generally, older teeth look worn at the incisal edge and have been ground down to a flat plane. The easiest method of reversing this is to lengthen the centrals (provided this does not interfere with excursive and protrusive movements).

difficulty. While most dentists have inadequate analytical knowledge to determine this accurately, they usually have enough "people skills" to sniff out unsuitable patients.

Many people view diastemas as undesirable, so when diastemas are present, this should be another area of discussion. The patient will answer very readily whether or not the spaces between the teeth bother him. Most often the response will be affirmative; the spaces make him feel less assertive or less confident, or unwilling to open his mouth to smile. Since this particular dental problem is relatively easy to eliminate with veneers, the long term prognosis is excellent unless the diastemas are unusually large.

The size and the shape of the teeth are also of concern. One common problem is the peg lateral. In such cases all the teeth are well formed and positioned except for two right in the front of the mouth. Obviously this situation is often distressing, and the patient should be encouraged to express his feelings on the subject. Many people also complain of disproportionately small teeth, since these result in the formation of spaces. Thankfully, these situations are often ideal for porcelain veneers.

Finally, there are a series of points to make to the patient with regards to his appearance that will firmly clarify in his mind whether there is a need for treatment.

First, ask the subjective question: "Would you feel more confident if your smile was improved?". Of course almost anyone can answer "yes" to this question. In answering, a patient usually will reveal where he hopes his improved appearance will have its greatest impact. This can help the dentist to tailor the treatment more specifically.

Next: "What appearance would you like?". By specifying the ultimate goal, the patient is focusing both the dentist's and his own attention on a reproducible model. Thus guided, the dentist can attempt a close approximation, resulting in less frustration for him and greater patient acceptance. Ideally, the patient can bring in a picture of how he would prefer to look. This communication can be augmented through the use of diagnostic wax-ups to be discussed shortly and computer imaging (chapter 8).

It is very important at this stage to involve the patient actively in goal selection and treatment planning. As an informed patient, he will cooperate and appreciate the treatment much more than a patient who is not at all involved with his own smile analysis.

The Diagnostic Wax Up

The importance of communication simply cannot be overemphasized. If the dentist does not clearly understand the patient's objectives, then it will merely be by chance alone that the expectations are fulfilled. Many times, words will suffice to create a full communication between the parties-but in many cases words are simply not enough. The dentist and patient often do not share a common language when it comes to the details of teeth. In these situations, more is needed.

Three devices have been used to help bridge the gap. Photographs are often used to allow the patient to see what the dentist is describing and to allow the patient to show the dentist what he wants. (This modality is more thoroughly discussed in chapter 8.)

Photography can pass from a static to a dynamic tool when combined with the power of computers. This mix can be especially powerful, since the anticipated changes in the patient's smile can be seen as if in final form, including the full face of the patient. (This exciting modality is also discussed in chapter 8.)

Still, as tantalizing as the photographic possibilities are, the images remain only two dimensional. At present the only three-dimensional tool we have at our disposal is that of the diagnostic wax-up. In certain cases, dentists may find it necessary to use diagnostic wax-ups for their own planning purposes. While with time and experience, most practitioners will be able to visualize the final esthetic result, the dentist, the technician, and the patient can all benefit from the foresight and clarity of communication provided by pre-treatment wax-ups.

In the end, the patient has the most to gain. He has the least capacity of anticipating both the advantages of treatment and the limitations that exist in his particular case. A verbal explanation by the dentist may create, in the patient's mind, an entirely different picture from what the dentist is trying to convey. Similarly, the patient's description of the desired results can be misunderstood by the dentist. A pre-treatment consultation including a wax-up will demonstrate exactly what is possible and what is not. The patient will have realistic expectations for the treatment, and this alone may avoid subsequent dissatisfaction. Since the patient has an opportunity to preview the treatment, he may have some very important contributions of his own to make. There often are aspects of esthetics that may be of great concern to the patient, and yet, due to the fact that they may be of little dental consequence, the dentist may not be sensitive to them. Here, a word to the dentist will allow him to change the bothersome features, thereby ensuring a more acceptable outcome. In addition, making the patient a part of the treatment process lets him feel more positive about the final result.

By utilizing the diagnostic wax-up, the dentist will have had an opportunity to evaluate both the approximate final result and the problems that may arise. It may be decided on the basis of the wax-ups that more space is required and that more tooth structure will have to be reduced, or that it is impossible to close the existing diastemas without enlarging the teeth beyond normal mesio-distal proportion. The practitioner may find that the patient's requests are unreasonable, in which instance it may be advisable to drop the case if the demands cannot be modified to an acceptable level.

In addition, communication with the laboratory technician is not always one hundred per cent clear, and it is much better for the dentist to find the gremlins at this stage of treatment than with the final porcelain. In short, problems are much more easily handled in wax than in veneers.

Wax-ups also can be a boon to the technician. Since there is a very clear model of what is desired by both the dentist and the patient, the element of guesswork is eliminated. The laboratory-fabricated porcelain veneer is ideally fused on to the tooth with minimal adjustment and polishing; therefore, if the technician can create a very close to ideal veneer based upon the corrected wax-up, the dentist will have a much easier procedure intra-orally. Of course the number of remakes is considerably reduced.

The wax-up can be prepared by either the laboratory or the dentist. If the technician does the work, there will be an added charge, but this is negligible with respect to both the total price charged for the veneers and the number of problems that can be eliminated.

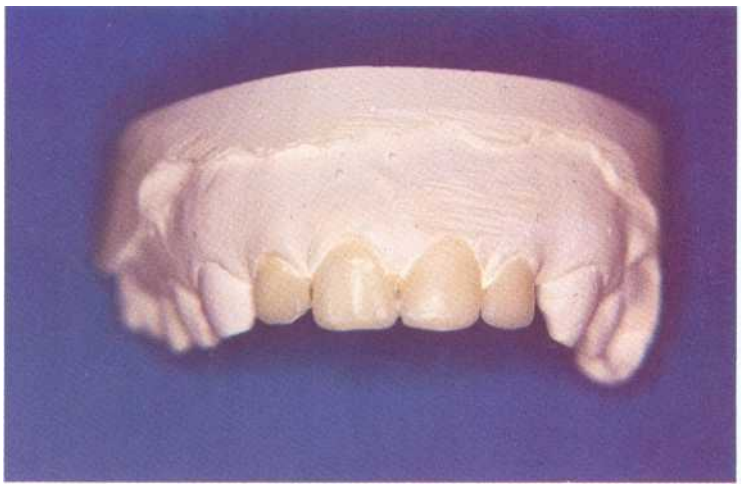


Fig. 4-35

The wax-up should be done in tooth colored wax.

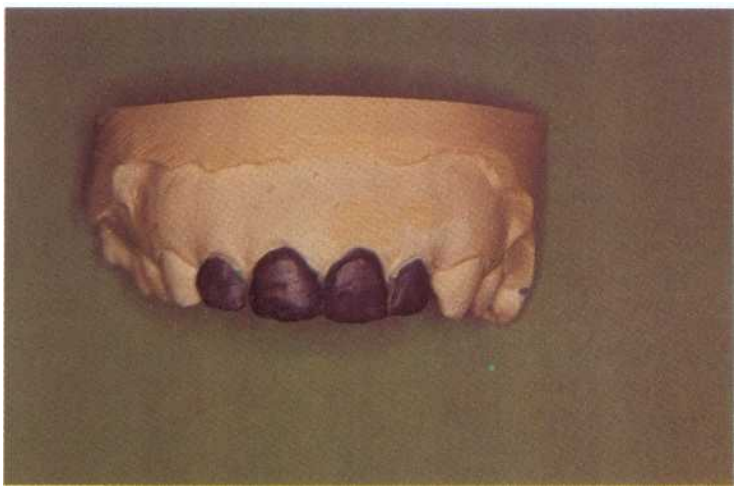


Fig. 4-36

While dental professionals may be able to appreciate a blue, green, or multi-hued wax tooth, it is unlikely that the patient will share their appreciation. A dentist who does present a case in such a colored wax may find himself explaining for extended periods how the final porcelain will be tooth shaded and not blue.

One area that cannot be previewed with a wax-up is the color change that may be effected with porcelain veneers. The patient must be told repeatedly that the color is only that of the diagnostic wax and that the porcelain will be much more true to life.

Interestingly, while the diagnostic wax-up is intended to be a communication tool, it also seems to act as a motivator. The authors have noted that in some cases when the patient was considering treatment but was not yet fully committed, wax-ups have had the effect of tipping the scales in favor of treatment.

Fig. 4-37

This patient, for instance, was not sure that veneers could help her appearance, and she was afraid that the teeth would be too big. She initially asked for veneers only on the centrals.

Fig. 4-38

Models were taken and sent to the laboratory for diagnostic wax-ups. The technician, following the guidelines from the dentist, began to reshape the teeth. Before showing it to the patient, the diagnostic wax-up should be clean and free of any extraneous wax or material that will detract from the clarity of presentation.

The before and waxed-up models were shown to the patient. The dentist evaluated the esthetic result and considered the input from the patient. On examining the wax-up, this patient chose to have four veneers instead of two. The dentist made the necessary adjustments in the wax-up model and then proceeded with tooth preparation. Then the impressions and wax-ups were both sent to the laboratory.

Fig. 4-39

This finished case demonstrates what is in some aspects a compromise treatment. But since the patient was aware of the limitations beforehand, she was pleased with the results.

SMILE ANALYSIS

Face shape modifier

Main shape		Modifier	
__	Square	__	Ovoid
__	Square tapering		
__	Tapering		
__	Ovoid		

Size

Mesio-distal (at temples) _____

Vertical (taken at chin) _____

Distal of cuspid to distal of cuspid _____

Mold _____

Teeth shown 7 6 5 4 3 2 1|1 2 3 4 5 6 7

Midline disharmonies

Face to maxillary teeth _____

Maxillary to mandibular teeth _____

Lipline High ___ Normal ___ Low ___

Gingival contours _____

Malpositioned teeth _____

Tooth length descrepincies _____

Occlusal disharmonies _____

Shade

Basic shade _____
Gingival modifier _____
Incisal modifier _____
Degree of masking needed _____
Characterizations _____

Chapter 5 TOOTH PREPARATION FOR PORCELAIN LAMINATE VENEERS

BASIC CONSIDERATIONS

As with amalgam preparations, there is perhaps an unlimited number of possibilities for porcelain laminate preparation types. For teaching purposes, however, we have limited the preparation types to six distinct groups. While these six preparation types should serve as a guide for the dentist, it must always be remembered that differing circumstances of tooth shape, placement, and color must dictate reasonable flexibility in design.

Although the specific details of the various preparation types may vary, the considerations which must be embodied in any preparation design are always the same. The eight cardinal rules for porcelain veneer preparations are:

1) The preparation should be as conservative as possible.
2) It should allow for a covering of approximately 0.5 mm of porcelain without giving the tooth an overly thick appearance.
3) It should not penetrate into dentin if at all possible, especially at the borders of the preparation where leakage is most likely.
4) It should allow for a cleansable gingival margin.
5) It should not include any sharp internal angles, especially at the incisal edge where the stresses will be the greatest.
6) It should allow for a path of insertion of the veneer, which is free from undercuts.
7) At least enough clearance must be present interproximally to allow for a mylar strip to be placed between adjacent teeth during fusing.
8) Any area of the tooth which is visually accessible should be covered by porcelain.

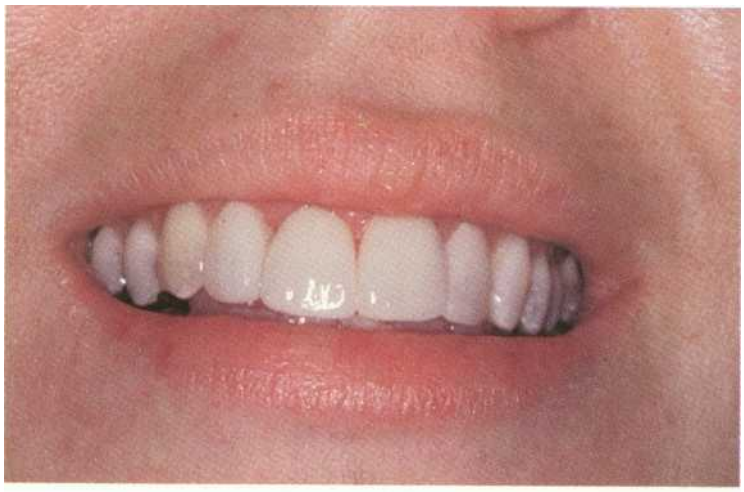


Fig. 5-1

Most of these rules are fully self-explanatory and thus need no further clarification. Rule number eight, however, is perhaps the one most often neglected. It is extremely common to place veneers that seem to cover all visible areas when viewed directly from the front of the tooth, but which fall short of the mark when seen from an angle. Such is the case in this example. The laminate on the right lateral incisor covers most of the facial areas adequately, but the proximal areas near the gingiva are exposed. Often these areas are adequately hidden with composite at the time of fusing, but after a few years the error in design becomes glaring.

Fig. 5-2

This pitfall can be avoided easily enough, but it requires an acute sensitivity to the problem during preparation and fabrication. Before preparation, the dentist must make sure that there is a path of insertion free from undercuts that allows porcelain to cover all areas visually accessible from any angle. This requires careful observation of the tooth being laminated from various extreme angles to determine which areas of the tooth are open to view. Only then should the dentist begin any preparation of the tooth. A mistake at this stage cannot be rectified later. Similarly, a failure in the design stage by the laboratory is uncorrectable later. In some cases the interproximal design must be as aggressive as shown here.

VENEER MARGIN PLACEMENT

Because of the requirements of crown and bridge technique, we have become used to routinely locating margins subgingivally. While it is readily accepted that this placement is less desirable from a hygienic point of view than a supragingival one, the demands of esthetics are respected. As procedures have been modified, and as new techniques have been introduced, dentists have clung to certain habits without questioning their current value. It is obvious that porcelain laminates are quite different in many respects than conventional crowns. We must therefore approach the question of margin placement of porcelain veneers with an open mind, unclouded by what we have learned for other restorative procedures.

When dealing with margin placement, the first consideration is the micro-environment of the margin.

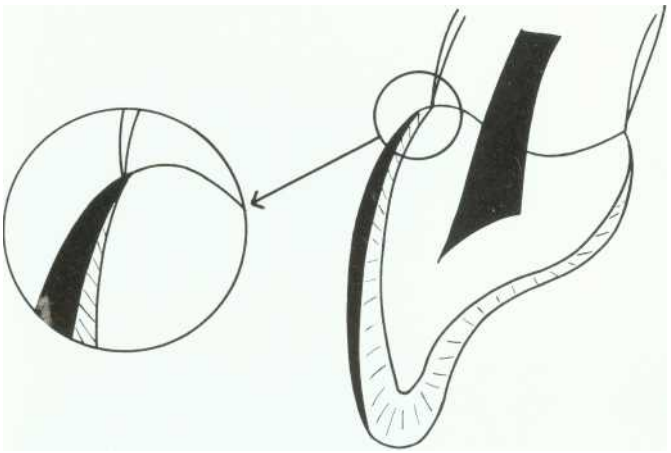


Fig. 5-3

There is, ideally, some gingival enamel that, through the use of a composite bonding agent and a silane coupler, is fused to a knife-edge porcelain margin. The enamel certainly has no potential for gingival irritation, and porcelain has shown itself to be very bio-compatible. The only potential problem in this microcosm is the composite bonding agent. The thickness of this layer is kept to an absolute minimum through the use of precise impression, laboratory fabrication, and seating techniques. But no matter how careful the operator is, there will be a narrow band which could potentially cause gingival irritation and subsequent recession. The only method which can minimize these harmful periodontal effects, is the supragingival placement of the margin. Where the composite bonding layer cannot come into intimate contact with gingiva, it will not cause irritation.

This solution raises the question of esthetics. After all, most people treated with porcelain veneers are seeking, above all, cosmetic help.

The reason given by some operators for subgingival placement of porcelain laminates is to conceal the margin of the laminate from view. In fact, concealment is not a problem for most teeth. Since the gingival margin of the veneer can be made with a knife edge, the supragingival veneer margin is blended into the gingival enamel with a color gradient. As the porcelain becomes thinner and thinner toward the gingival margin, its capacity to modify the underlying inherent color decreases. Since the composite bonding materials have a minimal shade masking effect in their ideal thickness, their contribution to color at the gingival area is negligible.

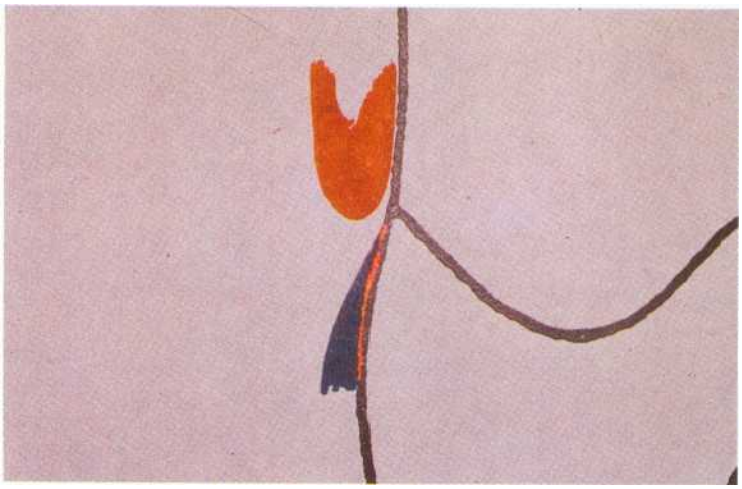


Fig. 5-4

Thus we have a gradual, lifelike, color gradient readily established. The margin will not be noticed, even in full view, because there is not an abrupt change. While on close inspection, the gradient can be seen, the actual position of the well-finished margin is hidden.

In cases in which maximum hiding of the natural tooth shade is necessary, this gradual blending of shade is not desirable. In such situations, the dictates of esthetics demand gingival preparation. Fortunately, this is not the usual situation.

Another problem inherent with subgingival margins is the difficulties in creating a dry field for fusing in the gingival sulcus. While it is theoretically possible to do so, from a purely pragmatic point of view, this goal is rarely attained. If fusing is attempted in a wet field, it is doomed to failure, inevitably resulting in leakage and staining under the gingival margin of the laminate.

The choice of the supragingival margin makes taking an impression an easier and more predictable phase of the procedure and allows the laboratory that much more ease in the correct fabrication of the veneer.

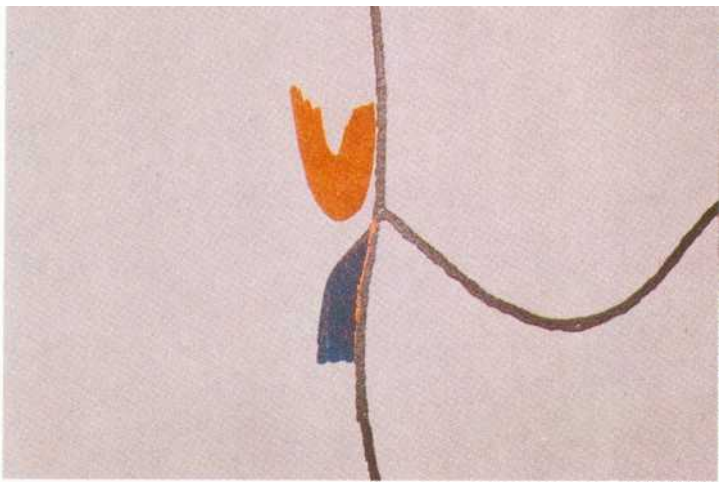


Fig. 5-5

It is, of course, desirable to maintain the natural emergence angle of the tooth as much as possible. If the contour of the facial aspect must be changed, the further from the gingiva that this change occurs, the less likely that food will become trapped and cause irritation.

The important point to remember here, however, is that wherever the laminate ends, the requirement for patient hygiene must not be violated. The ability or inability of the patient to clean the gingival sulcus is the final criterion as to the acceptable emergence angle. In some cases, due to the angle and position of the veneered tooth, it is possible to create a large change in the emergence angle without compromising the cleansability of the sulcus. In these cases, the periodontal health of the surrounding tissues will be maintained.

PREPARATION TYPES

With these factors in mind, here are the six basic preparation types:

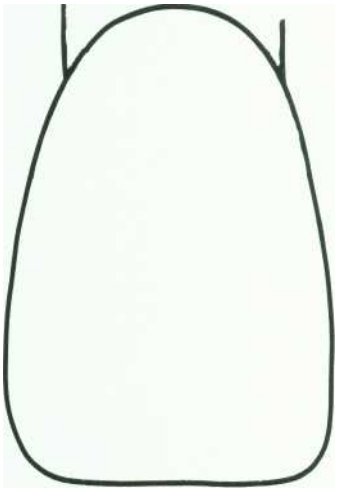


Fig. 5-6

Type I. Minimal Preparation. This preparation type is well described by its name. In a minimal preparation, no tooth reduction is undertaken except for that necessary to provide a path of insertion that is free from undercuts. Often this means that no preparation is necessary.

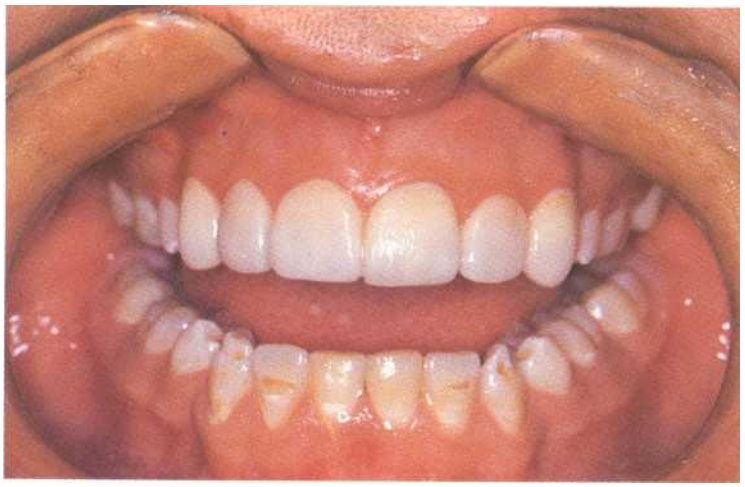


Fig. 5-7

Provided that the increased prominence of the veneered tooth is not a problem, the tooth need not be reduced at all.

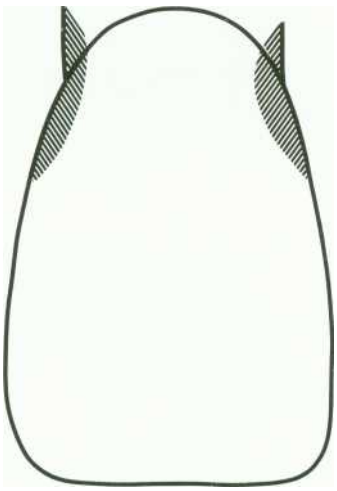


Fig. 5-8

Often, however, some slight preparation is needed to create a proper path of insertion. Such is the case when gingival recession has uncovered the interproximal tooth structure. Since many teeth display a slight concavity on their proximal surface, it is often necessary to slightly reduce the proximo-facial line angle near the gingival margin. (Note: In all the schematics used to illustrate the preparation types in this chapter, the areas with stripes indicate places where reduction of the tooth surface may be desirable. The stippled areas represent porcelain.)

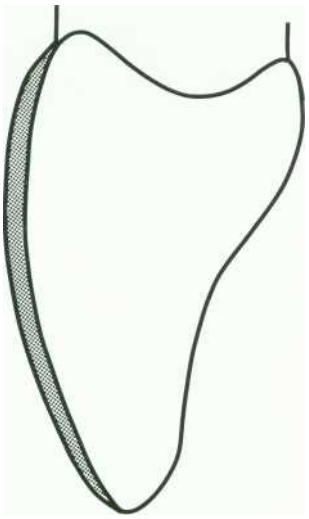
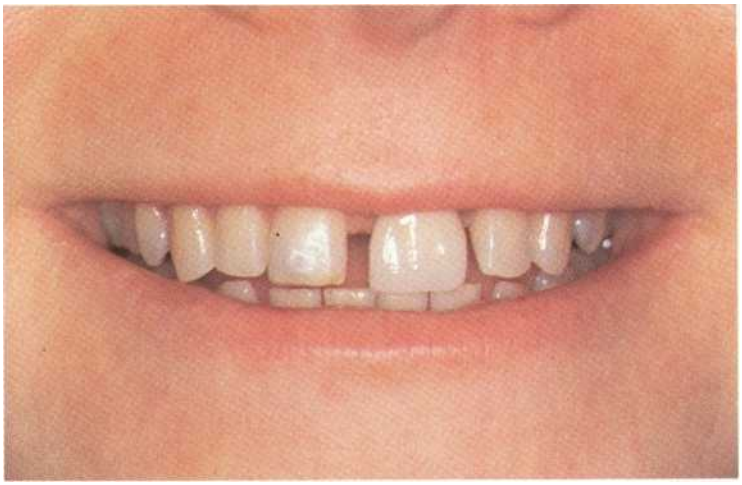


Fig. 5-9

This results in a veneer which comes to a knife edge on all its margins.



Such was the case for this patient who had received preformed plastic laminates just two years earlier (see Figs. 2-11, 2-12, and 2-13). The plastic laminates were obviously of only limited success.

Fig. 5-10

Because of the position of the teeth, their shade, and their contour, absolutely no preparation of the teeth was required to achieve this very pleasing result in porcelain. These laminates have served for over five years at the date of publication of this text.

Fig. 5-11

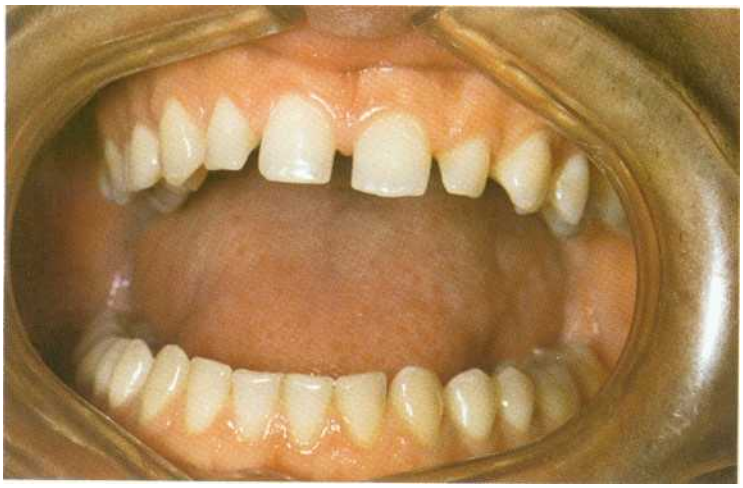


Fig. 5-12

Another typical case requiring minimal or no preparation is shown here (Figs. 5-12, 5-13)).

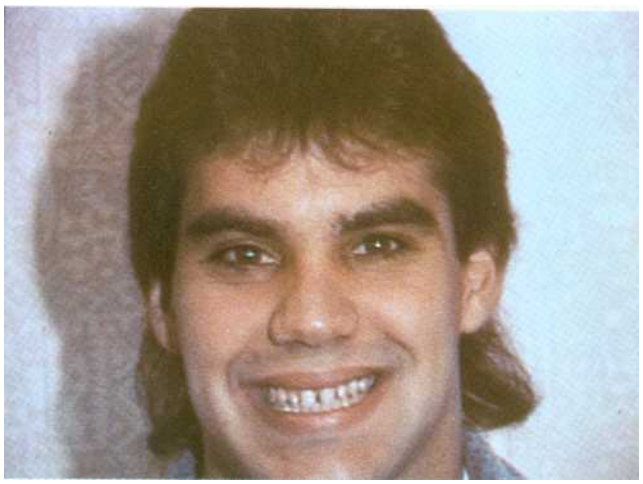


Fig. 5-13

Fig. 5-14

Four veneers were used, and the only preparation required in this case was to slightly reduce the prominence of the disto-incisal corners of the two central incisors (Figs. 5-14, 5-15).

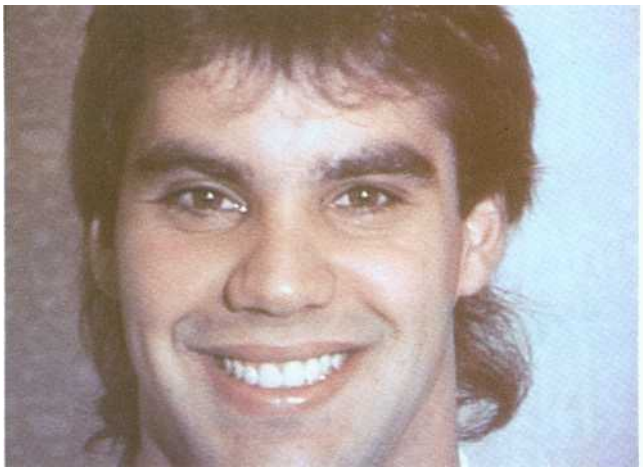


Fig. 5-15

Type II. **Incisal Preparation.** On occasion, for reasons of shade control, it is advantageous to have a greater thickness of porcelain at the incisal edge than at the knife edged finish line provided by the Type I preparation. In these cases, it is suggested that the dentist cut into the incisal edge in such a way as to allow for an even thickness of porcelain as the incisal edge is approached. This is easily achieved with a cylindrical instrument, such as a 556 bur or a diamond cylinder. The dentist should be aware of the direction of the enamel prisms to avoid undercutting them.

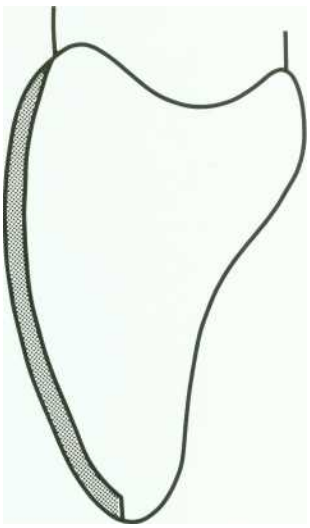


Fig. 5-16

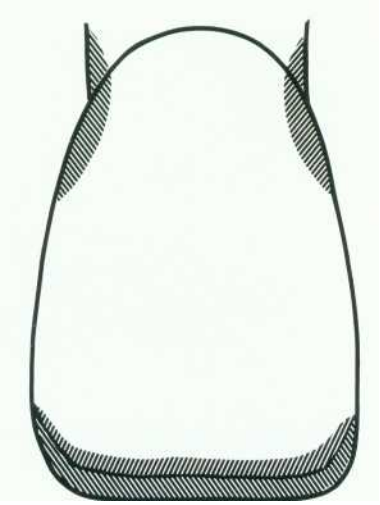


Fig. 5-17

As in the Type I preparation, the dentist may find that slight judicious grinding at the gingival third of the facio-proximal line angle will be helpful in creating an undercut free path of insertion.

Fig. 5-18

A clinical example of the Type II preparation is shown in the next three figures. Here is how the teeth looked before preparation.

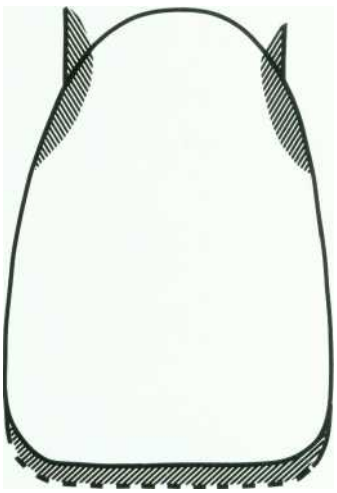
Fig. 5-19

In this figure the two central incisors have been prepared for the laminates: Normally, the Class III restorations would have been replaced with bonded restorations prior to preparation. In this case, however, the Class III restorations were replaced at the time of fusing.

The two laminates were fused into place at the next visit, and this photograph was taken immediately after fusing. Notice that there is no tissue blanching at the gingival margin, despite the fact that there was no tooth reduction in that area.

Fig. 5-20

Type III. **Over the Incisal Edge.** In this design, the porcelain extends beyond the incisal edge. If the tooth is already shortened, then all that is needed is to ensure that there are no sharp angles protruding from the tooth in the areas where the veneer is to be placed (including the inciso-proximal angles) and to be certain that the path of insertion is free from undercuts. In addition, the margin of the veneer should terminate on enamel if at all possible. Often this means a slight reduction of the lingual aspect of the incisal edge to make room for the porcelain.



Seen from the facial, the preparation would look like this.

Fig. 5-21

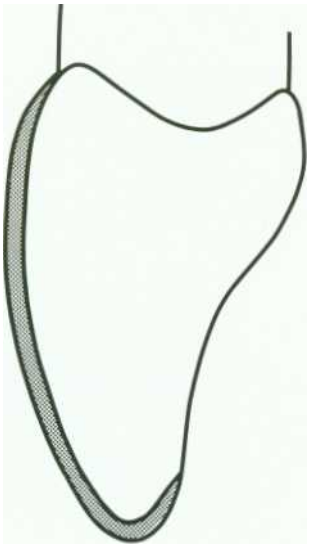


Fig. 5-22

A cross-section of a tooth with a Type III lamination in place looks like this.

Fig. 5-23

The path of insertion for a Type III preparation is usually not truly inciso-gingival. Instead, it is usually a hinged path. This fact is of clinical significance. If the path of insertion were to be inciso-gingival, the normal bulge at the gingival third of the facial surface would have to be reduced.

Fig. 5-24

Here is an example of a clinical case using a Type III preparation.

This patient arrived in the office with a worn and discolored plastic laminate. After removing the plastic, the tooth appeared both shortened and darkened at the incisal third. The tooth was vital, but the discoloration came from an earlier placement of pins. The incisal edge was rounded (Fig. 5-24) and a porcelain laminate was fused in place (Fig. 5-25).

Fig. 5-25

As the occlusal view shows, the laminate extended over the incisal edge to end on the lingual enamel.

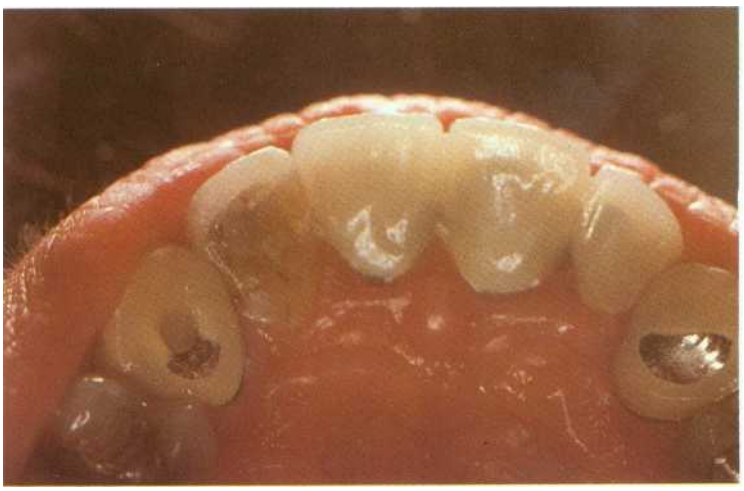


Fig. 5-26

In cases where the tooth is not already shortened, the dentist should reduce the incisal edge as shown in this clinical case in which the patient had fractured the incisal edges of both central incisors.

Fig. 5-27

Fig. 5-28

After adjusting the incisal edges, and after slightly reducing the proximals near the gingiva, an impression was sent to John Morrison of Mid Kent Dental Laboratories (Sevenoaks, Kent, England).

Fig. 5-29

The processed laminates were then returned and fused into place.

One concern with the Type III preparation is the amount of unsupported porcelain at the incisal edge. It is too early in the development of the porcelain laminate technique to be certain, but it is currently believed that the limit will be the same as for porcelain fused to metal restorations. In the latter procedure, it is undesirable to have the porcelain extend more than 2 mm incisally past the metal framework. Extension well beyond this length is believed to invite fracture through the incisal porcelain. Such is probably also the case with porcelain laminate veneers. It is with cases such as this one that we shall perhaps learn the limitations of the porcelain laminate.

Fig. 5-30

In this case the patient had fractured their central incisor.

Fig. 5-31

A porcelain laminate was fused into place to create a restoration with excellent esthetics. The restoration was conservative, and the appearance was beautiful. It is only with time that we will begin to know whether this restoration and others like it are overextending the technique (Figs. 5-31, 5-32).

Fig. 5-32

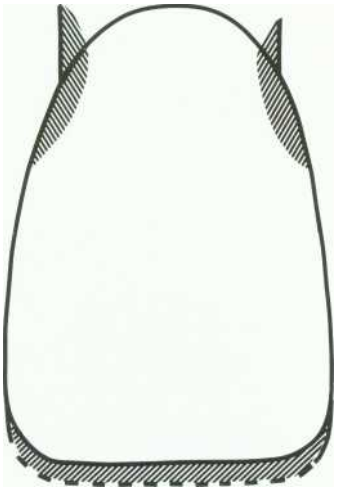


Fig. 5-33

Type IV. **Over the Incisal Edge with a Lingual Ledge.** The Type IV preparation is very similar to the Type III preparation. They both extend past the incisal edge of the tooth and wrap around to the lingual surface. In fact, from the facial, the two preparation types are identical.

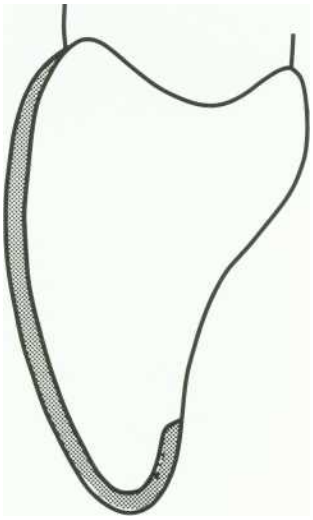


Fig. 5-34

The difference is found in the gingival margin of the lingual porcelain. In the Type III preparation, the laminate ends in a knife edge. In the Type IV preparation, the gingival porcelain on the lingual is a deep chamfer or even a shoulder. Theoretically this increased bulk is designed to provide increased strength in situations where the fusing strengths are expected to be below optimal.

Fig. 5-35

A clinical example of such a use is shown here.

Fig. 5-36

This patient exhibited severe wear of the plastic facings present on the pontics of this etched metal bridge. The teeth were prepared by lowering the incisal edge of the pontics being repaired, reducing the bulk of the plastic on the facial

Fig. 5-37

. . . and cutting a ledge on the lingual.

Fig. 5-38

True fusing was not possible here, but standard cementing was used to adhere the facings in place.

Fig. 5-39

Fig. 5-40

Type V. Maximal Preparation. The Type V preparation consists of a general reduction of the entire labial surface of the tooth to be veneered. In addition, it is usual with a Type V preparation to include some sort of chamfer finish line at the gingival. This preparation type is used whenever maximum bulk of porcelain is desired for masking out underlying discolorations, or whenever any increase in labial bulk must be minimized. Such would be the case when treating an individual tooth that is correctly aligned with the neighboring teeth, as seen in these views, or whenever the teeth to be laminated are already in slight labio-version (Figs. 5-39, 5-40).

One area of concern with a Type V preparation is the gingival chamfer. It must be recognized that in the adult any such finish line will routinely end in dentin. This brings with it several disadvantages, perhaps the most obvious one being patient discomfort during preparation. Clearly, drilling into dentin must be considered a less comfortable procedure than drilling into enamel.

Fig. 5-41

The second disadvantage is the potential for difficulties of adhesion onto the dentin. It is generally considered unwise to place composite resin directly onto exposed dentin for fear of creating hypersensitivity. Because of the precision fit of the laminate, there is insufficient space between the tooth and laminate to allow for a layer of a liner such as glass ionomer cement covered by a layer of composite. Experience to date has shown that these chamfers are so shallow as to permit placement of composite directly on the dentin without untoward effects.

Another advantage of the Type V preparation is that it makes the least change in the labio-lingual thickness of the tooth, and the increased thickness of porcelain is believed to lead to a greater control of the final color of the tooth.

Since the porcelain laminate technique is primarily an esthetic one, color is almost always of absolute vital importance. Unfortunately, however, control of the color of porcelain laminates also can be one of the greatest esthetic challenge the dentist may face.

Color control is never a problem in cases where the veneer is to match the underlying tooth color. In those cases it is merely necessary to use both a porcelain and composite of a shade that matches the tooth. Difficulty arises when the finished product is to be a very different shade than the underlying tooth because the porcelain laminate must be translucent. If the laminate were to be made fully opaque, it would have a lifeless appearance compared to natural teeth.

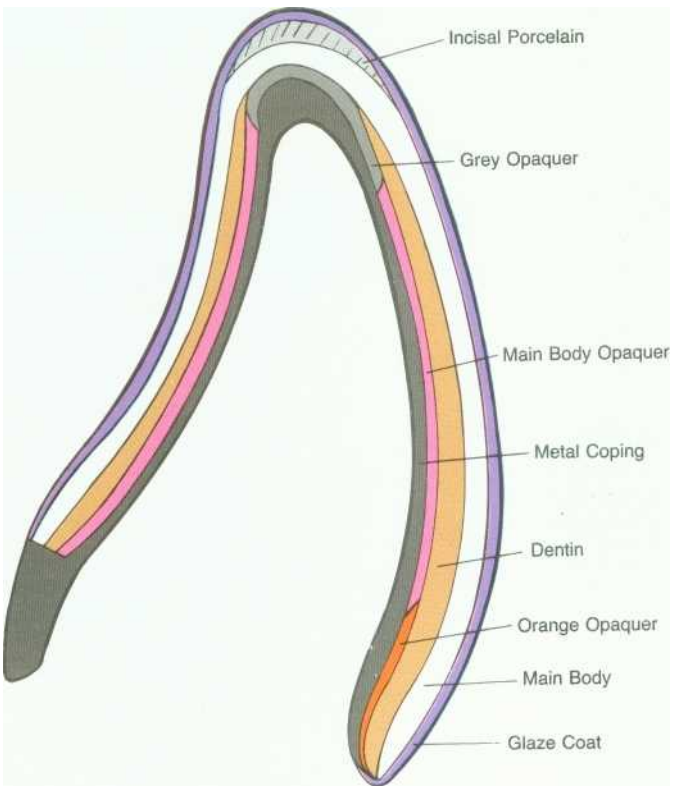


Fig. 5-42

In order to have a natural appearance, it is necessary to have light penetrate at least a short distance into the porcelain before being reflected back. This creates the optical illusion of depth. In a restoration in which porcelain is fused to metal, the dentist accomplishes this by painting a layer of opaquer over the metal, and then by covering it with a generous layer of translucent body porcelain. One millimeter of porcelain and opaquer often is used to create the lifelike restorations to which we have become accustomed.

Carrying this approach to the veneers, the ideal situation would be for the laminate to have a micro-thin layer of fully opaque material on the intaglio, with the main body being composed of translucent material. At present, due to the thickness required by the opaquer, such a fabrication technique has not been developed.

Fig. 5-43

Perhaps the most challenging clinical situation of them all is when two or more teeth of extremely different coloration need to be matched to the surrounding dentition. This is not a very difficult problem with porcelain fused to metal, but with porcelain laminates it calls to the fore all of the dentist's artistic and technical skills. In such cases, a knowledge of the esthetic qualities of the materials and the requirement of a trained eye are important. In addition, this situation has led to an intense search for methods to precisely control the shade of the finished veneer. This search has resulted in the development of the Class VI preparation.

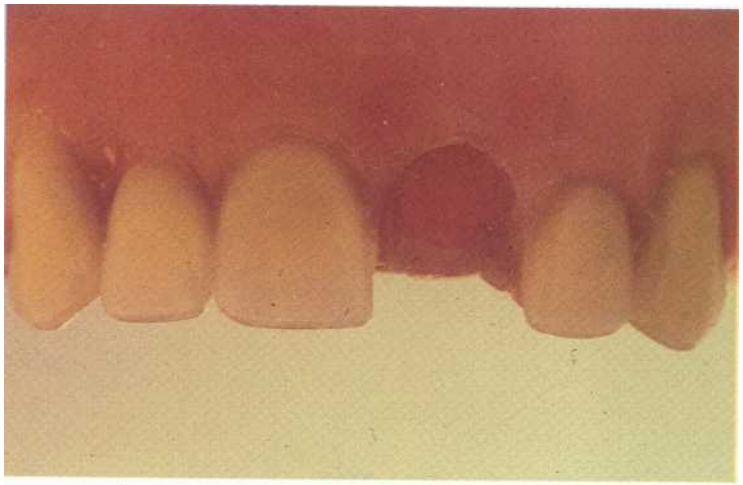


Fig. 5-44

By 1984 it was clear that some preparation types give the technician greater control, while others put more control in the hands of the dentist. This figure shows a wax "set-up" made using denture teeth. One central incisor has been removed and used to make a mold. Two models of the incisor were made from this mold out of dark brown plastic. Specks of red and other colors, as well as a stainless steel wire, were also mixed into the plastic. The result was two "teeth" identical in shape to the original denture tooth, but dramatically darker and discolored.

Fig. 5-45

Then each of the two models (dies) were prepared. One of the dies was given a minor amount of preparation. It was a "Type V" (maximal) preparation, but only about .4 mm of die was removed. The second die was given a much more aggressive Type V preparation, in some places cutting nearly .9 mm into the die.

These two dies were then placed into the wax-up, and an impression was taken of each of them. Cosmetic Concept Dental Laboratories (Calgary, Alberta, Canada) created a porcelain veneer for each die. The laboratory technique and materials were identical for both veneers. The resulting veneers differed by nearly 100 percent in maximum thickness. The first veneer with the shallow preparation had a maximum thickness of .5 mm, and the deep preparation resulted in a veneer with a maximum thickness of 1.0 mm.

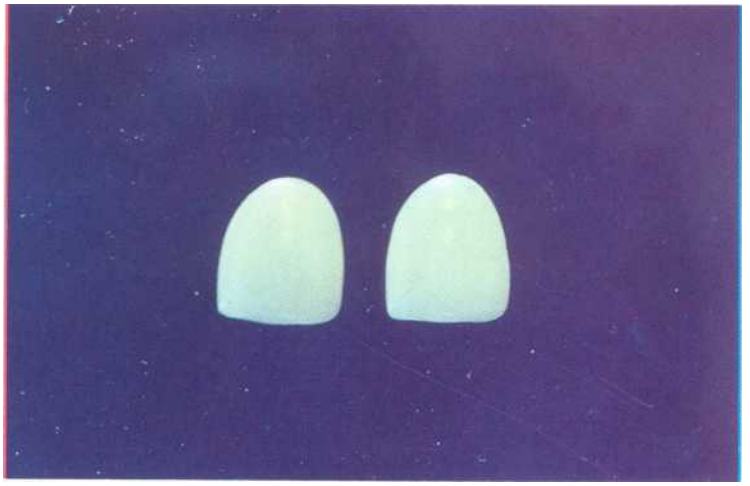


Fig. 5-46

Side by side on the workbench, the veneers look nearly identical. Only by using calipers is it possible to realize that the veneer on the left is twice as thick as the one on the right.

Fig. 5-4 7

When lit from behind, however, the difference in thickness becomes apparent. Under these circumstances, the thicker veneer appears slightly darker than the thinner veneer because the former transmits slightly less light than the latter. It is easy to see that the thicker veneer will do a better job of hiding underlying discolorations than the thinner veneer. Perhaps even more importantly, it is also easy to see that even with such a very aggressive preparation, the difference in hiding power will be small .

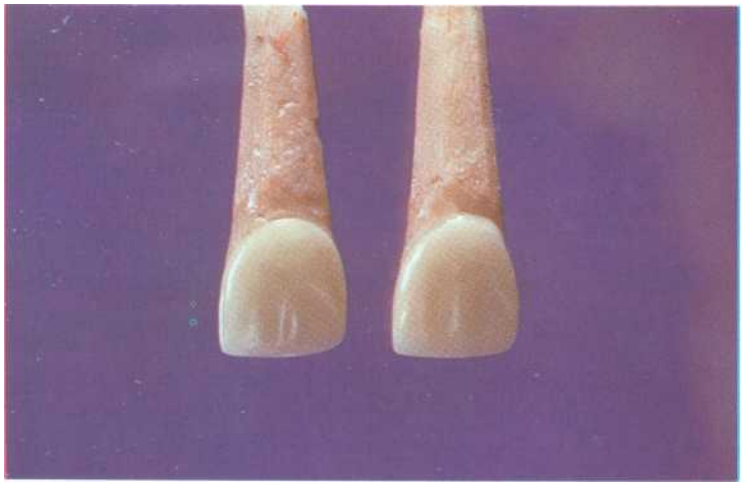


Fig. 5-48

Placed on the dies without the luting agent, the veneers still appear identical. With the luting composite, however, a slight difference becomes discernible. As expected, the thicker veneer (on the left) does a perceptibly better job of hiding the underlying discoloration than does the thinner veneer.

Fig. 5-49

In the mouth, the thicker veneer matches the surrounding teeth more accurately than the thin one does.

Thus in cases of slight discoloration, a thick veneer can be used to mask the underlying discoloration with little difficulty.

Fig. 5-50

When the porcelain itself is not sufficient to mask the discoloration, as in our extreme example, the dentist must find some way to deal with the color chairside. In freehand composite veneers, it is common to neutralize the unwanted color first and then to add the desired color. This is a very effective way to handle the situation for freehand veneers, but it is completely inappropriate with the porcelain veneers.

Color can be "neutralized" by adding its complementary color (see chapter 6). For example, we can take a yellow sample and neutralize the yellow by adding violet. When we do this, the yellow becomes greyish.

What does this mean clinically? It means that we have removed the offending yellow but have also changed the value (brightness) of the sample substantially in the process. This is an important concept. Since brightness is more important to the eye than color when shade matching, we have taken a bad situation and probably made it worse.

When "freehanding" veneers this is not a problem, but it is a serious complication for porcelain laminates. If this were to be a freehand composite veneer, the "neutralizing layer" of pigment would then be covered with a layer which would bring up the value to what we desired. Unfortunately, when using the porcelain laminates. the amount of space for the composite luting agent is minimal, and does not not allow for multiple layers of pigmentation within the luting agent. It also is important to note that the thickness of the luting composite for preparation types I-IV remains the same whether the tooth has been conservatively or aggressively prepared.

The result is that the most predictable results occur when using the luting composite either to modify the underlying discoloration slightly or to simply mask over it. One common method used to mask minor discolorations is to coat the inside of the veneer with an opaquer composed of titanium dioxide and resin. This layer is painted on, but not cured prior to insertion, because if it were to have puddled in any of the internal angles of the veneer the hardened resin would prevent accurate placement. In addition hardening this layer before placing the veneer on the tooth often creates a thickened layer of luting composite, which in turn causes the veneer to be too physically prominent. Sometimes this effect is augmented with a layer of opaquer on the tooth as well.

Fig. 5-51

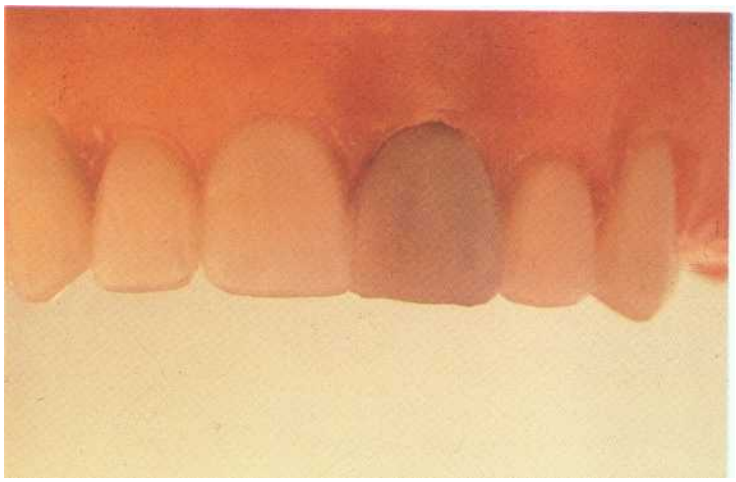


Fig. 5-52

To demonstrate the degree of opaqueing that can be expected with this technique, we painted both the thick and thin veneer and die with opaquer, and then luted the veneers as usual. As can be seen in these illustrations, when the technique of painting the veneer and die with opaquer is used, the results are improved. These figures also show the differences that can be expected between the thick and thin veneer. Once again the thick veneer (Fig. 5-51) shows a greater masking effect than the thinner veneer (Fig. 5-52).

Even though these photographs show that the masking effect of the painted opaquer is slight, it is clear that in cases where the masking effect of the porcelain is not enough, the addition of a layer of opaquer can help.

A still greater blocking effect can be achieved by adding the opaquer directly to the luting composite. The most common opaquers consist of either of pure titanium dioxide or a mixture of titanium dioxide with a transparent filler. These materials should be used carefully. The addition of a slight amount of titanium dioxide slightly increases the value of the luting composite, while making it more opaque. Any more than a tiny amount, however, causes the composite to become a dense white. Sometimes this density is desirable, and other times it is not. Clinical judgment on a case-by-case basis is important.

Fig. 5-53

In the case shown here, there was a distinct improvement in value when a dense white composite was used. Unfortunately, the desired hue was not even approached by this method. It is interesting to note, however, that in this case the thin veneer displayed the greater amount of change when compared to the thick veneer.

Fig. 5-54

This occurred because the too white undercoating shows more easily through the thin veneer than the thick one.

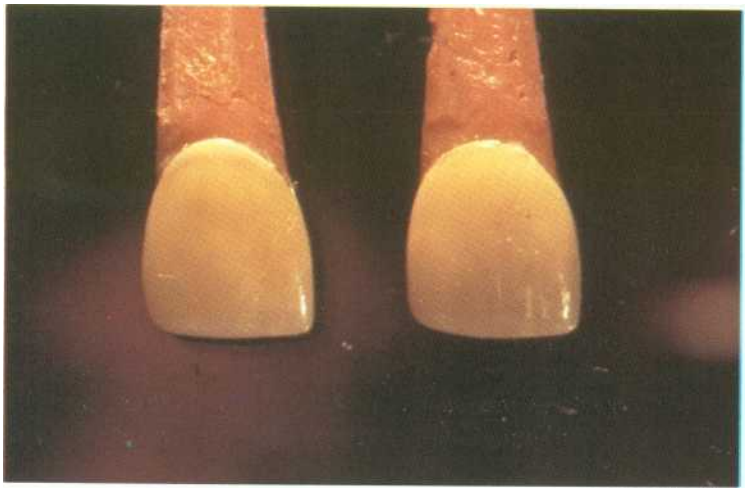


Fig. 5-55

It would seem logical that a thick veneer will always mask stains better than a thin one, but this is not always true. When using very opaque luting agents a thin veneer (on the left) can be superior at masking.

Type VI. **Double Preparation.** This finding suggests the method for maximum control of the final color by the dentist. Since the dentist has control of the density and shade of the luting agent, the thicker the layer of composite, the greater the amount of control he will have. As a direct result of this observation, in May 1987 McLaughlin published the sixth preparation category (Type VI),' called the "double preparation".

The double preparation is used when the dentist desires maximum change between the natural color of the tooth and the final shade. This preparation consists of two stages. In the first stage the dentist prepares the tooth using a Type I (minimal) preparation and then takes an impression. When the veneers arrive, and after they are tried on for shape and size, the areas of the tooth requiring maximum change in color are reprepared into a Type V (maximal). preparation. This creates a gap between the veneer and tooth sufficient enough to place a totally opaque masking layer of composite. Although the composite used should be totally opaque, it must also be the final shade desired for the restoration (see chapter 7)

In our example, we took the die which had received the more conservative preparation and deepened the preparation to equal that of the other die. An opaque composite was mixed, and the veneer was fused into place using standard technique. This photograph shows that even severely discolored teeth can be masked using the double preparation and opaque composite.

Fig. 5-56

PREPARATION VS. NON-PREPARATION

The decision of whether or not to prepare a tooth prior to the fabrication of a porcelain veneer is dependent on three factors; the condition of the tooth, the reason it is to be laminated, and the predisposition of the dentist.

In certain cases, such as a very darkly stained tooth, or a tooth in labial version, the choices are limited. In order to create a thick enough veneer to mask dark stains, some enamel may have to be removed. Similarly, a tooth may be buccally positioned, a factor that certainly precludes the addition of an extra half millimeter to its labio-lingual dimension. A tooth may be rotated to an extent that a mesio- or disto-proximal line angle protrudes from the arch. This protrusion should be eliminated prior to beginning any cosmetic procedures. These are situations that are, to a great extent, beyond the control of the operator.

Some practitioners do not feel comfortable adding anything to a tooth that has not been reduced. While this can apply to full crowns and bridges, in the area of Cosmetic Dentistry this attitude must not be taken for granted.

It should always be an objective of Cosmetic Dentistry to enhance the patient's appearance as much as possible, while keeping tooth modification minimal. Whenever possible, Cosmetic Dental procedures should be planned so they are essentially reversible. If the patient tires of his new appearance, or if a superior technique becomes available, it should ideally be possible to return the tooth to its original condition. Obviously, if any preparation has been performed, this cannot be accomplished.

Minimal or no preparation also is immediately desirable from the patient's point of view. It is easier to understand and subsequently to submit one's self to a constructive procedure rather than a destructive one. When little or no reduction is

done, there also is no need for anesthesia. It is usual practice for the entire minimal modification type of procedure, including the fusing process, to be done without the use of an injection. This is certainly a desirable point that the dentist would want to bring to the attention of the patient during the case presentation. The lack of a need for anesthetics also can be a boon in the treatment of the elderly, who may have complicating medical conditions, as well as the young, who may be difficult to anesthetize.

In addition, anything more than minor preparation brings with it further complications.

TEMPORIZATION

One of the greatest problems facing the dentist who does undertake maximal preparation is that of temporization. Because so little (less than 1 mm) has been removed from the tooth, and because care has been taken not to leave any undercut areas, there is literally nothing for a temporary to hold on to without etching.

In all such cases the problems are the same. The dentist is faced with the dilemma of choosing the strength with which the temporary will adhere to the tooth. Too little strength, and the temporary pops off the first time the patient sneezes. Too much strength, and the dentist literally has to grind the veneer off while attempting to leave the underlying topography of the tooth unaltered -a tricky proposition at best. If too much is ground, it could result in complications when seating the laminate, while too little would guarantee that the laminate would not properly fit. Additionally, if the original preparation went down to the dentin, anesthesia would probably be needed to grind away the temporary. On top of all this, the temporaries often represent a compromise in esthetics.

The adhesion of the temporary has been addressed in several ways. Sometimes excess composite can be extruded between the contacts of the adjoining teeth, and this can serve as a weak, albeit unhygeinic, attachment. Sometimes the temporaries are "spot welded" to the tooth by etching only one or two spots on the labial surface of the tooth each about a millimeter in diameter. Neither system is very good, but they both work to a fashion. Unfortunately, while either of these methods can hold the temporary in place for a short time, they will sometimes debond by themselves, causing embarrassment for the patient.

At the same time that the dentist is attempting to make a temporary that will not be inadvertently removed, but will easily part from the tooth on command, still another consideration must be made. A serious problem on occasion has been the percolation that occurs at the unetched margins of the temporary veneers. Although the time involved is too short for any major dental decay to begin, the presence of oral fluids in close proximity to freshly prepared enamel and dentin can be uncomfortable.

That having been said, the authors have attempted a number of methods of temporization: Preformed Mastique Tm acrylic veneers (L.D. Caulk Co., Milford, Delaware) have been tried. The esthetics of this method (considering the very short temporal requirement of about one or two weeks) are relatively good.

Another method is to use somewhat flowing composite resin and "freehand" a quick veneer. This method is also serviceable. Still another method is to take a pre-preparation alginate impression and use it as a mold to make either self-cure composite or plastic veneers, which are then adhered by either the "spot welding" or "interproximal excess" methods.

As can be readily appreciated, temporary veneers take much time to fabricate and even so engender more problems than any other aspect of the entire procedure.

Of course, the patient is better served when the preparation is restricted as much as possible, or even eliminated altogether. In the past, dentists have measured their effectiveness by the amount of tooth structure they have replaced; in the future, we must evaluate our success by the amount of tooth structure we can preserve.

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1. McLaughlin, G.: Controlling color in the porcelain laminate. Compend Cont Educ. 8(5):362-371, 1987.

Chapter 6 CLINICAL PROCEDURE FOR PORCELAIN LAMINATE VENEERS

PREPARATION

Once the dentist has determined the type of preparation to be used for each tooth, the preparation can actually begin. The instrumentation used will vary from operator to operator. Many companies produce burs and diamonds that have been specifically designed for use with porcelain laminate veneers. With experience, each dentist will develop his own favorite instruments for each of the preparation types. In actual practice, most preparations can be completely accomplished using only one or two instruments.

For the sake of simplicity, we will list the burs and diamonds we have found most useful in our hands. The burs and points described are found in the Shofu Porcelain Veneer Kit (Shofu Dental Corporation, Menlo Park, California) unless otherwise attributed to another company.

Fig. 6-1

Prior to any enamel reduction, it should be decided whether local anesthetic is required. It has been the authors' experience that most preparations can be comfortably accomplished without the need for a local anesthetic.

For all preparation types, the operator must constantly keep the desired final result in mind throughout the preparation phase. He also must keep in mind the space available in the arch for the veneers and the intended path of insertion.

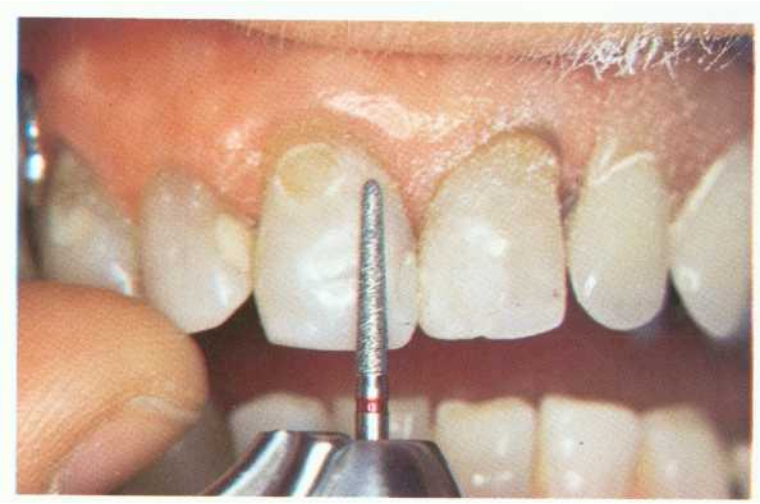


Fig. 6-2

If only enamel polishing is needed, then a polishing cup, such as the Quasite cup, will remove the plaque or other foreign material on the surfaces of the teeth. A prophylaxis paste or laboratory pumice may be utilized in conjunction with the cup. As a final step for the Type I preparation, the contact points between the veneered tooth and its neighbors should be checked to verify that an interproximal mylar strip can be placed during the fusing process. If the contacts are too tight, they should be relieved using a polishing strip.

Instrumentation for the Type II-Incisal Preparation

As described in the previous chapter, it is often desirable to create along the incisal edge a thickness of porcelain greater than that afforded by the Type I preparation. Such a situation calls for a Type II preparation. Because of the great similarity between the Type I and Type II preparations, the technique for the Type II preparation is exactly the same as for the Type I, except that a reduction of the facial enamel on the incisal I to 2 millimeters of the tooth is necessary. This reduction is accomplished by using a torpedo shaped diamond bur such as the Robot 835F. Thus the entire Type I and II preparations can be accomplished with only a single diamond.

Instrumentation for the Type I-Minimal Preparation

The Type I (minimal) preparation often requires a slight reduction of the facio-proximal region near the gingiva in order to provide a path of insertion that is free from undercuts. For this purpose a torpedo shaped instrument, such as the Robot 835F diamond, will do the job nicely. If a slight removal of surface irregularities (i.e. ridges) is required, then the same tip can be used to gently smooth the labial surface.

Instrumentation for Types III and IV- "Over the Incisal Edge" and "Over the Incisal Edge With a Ledge" Preparations

The dentist may decide to shoe the incisal edge completely, as in the Type III or Type IV Preparations. In such cases a coarser diamond, such as the Robot 835, is used on the incisal edge, since more tooth structure must be removed than in the delicate Type I and II preparations. On the lingual surface, many dentists find a football shaped diamond such, as the Robot 883F, is handy for creating a nice knife-edged margin for the Type III preparation.

Fig. 6-3

If a lingual ledge is desired (Type IV), then the usual instrument used on the lingual surface is a cylindrical or torpedo shaped diamond, such as the Robot 835F.

After adjusting the incisal edge, the more refined adjustments to the proximal areas along the gingival can be made using a finer diamond, such as the Robot 835F. In addition, the areas cut by the coarse diamond should be smoothed using the finer diamond as a finishing step. In fact, when any coarse diamonds are used for preparation, it is useful to finish the tooth with a fine diamond prior to taking the impression, since any striations of the tooth surface can complicate the laboratory procedure.

Instrumentation for the Type V-Maximal Preparation

If a Type V Preparation is indicated, then a coarse diamond such as the Robot 835 should be utilized, taking care to leave as much enamel intact as possible. This is especially important along the borders of the preparation.Leaving intact enamel serves two purposes: first the tooth will be less sensitive following the procedure; and second, bonding agents currently exhibit significantly higher bond strength to enamel than to dentin.

Fig. 6-4

Since it is highly desirable to refrain from penetrating the enamel during preparation, many dentists prefer to use a depth-limiting or depth-marking diamond such as the Lasco DC4 (Lasco Diamond Products, Chatsworth, Ca.). It should be remembered, however, that the proper depth of enamel reduction is not consistent over the full surface of the tooth. Thinner enamel in the gingival regions, for instance, dictates that the enamel reduction be limited or even curtailed in this region. Still, many dentists find the depth-marking diamond to be helpful in visualizing the proper depth of enamel reduction.

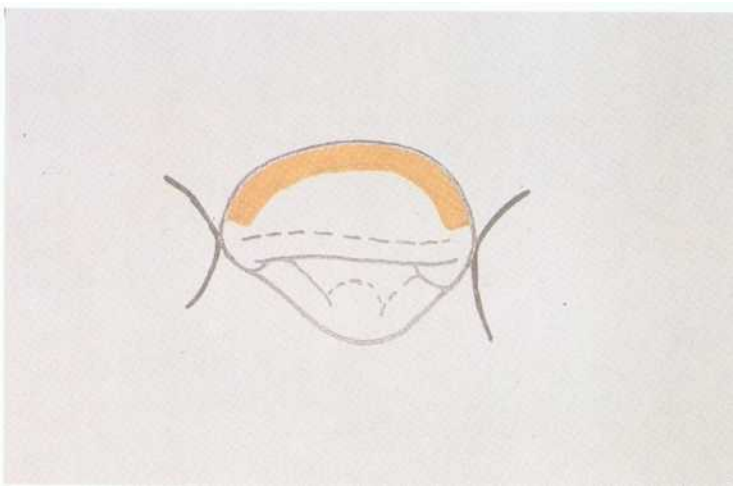


Fig. 6-5

In all cases, the enamel reduction should not be carried past the contact points mesially and distally, since this could place the margins in a less accessible area for cleansing and might create undercuts (considering the labial approach of the veneer placement). In addition, the loss, of proximal contact would allow for tooth movement during the fabrication of the veneer. Where inciso-lingual reduction of the enamel is desired, a football shaped diamond, such as the Robot 883F, will remove the excess tooth structure.

Fig. 6-6

IMPRESSION TAKING

Following the preparation phase, the appropriate impressions need to be taken. The required records are an accurate model of the prepared teeth and their neighbors, a counter model, and a bite registration.

The impression materials of choice are the polyvinylsiloxanes, such as Mirror 3, (Kerr Manufacturing Company, Romulus, Michigan) and Express (3M, St Paul, Minnesota) or the polyethylethers, such as Impregum (Espe-Premier, Norristown, Pa.).

Fig. 6-7

If taken separately, the bite registration material should be a putty or silicone type. When these materials are used, the laboratory has the option of cutting away part of the registration material to see the interdental relationships better. Wax wafers may be used, but they do not have as reliable a rigidity as the first two substances.

Fig. 6-8

There are two slightly differing techniques of taking impressions for veneers. One is the standard full tray system that dentists are familiar with from use in crown and bridge procedures. An anterior sectional impression is usually more than adequate. Only those teeth to be veneered and the adjacent two teeth on either side are of any consequence unless the contralateral tooth is being used for reference.

Fig. 6-9

The common method is to place the putty in the tray . . . ,

Fig. 6-10

and to inject the tip-mixed light body directly onto the teeth, along the cervical margin and interproximally.

Fig. 6-11

The putty filled tray is then compressed over the arch.

Fig. 6-12

The resulting impression will show the margins, the labial surfaces, and the interdental areas clearly, so the laboratory technician will have a clean model upon which to fabricate the veneers. The pressure of the putty will force a small flash of light-body material subgingivally, demonstrating to the technician both the space available and the nature of the free gingiva.

Another, and perhaps easier, technique for impressions is the use of the Anterior Triple Tray (Espe-Premier, Norristown, Pennsylvania). This is a single-step procedure that utilizes putty on both sides of the tray gauze and light body on the teeth to be veneered. The light body is spread on the appropriate teeth, and the patient is asked to bite into the puttied tray.

Fig. 6-13

The final impression, the opponent, and the bite are all ready within seven minutes.

Fig. 6-14

If retraction cords are used, the subgingival areas will be more visible, but the laboratory will have no idea of the location of the gingival margin, and will have to guess the cervical finish line for the veneer (unless a cervical finish line has been incorporated in the design). Perhaps as a carry-over from full coverage types of preparations, some dentists insist on using retraction cords in taking impressions for porcelain veneers. While the authors of this text do not subscribe to this idea, the choice remains a matter of personal preference.

Once the impressions and occlusal records have been taken, the shade is established, the laboratory prescription written (see chapter 7), and everything is sent to a laboratory. When the veneers are returned, the internal aspect of the veneers will already have been etched at the laboratory. The dentist need only clean the teeth being veneered before the placement procedures can begin.

Fig. 6-15

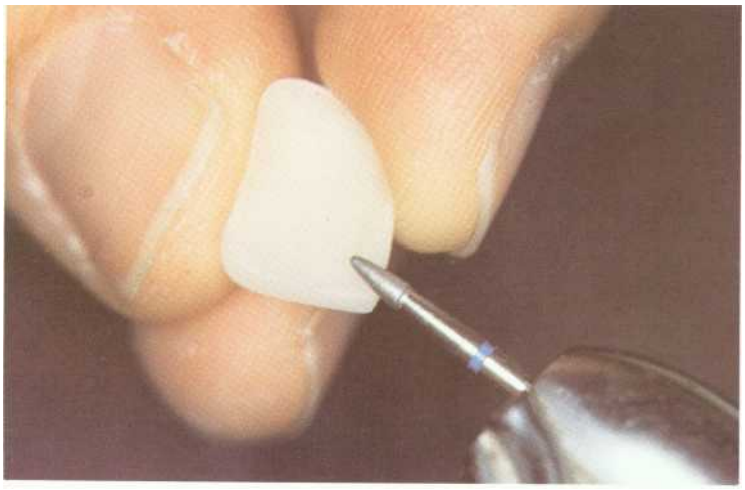


Fig. 6-16

Fig. 6-17

PLACEMENT

The veneers are tried on to establish their fit, length, and mesio-distal dimension. All the veneers to be fused must be placed simultaneously in order to accurately observe their interrelationships and esthetic impact. At this time, the dentist is primarily concerned with verifying that all areas of tooth needing coverage will be adequately covered by the veneer and that all veneers will be seated properly. At this try-in, the dentist should place the veneers on the teeth in the order that he will be fusing them. This is done to discover if any veneer interferes with the seating of its neighbor.

Should any adjustments be necessary at this stage, they may be carefully undertaken with a high-speed diamond, such as the Hybrid T&F 0931 or the 0935 in a concentric handpiece. This step must be very gently accomplished because the unsupported porcelain is very fragile and can break even with medium finger pressure. Generally, little adjustment is needed at this stage if the laboratory has taken care in the production of the veneers.

ATTACHMENT OF THE VENEERS

Many manufacturers make kits for fusing porcelain veneers to teeth. Each has its proponents and detractors. In the end, the choice of kits is a personal decision. The authors have chosen to demonstrate the Porcelite Kit (Kerr Manufacturing Company, Romulus, Michigan) because of its completeness (all the items needed for this phase of porcelain veneers are included) and because its composite shades are well suited to most cases without further alteration. It is logically packaged, allowing the operator to visualize the sequence from left to right. There are separate modules for etching, fusing, and color modification.

After the initial contouring is complete, the etched concave surfaces of the veneers are treated with an orthophosphoric etch *liquid.*

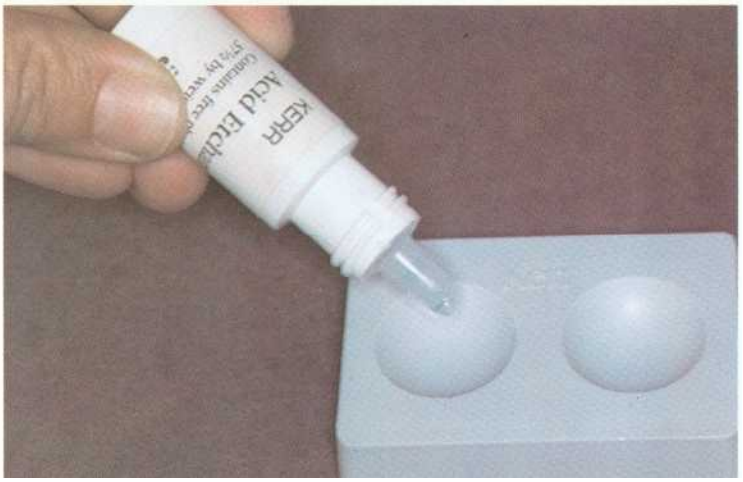


Fig. 6-18

This is essentially a degreasing step to remove any materials that may have collected on the veneer's laboratory-etched fusing surface.

Fig. 6-19

After one minute, the etchant is washed off with water.

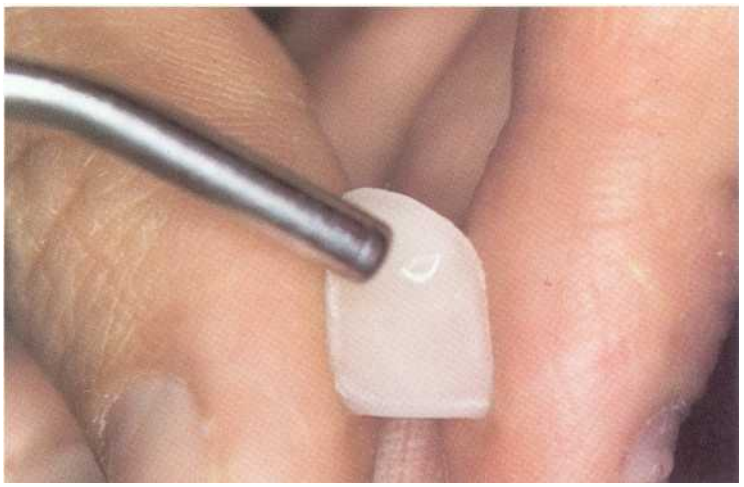


Fig. 6-20

Fig. 6-21

A second application of liquid etchant is placed, and this is not washed off.

Fig. 6-22

Then the Kerr Porcelain Primer (the silane) is applied. It can be seen displacing the layer of etchant on the veneer.

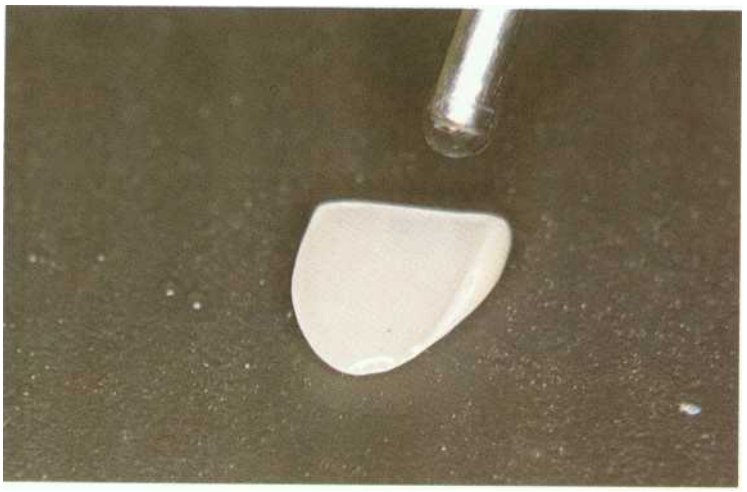
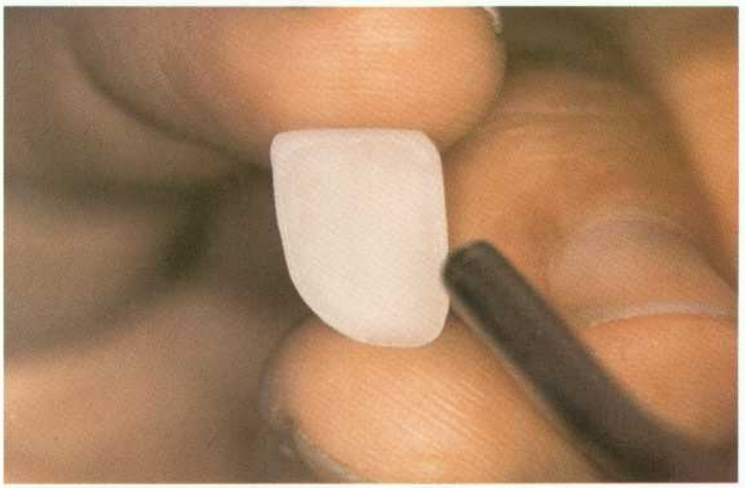


Fig. 6-23

Alter one minute, the veneer is thoroughly rinsed . . .

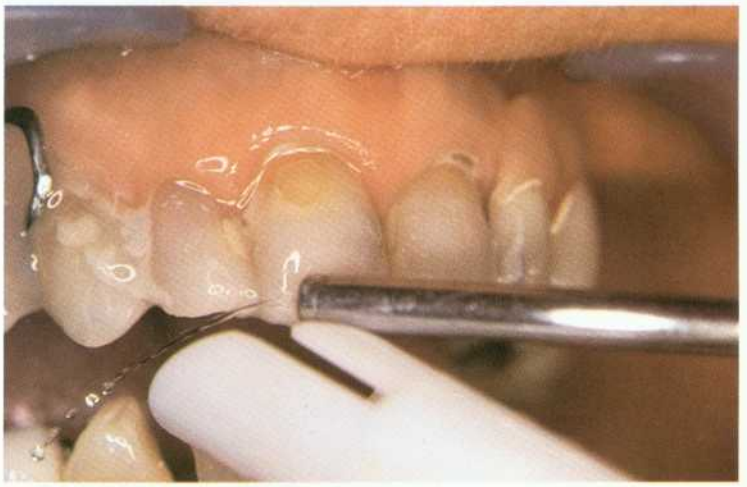


and then gently air-dried.

Fig. 6-24

The teeth that are to be veneered are then cleaned again with pumice . . .

Fig. 6-25



and rinsed.

Fig. 6-26

The teeth are then isolated from each other by mylar strips (and wedges if necessary). The. lips are retracted from the operating area by means of cotton rolls or lip retractors. The following fusing procedure is then followed, completing one tooth at a time.

Fig. 6-27

The teeth are etched with an orthophosphoric acid etchant ...

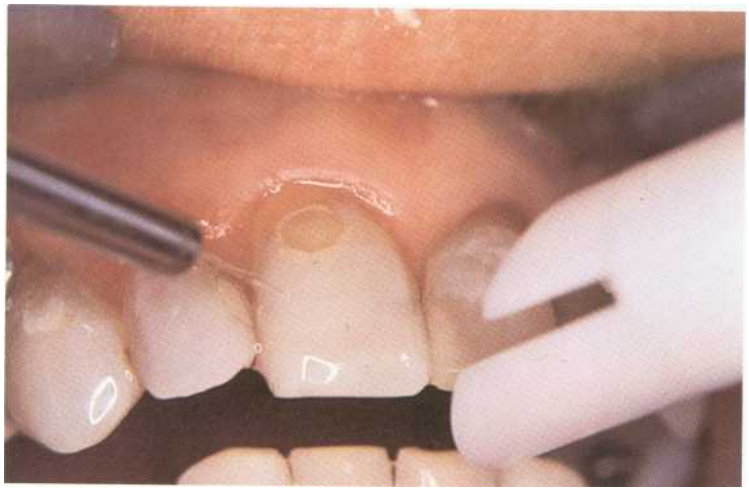
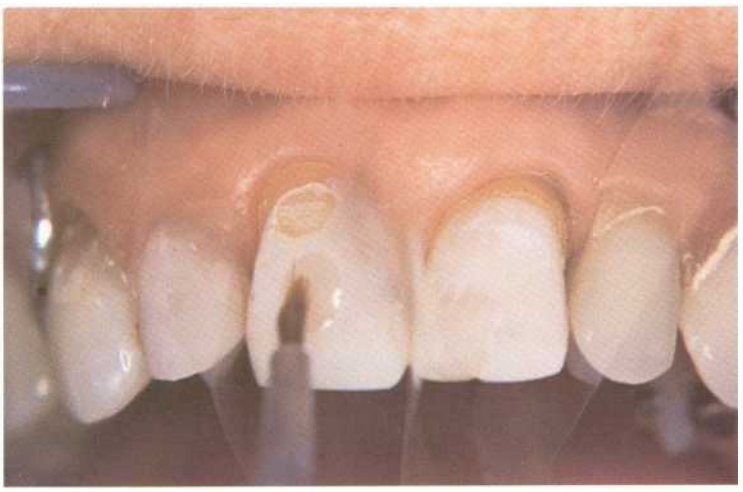


Fig. 6-28

very thoroughly rinsed (Fig. 6-28), and gently air dried. The properly etched tooth surface should exhibit a frosty appearance.

The Kerr Bondlite is mixed for about ten seconds in the special dish provided.

Fig. 6-29



Approximately one drop each of the activator and resin per veneer is required. The Bondlite is then applied in a very thin layer to both the etched tooth surface . . .

Fig. 6-30

and the bonding surface of the veneer. A gentle stream of air should be used to spread the Bondlite into as thin a layer as possible. Do not light cure at this time.

Fig. 6-31

Fig. 6-32

If needed, a Porcelite Shade Modifier is selected. These are pastel-like colors that provide a moderate amount of shade modification. It is provided in the six following shades: untinted, universal, yellow, yellow-brown, gray-brown, and opaquer.

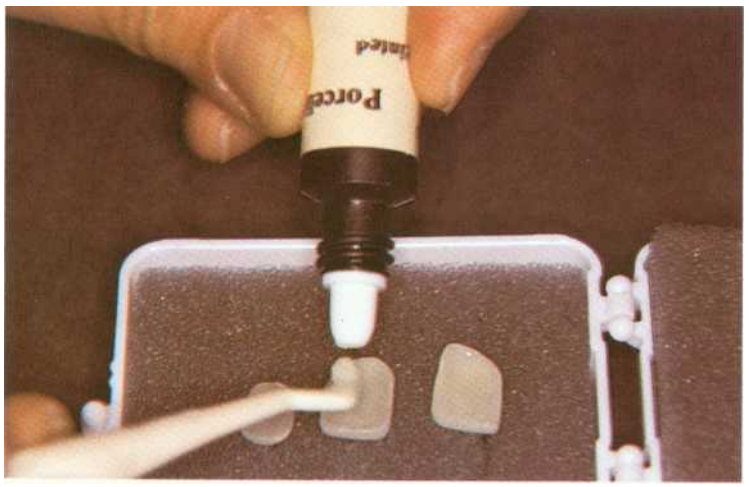


Fig. 6-33

Esthetic requirements often dictate that no one particular shade modifier be used on its own; rather, a gradient of color is created, more dark-yellow toward the gingival, brighter in the main body of the tooth, and more blue-gray translucent at the incisal. Shading requires clinical judgment and the ability to readily visualize both needs and results. This, of course, improves with practice. There is no need to blend the shades at this point. Even if the shade modifiers are placed on the veneer in separate spots, the pressure of placing the veneer onto the tooth surface tends to blend the various modifiers into an esthetically pleasing gradient.

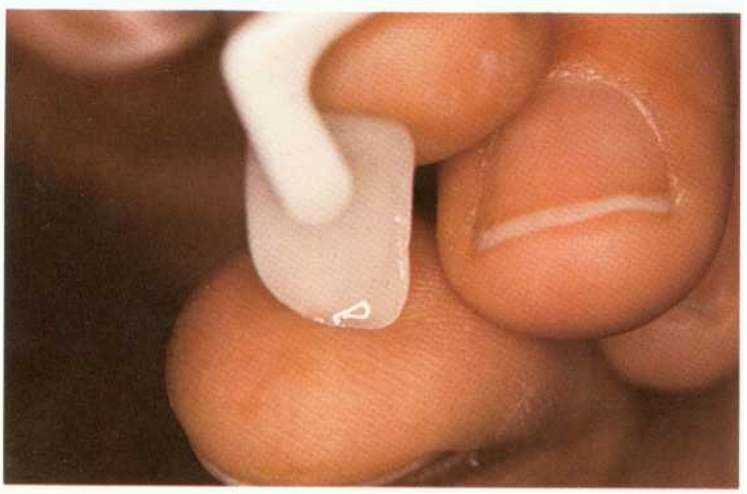


Fig. 6-34

The veneer is then filled with the proper shade of composite cement, being careful to avoid entrapping any air bubbles. Place the veneer against the tooth and apply gentle pressure until the veneer is seated. The veneer should not be exposed to strong light until the position and appearance has been verified.

The veneer is now examined for position, color, success in stain masking, and its relationship to the other teeth or previously placed veneers. For the first veneer, the patient should be consulted at the time of color modification. If the resulting appearance is the desired one, the veneer is again checked for position on the tooth with light finger pressure, and then the cure is begun.

Fig. 6-35

If the color is incorrect, the veneer is carefully taken off the tooth. Both the luting-composite and the shade modifiers can be removed from the veneer and the tooth by a brush or cotton swab dipped in Bondlite. Then different color modifiers are selected, and the process is repeated. In particularly difficult cases, this step may have to be done a number of times. There is no specific number of trials; when the color is correct, then the dentist can continue.

If further, or more distinctive color characterization is required, then this may be accomplished with the Command Shade Modification Kit (or any other similar kit) as described in chapter 7.

Light curing is a prerequisite modality when dealing with porcelain veneers. Self cure materials, even if available, could not give the type of temporal latitude that is required in the placement of laminates. Although most curing lights may be used in this procedure, the ideal unit would incorporate a very strong output (because the light must pass through a half millimeter of porcelain before it reaches the composite), a low heat output (for patient and operator comfort during this often long treatment), and, if possible, a readily interchangeable wide-diameter and curved wands.

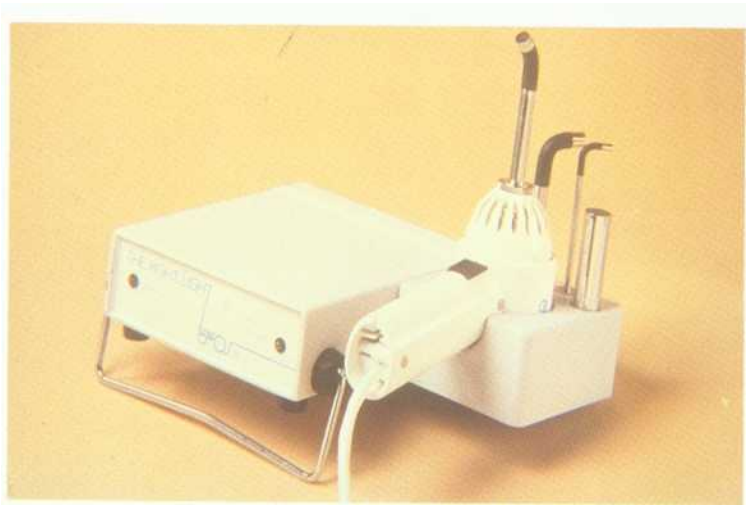


Fig. 6-36

Since different units provide lights of differing intensities, we will describe the appropriate times using one particular light: the EFOS 35 (Engineered Fiber Optic Systems, Mississauga, Ontario).

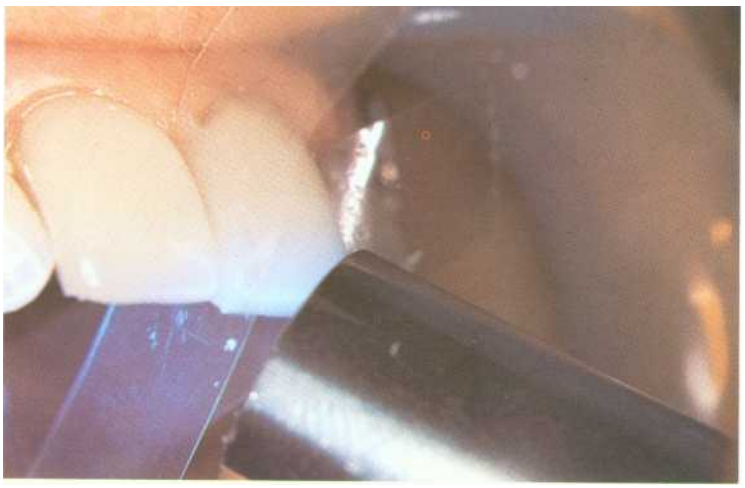


Fig. 6-37

When the operator is ready to cure the veneer, he begins by shining the light on the incisal edge for a period of five seconds using the curved wand tip. Generally, while this is being done, it is a good idea to keep a very slight finger (or instrument) pressure on the labial surface of the veneer to prevent it from accidentally lifting away at the gingival.

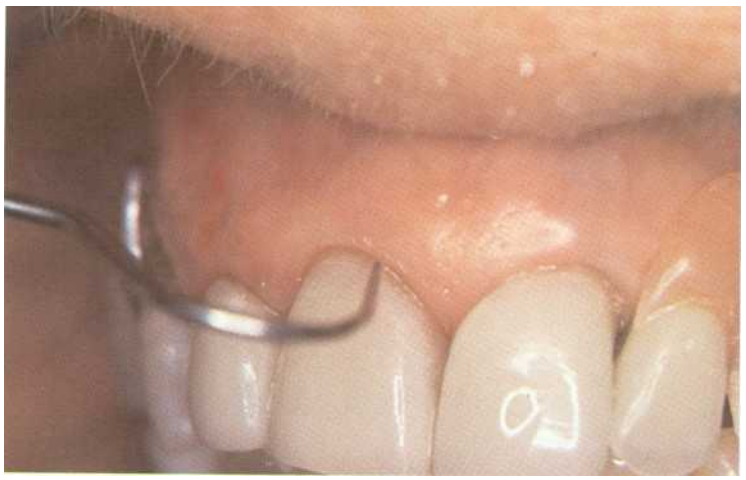


Fig. 6-38

The excess composite all around the veneer (proximal, gingival, and lingual) will still be in a plastic stage at this time, and should be gently removed with an explorer or a scaler. The emphasis is on "gently" here, without nicking the periodontal tissues. It is clearly desirable to avoid any gingival bleeding at this point in the placement procedure. The wetness of bleeding can weaken or destroy any subsequent fusing as well as cause discoloration and formation of voids.

When the flash elimination is completed, the labial surface of the veneer should be cured with the wide-diameter wand for 40 seconds. Following this, the veneer is cured from the inciso-lingual direction for 20 seconds with the curved wand.

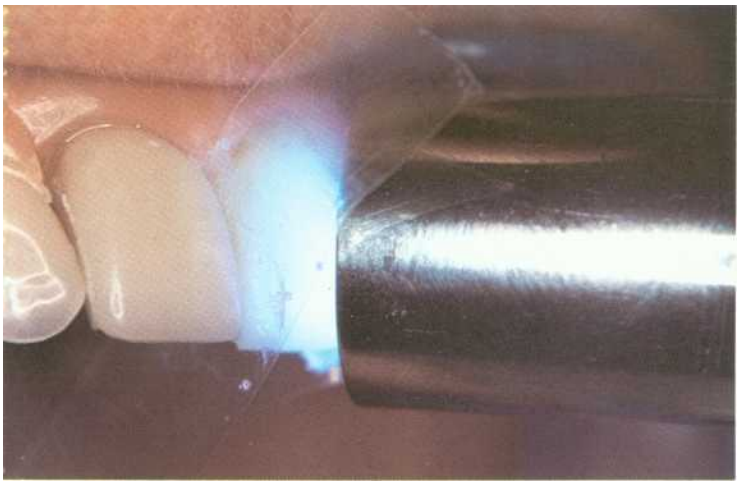


Fig. 6-39

The interproximal flash is again removed, and the fit of the adjacent veneers are rechecked at this time. If there is any change in the seating of the unfused veneers from the previous try-in (before the current veneer was fused), the offending area must be identified and removed. This flash removal can be done with a high-speed diamond such as a Hybrid T&F 0937 or with metal polishing strips such as G-C Metal Strips (G-C International Corporation, Scottsdale, Arizona). If the seating of the remaining veneers is not verified each time a veneer has been placed, there might be a discrepancy that will interfere with the fusing location of the adjacent veneer. This error could become cumulative and result in a situation where the last veneer may be distally displaced by up to one millimeter.

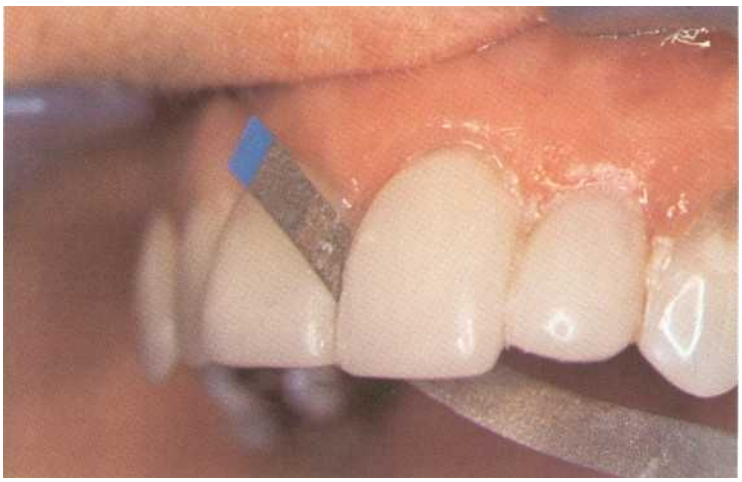
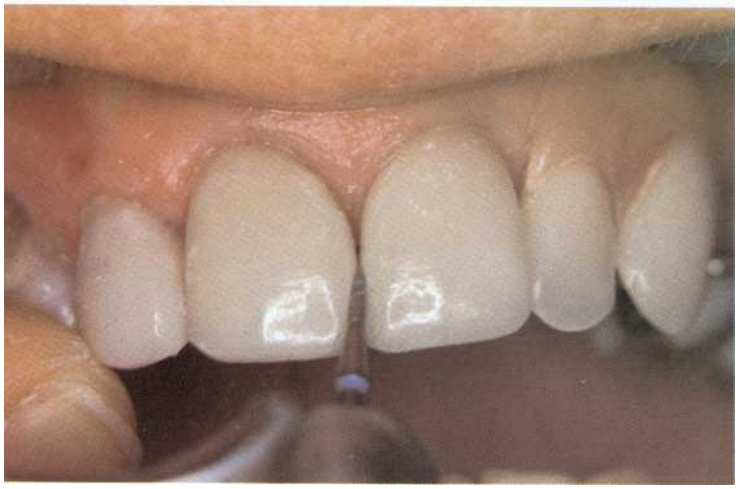


Fig. 6-40

The order of veneer placement is a matter of personal preference, but most practitioners seem to prefer placing one of the central incisor veneers first, followed by the other central incisor. This is then followed by a lateral incisor, then the other lateral incisor, and so on. Once the general color scheme has been established, all the teeth being veneered will be shaded according to that pattern. The experienced practitioner will often shade the lateral incisors slightly different from the centrals (usually a bit darker), and the cuspids slightly different yet again (usually somewhat yellower). Any pattern of veneer placement is acceptable, but it is usually easier for the dentist to keep track of the specific variations in shading and highlighting if he does the corresponding teeth on either side one after the other.

POLISHING

After the veneers are all fused into place, the polishing process can be initiated. Some operators prefer to polish each veneer and its margins before the next veneer is placed; but the authors feel that this tends to increase the possibility of gingival bleeding and, therefore, may make the remainder of the veneers much more difficult to place.



Using a thin, pointed, high-speed instrument such as the 0937 (Fig. 6-41), all the remaining interproximal composite excess must be removed from both labial and lingual aspects. As much as possible, it is important to blend the porcelain margins to the tooth surfaces and thereby eliminate any potential traps for bacteria or food. If there are any marginal voids, composite can be added at this stage to fill them.

All lingual flash is removed with a fine, football-shaped diamond or stone, such as the 883F. The veneer must always be contoured to the tooth lingually and checked for unwanted occlusal interferences. The 883F is used for selective removal of lingual porcelain, composite, or opposing tooth structure, until the desired occlusal harmony is achieved.

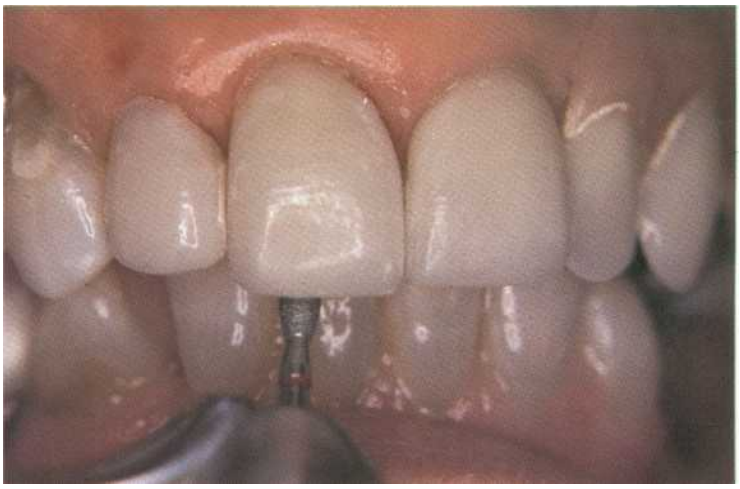


Fig. 6-42

Very often the porcelain and the luting composite form a cervical ledge either at or slightly gingival to the free gingival margin. This ledge at the cervical margin of the veneer must be removed to ensure a completely smooth transition between the tooth and the veneer. If possible, the finish line should be supragingival. l This reduction of the porcelain margin is done with the 0931

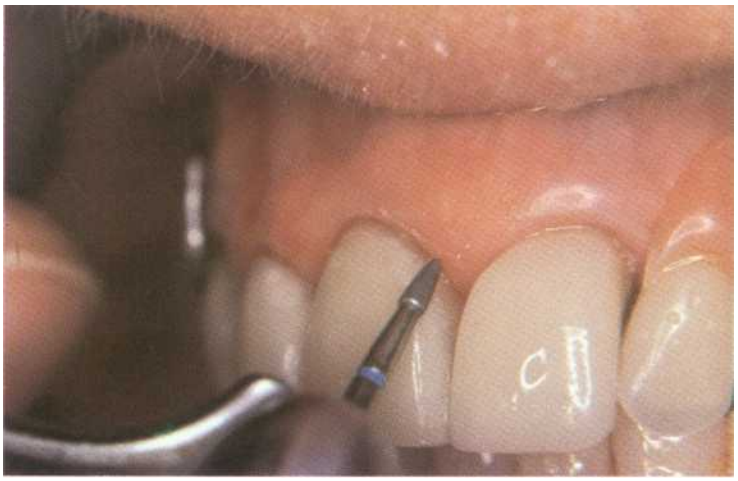


Fig. 6-43

. . . or the 0935 and the contouring is carried interproximally as far as the areas that were finished with the 0937.

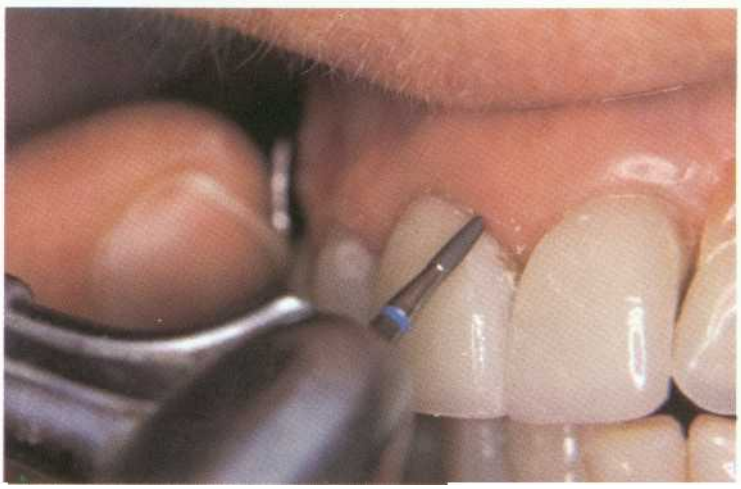


Fig. 6-44

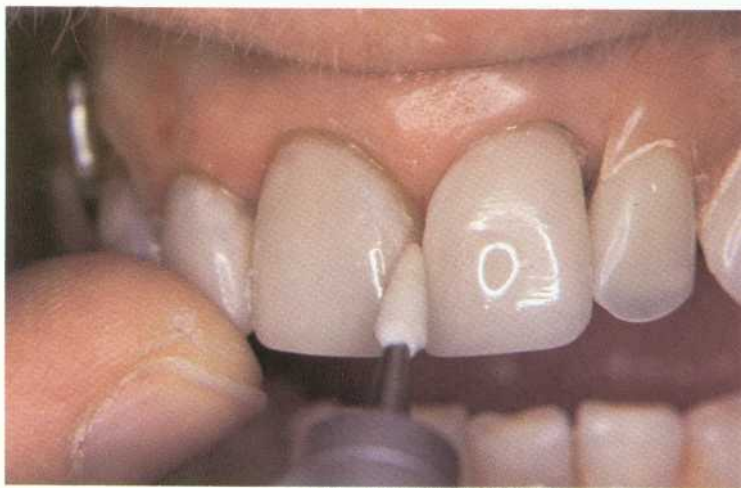


Fig. 6-45

When all the excess composite has been removed and all the margins are smooth, a finishing stone, such as a Dura White Point

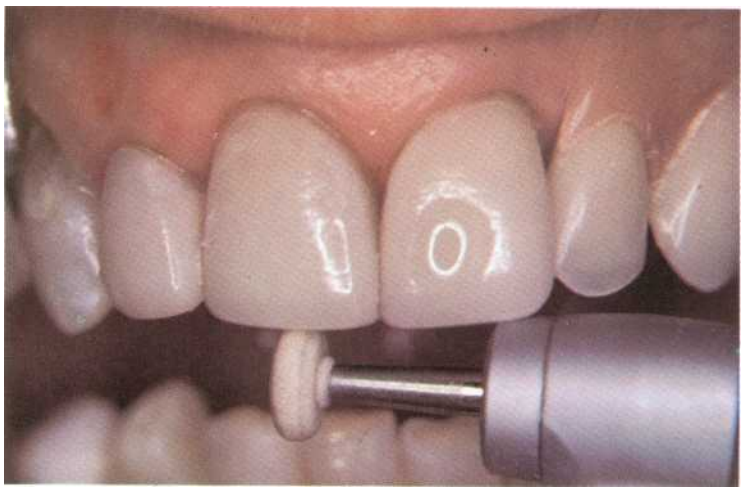


Fig. 6-46

. . . or Dura White Wheel is utilized to create a continuous transition that is not detectable by passing an explorer from the tooth to the veneer. The White Wheel RE1 0229 is suitable in open, accessible areas, while the White Point FL2 0223 is especially suited for interproximal and gingival marginal situations.

Impregnated silicone disks, such as the Ceramiste' Discs, polish the embrasure areas to a high luster. They should be used both lingually and labially and are often employed to polish the cervical margins. The Ceramiste' Discs come in three textures: the disc without yellow lines-0252 is to be used first, . . .

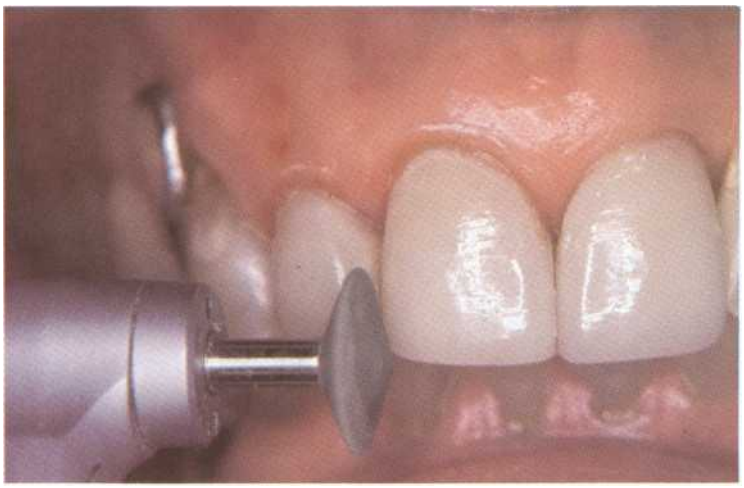


Fig. 6-47

then the disk with the single yellow line - 0255,

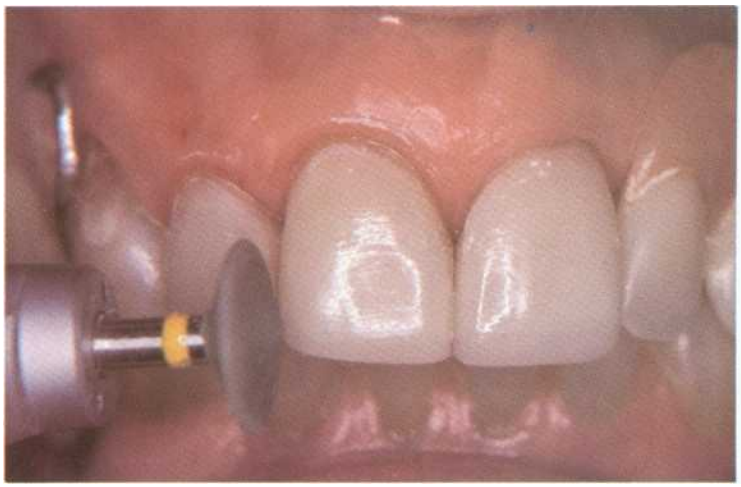


Fig. 6-48

. . . and finally the disk with the double yellow line-0258, which has the finest grit.

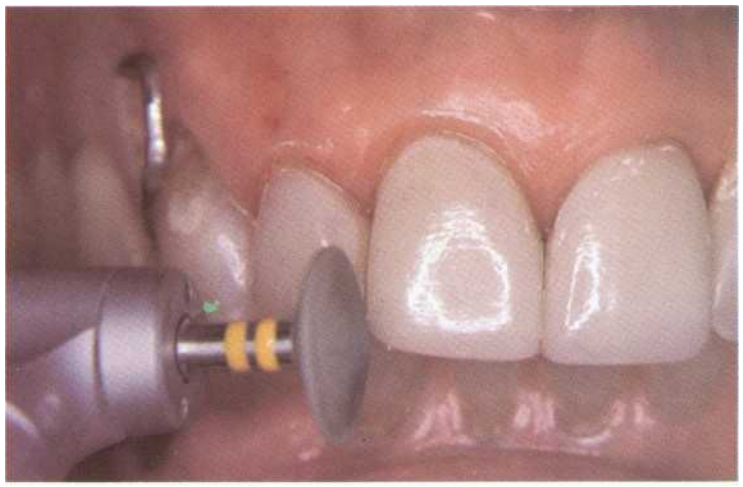


Fig. 6-49

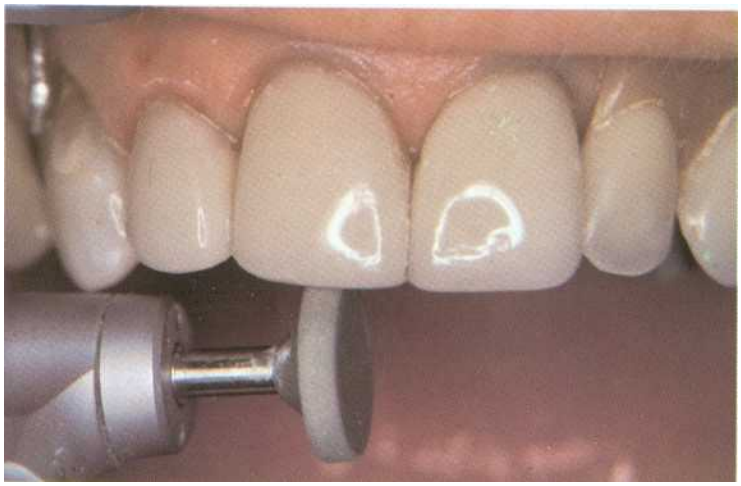


Fig. 6-50

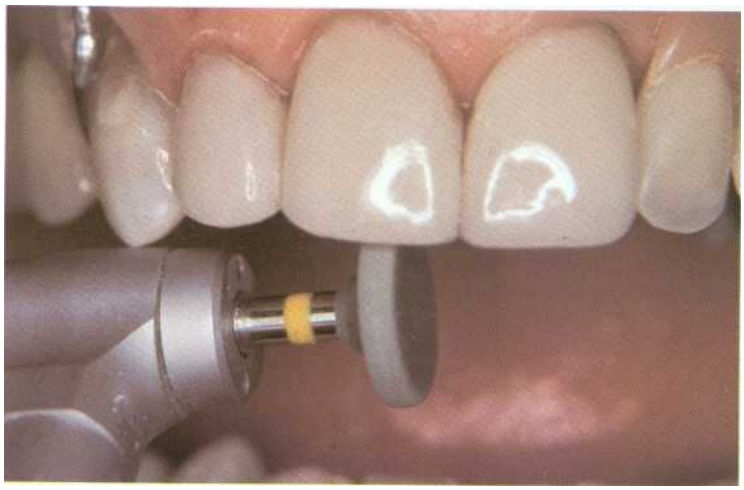


Fig. 6-51

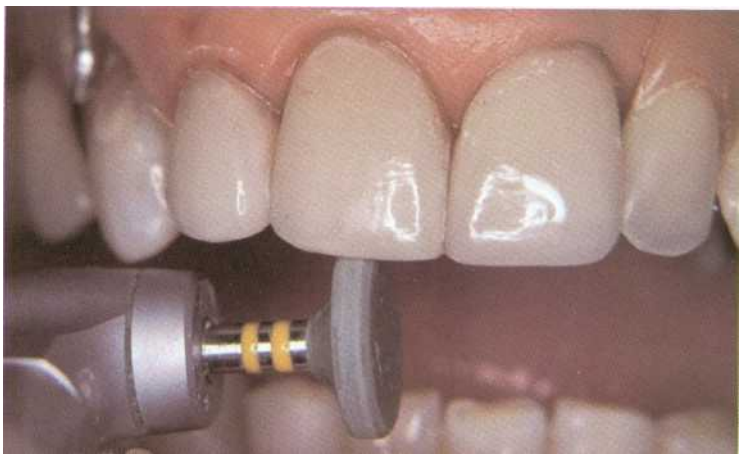


Fig. 6-52

Similarly, the lingual margins, and any labial parts of the veneers that have been adjusted, are polished with the impregnated wheels such as the Ceramiste' Wheels-0253, 0256, 0259. The three textures are used in the same sequence as the disks (Figs. 6-50, 6-51, 6-52).

The time spent polishing each tooth should be limited so as not to cause undue heating of the pulp, and should be done in a wet field if possible.

If the facial aspect of the porcelain has been altered, the final lifelike sheen is imparted through the use of polishing cups such as Quasite Cups, 0295. These are used in the same manner as prophylaxis cups-, ensuring that all surfaces are buffed.

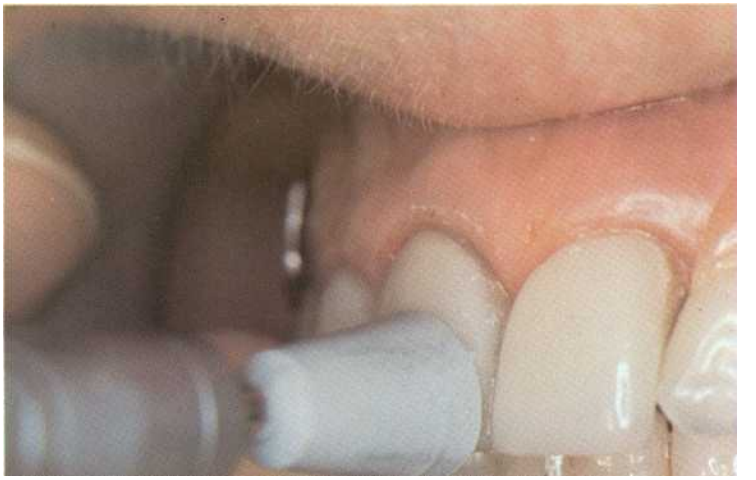


Fig. 6-53

It is important to go slightly subgingivally in the cervical areas of the teeth to be certain that these margins are particularly smooth and that all the minute remaining particles of composite or bonding agent are removed from these particularly irritable locations.

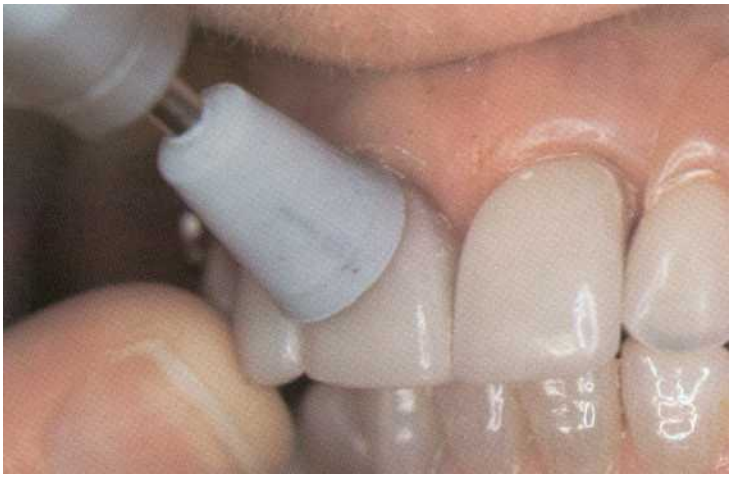


Fig. 6-54

Fig. 6-55

Fig. 6-56

POST-OPERATIVE INSTRUCTIONS

As with all dental procedures, the patient who has received porcelain veneers needs to be taught the proper maintenance of his new teeth, as well as what to expect from them in the future. To prevent misunderstanding or misinterpretation, the authors suggest that the post-operative instruction sheet on page 118, or an information sheet similar to it, be given to the patient after completion of the porcelain veneer procedure. The reader is invited to copy the page included in this text if he so desires.

Of short term concern to the patient will be that his lips may feel full for several hours. This results not only from the increased labial dimension of the veneers, but also from the fact the the lips have been packed with cotton rolls or held in an extended position by a lip retractor for an extended period of time to ensure the dryness of the operating field.

The Quasite Cups may be used wet or in conjunction with a diamond or composite polishing paste, such as Command Ultrafine Luster Paste (Kerr-Sybron, Romulus, Michigan). Again, to prevent overheating, the polish should be restricted to several seconds per tooth (Figs. 6-55, 6-56).

If the incisal lengths of the anterior teeth have been increased, the patient may have temporary difficulty articulating the sounds of D and T. The tongue will acclimate within hours, though, to the new reality, and this problem will quickly disappear. The patient should be warned, however, so he will not assume this is a permanent condition.

The patient should realize that the veneers are there to be enjoyed. While there are some restrictions with the veneers, they are virtually the same restrictions that should be observed with natural teeth. The new veneers should not be used for chewing on pens, pencils, ice cubes, or chicken bones. The patient should avoid trimming his fingernails or cutting nylon fishing lines with his restorations. He should be made to understand that the gentler he is with the veneers, the longer they will last.

Although these rules are self-explanatory, for many patients they will involve the changing of habits established over many years, and the process may be much more difficult than the dentist realizes.

The patient also should be advised to avoid having fluoride gel placed on the veneers in subsequent dental recall appointments. The free hydrofluoric acid in the gel can etch the surface of the porcelain, gradually eliminating the highly esthetic glazed surface.

As the literature indicates that the silane bond increases in strength for the first 24 hours after fusion, the patient should be advised not to chew gum or any hard or sticky foods for one day. Beyond that, he can consider the veneers as normal functional parts of his natural dentition.

In addition to listing what the patient should avoid, there must be a very clear indication to the patient that he must not only maintain his regular regimen of oral hygiene at home, but perhaps should improve it. Brushing and flossing of the teeth must not be discontinued.

Finally, the patient should be asked to return approximately one week post-operatively for a quick check of the cosmetic results and an evaluation of the gingival response. If anything has been missed during the fusion appointment, the dentist will have an opportunity to correct it at this stage.

REFERENCES

1. Silness, J.: Periodontal conditions in patients treated with dental bridges. 111. The relationship between the location of the crown margin and the periodontal condition. J Periodont Res. 5:225-229, 1970.

POST-OPERATIVE INSTRUCTIONS

Your porcelain veneers have been designed and created for optimal beauty and strength. Even though they are composed of fine porcelain, they have great strength due to their powerful attachment to the underlying tooth structure. Still, there are a few points which you should observe to minimize the chance of breakage.

DON'T CHEW ON:	PENS	PENCILS
	CHICKEN BONES	FISHING LINES
DON'T OPEN:	BOTTLES	NUTS
DO:	BRUSH AND FLOSS	

AVOID CHEWING HARD THINGS FOR 24 HOURS
(because the bond has not reached its full strength yet.)

AVOID FLUORIDE GEL ON YOUR VENEERS DURING CHECKUPS

If you feel uncomfortable while chewing, you should contact our office immediately for an adjustment of the bite.

And most importantly:

SMILE—IF YOU'VE GOT IT, FLAUNT IT

Chapter 7 COLOR AND THE PORCELAIN LAMINATE

The study of color can be extremely complex and involved. While it is not the purpose of this book to be a complete report on the art and science of color, there are certain aspects of color which have direct impact on the clinical practice of porcelain laminate veneers. In fact, the understanding of color and its manipulation is absolutely fundamental to the ability to create aesthetically pleasing restorations in the mouth.

At first this may seem a gargantuan task. In fact, just describing a given color can be a heroic pursuit because there are literally millions of discernible colors. By turning to the "Methuen Handbook of Colour" we can, if we wish, learn the names of over 8,000 of them. These include some of the less than classic colors of "Fancy Free", "Wafted Feather", and "Heart's Desire". While these names may evoke poetic images, they certainly do little to clearly communicate any of the dimensions of the shade they represent. Clearly there is a need for some distillation of color science, and it is obvious that some sort of order is vitally necessary if we are to develop skill in the manipulation of color without having to spend a lifetime developing a "feel" for what seems to work.

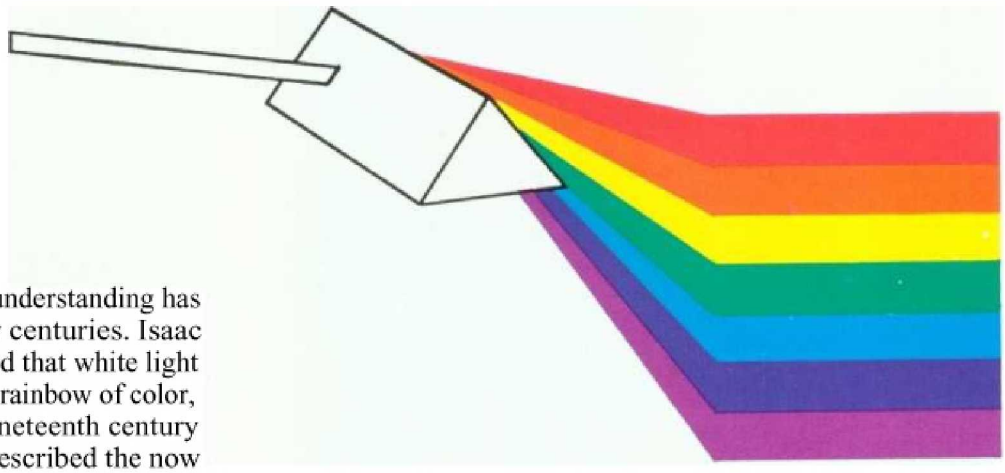


Fig. 7-1

The search for such an understanding has been a preoccupation for centuries. Isaac Newton in 1666 discovered that white light can be broken down into a rainbow of color, but it was not until the nineteenth century that E,~vald Hering first described the now familiar color circle .

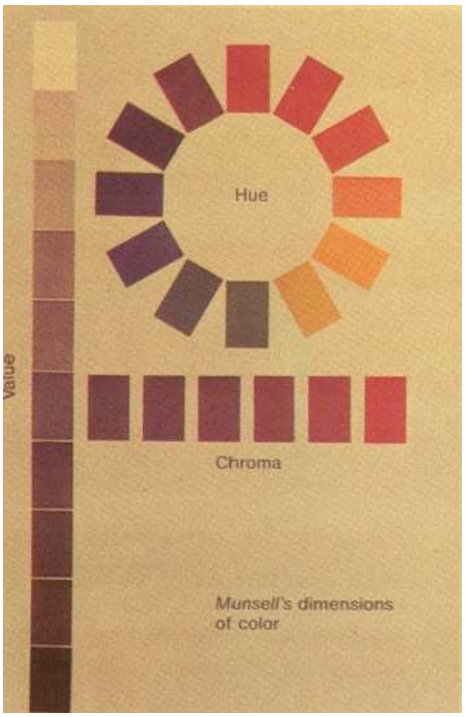


Fig. 7-2

While this created some organization of the color perception experience, it was only a beginning. At the time of its discovery, the color circle seemed to describe some basic law of physics, but it turns out that the organization of color into a color circle has more to do with the physiology of the eye and psychology of the observer. It does, however, form the basis for several of our present day workable systems of color.

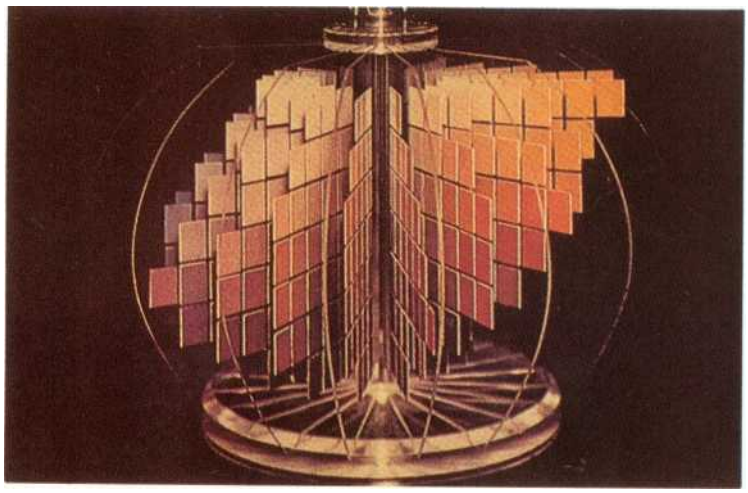


Fig. 7-3

In 1905 A. Munsell, an artist and art teacher, further modified the color circle further, devising a system of color organization which centered around three unique aspects of color: Hue, Chroma, and Value. Using these three aspects, Munsell was able to construct a three dimensional color wheel.

The Munsell system is not unique. Numerous other color wheels are available. Each is of different national origin, with versions from Britain, France, Germany, Argentina, and Sweden. Naturally enough, each system finds its greatest usage in its country of origin.

Unfortunately, while such systems provide a good way to describe color, they actually do little to teach us how to manipulate and control color in a clinical situation. In other words, rather than the Munsell system being a method which we use to control color, it merely serves as a relatively precise "language" to verbalize what we are doing. In fact, it is even of limited value in describing tooth color, since it is primarily involved with surface reflection. It does not make any distinction between one color that is relatively translucent and one that is opaque.

Differences in surface texture also are not addressed by such a system. All dentists have seen the differing appearance of porcelain crowns and plastic temporaries of the same color. Subtle differences in appearance can even be discerned between various brands of porcelain, variations that can transcend the qualities of hue, chroma, and value. Obviously, then, there are dimensions to the appearance of tooth shade beyond that of merely color. This situation is not unique to dentistry.

As a method of recreating the appearance of real objects on canvas, van Eyck in the fifteenth century developed a system of painting which he called the "wet" system. With this method, paintings consist of multiple layers. Different details o£ the paintings are placed in different stratum over the canvas. The layers of paint toward the outside are usually increasingly translucent, creating the illusion of depth and vitality which would be impossible if only opaque paints were used. Sometimes as many as 30 layers are used to create maximum effect. This is not that different from the technique a master dental technician uses when different shades of porcelain are employed to imitate the dentinal and enamel layers along with flecks of inlaid color.

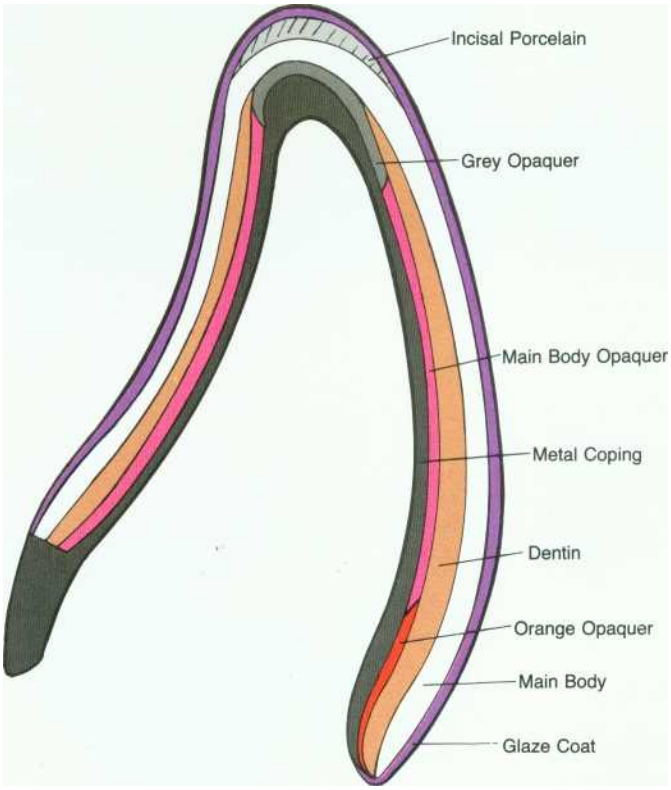


Fig. 7-4

Thus in some respects we are not much farther along than the artists of the Renaissance in our ability to control the chromatic appearance of our work. Nonetheless, there are several principles that guide us.Today's dentist must understand that there are several completely unique systems for understanding and manipulating color, and while each of them provide a workable framework for our understanding, they also may often seem to contradict the teachings of the other systems.

The Additive System

For instance, many textbooks discuss three primary colors of red, green, and blue. They teach that all other colors are made up of combinations of these three unique or "primary" colors.

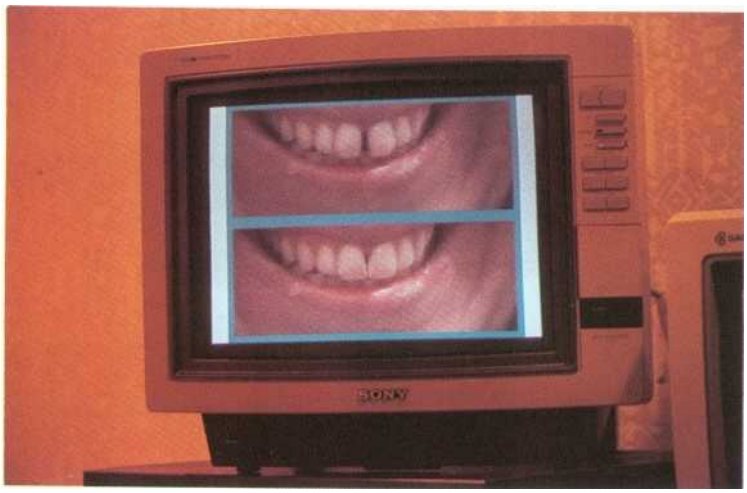


Fig. i-5

Knowledge of this system (the so called "additive" system of color) has enabled the creation of such devices as the modern color television. Using only three phosphors, each being of one of the three primary colors, the color television is able to produce a seemingly unlimited range of shades. One such television monitor boasts of a palette of 16,777,216 colors available on the screen.

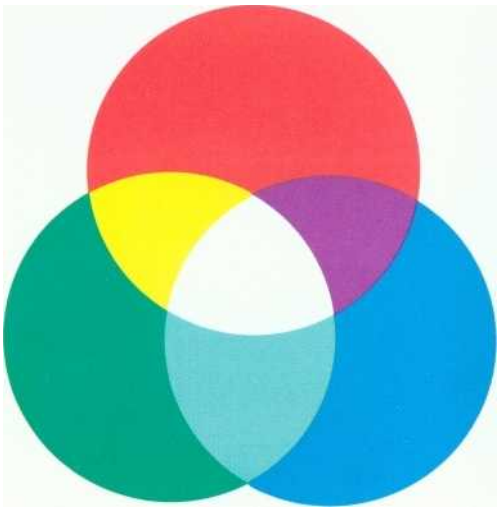


Fig. 7-6

In using the additive system, white is the balanced mixture of all the colors, and black is the absence of color. Yellow is a balanced mixture of red and green.

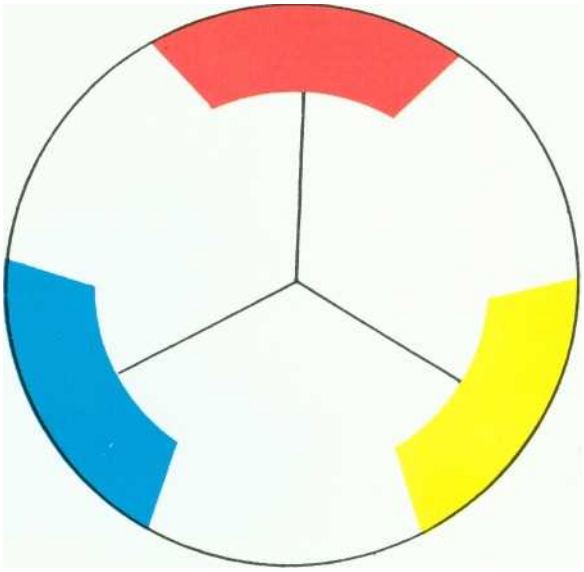


Fig. 7-7

The Subtractive System

Since the additive system of color does such a laudable job of organizing color, it may seem that there would be no need for any other approach. Those involved in art, however, tend to emphasize yet another arrangement. In this system, the so called "subtractive" system, the three primary colors are red, yellow, and blue.

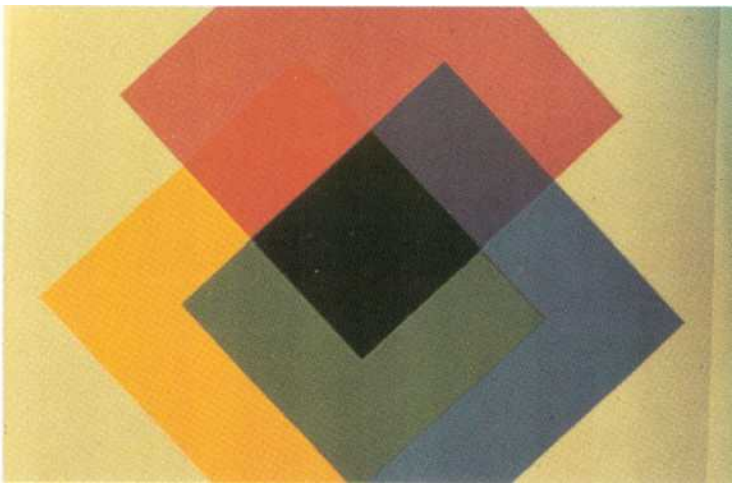


Fig. 7-8

In the subtractive system, black is the result of a mixture of the three primaries, and white is the absence of color. This system is popular because it is perhaps the easiest to use when dealing with pigments.

There are other systems as well. Each color system has its own strengths and deficiencies. Yet despite the apparent contradictions in the various color schemes, each popular system of analyzing color is correct within its own framework. Since we work with pigments when we deal with porcelain veneers, the easiest system for us to use as clinicians is the subtractive system.

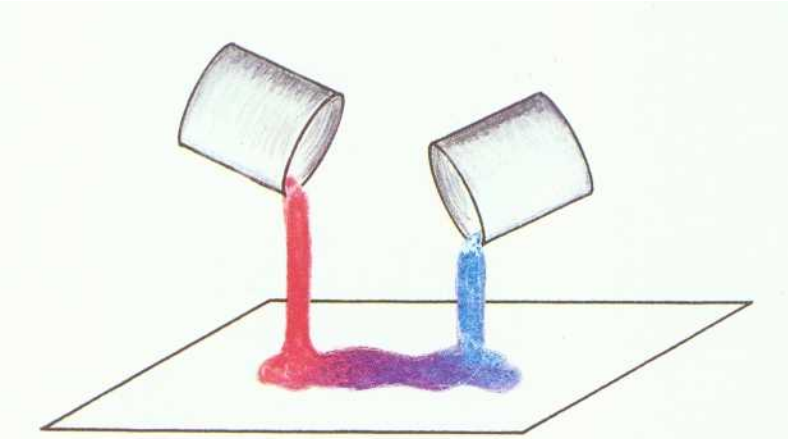


Fig. 7-9

The subtractive system is not only the easiest for us to use, but also the one with which we may be most familiar. The subtractive system is the one we have used since we first used crayons. We all know that if we mix red and blue, for instance, violet is the result.

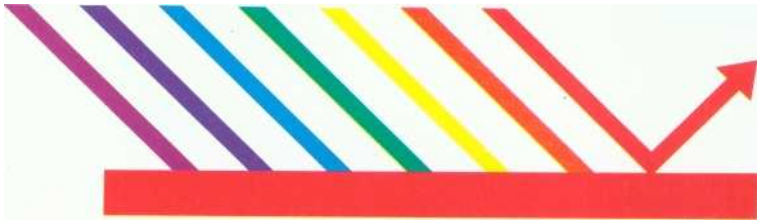


Fig. 7-10

This system works the way it does because the pigments within the crayons absorb certain parts of the spectrum and reflect others. Thus the pigments are "light traps". Red pigment, for instance, absorbs all parts of the light spectrum except red.

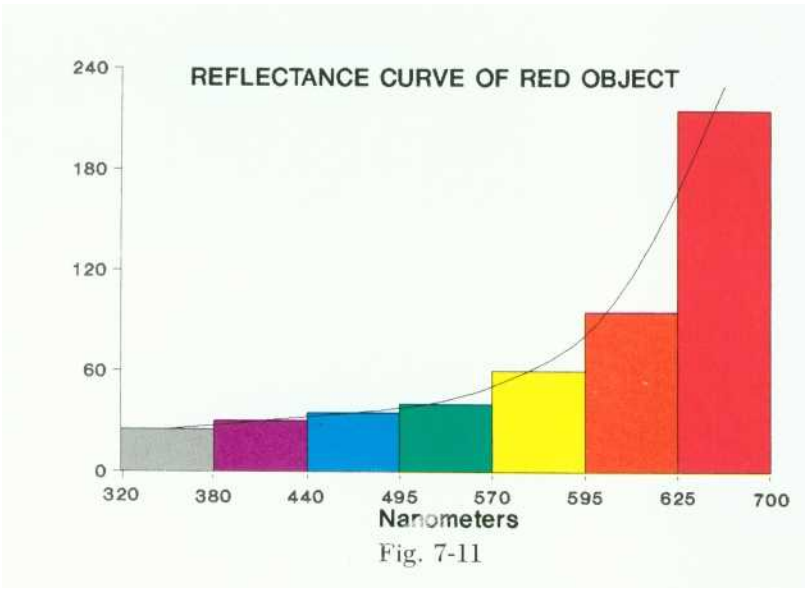


Fig. 7-11

If pigments displayed perfect efficiency, the mixture of any two primary colors would result in the production of black. If in our example one crayon absorbed all the spectrum except red, and the other one absorbed everything except blue, there would be nothing left over. Normal pigment concentrations, however, are notoriously inefficient in this regard and are almost always thinned out to create a relatively low saturation.Thus a red crayon selectively absorbs certain wavelengths, and reflects those centering around the 700 nm (red) range.

Because of our familiarity with the rudiments of this system, and because of its easy applicability to the dental situation, all of our discussions of color throughout this chapter will take place within the framework of the subtractive system of color.

In the subtractive system, when the three primary colors are arranged in the traditional color wheel, diametrically opposed colors are called complementary colors. Yellow and violet, for instance, are complementary colors. The mixture of two highly saturated complementary colors results in the elimination of color and the production of black. Since the pigments we use are poorly saturated and imperfect, the mixtures of our stains usually produce some shade of grey instead of black.

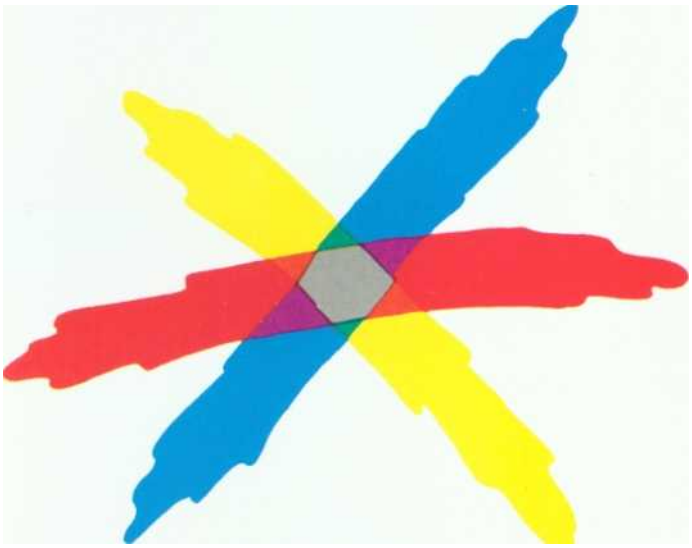


Fig. 7-12

PROBLEMS INHERENT TO MATCHING THE SHADES OF TEETH

There is a list of difficulties the dentist must overcome when trying to make a perfect match of a tooth's color. Not the least of these problems is discovering the actual color of the tooth being matched. As every dentist knows, this sounds easier in theory than it is in practice.

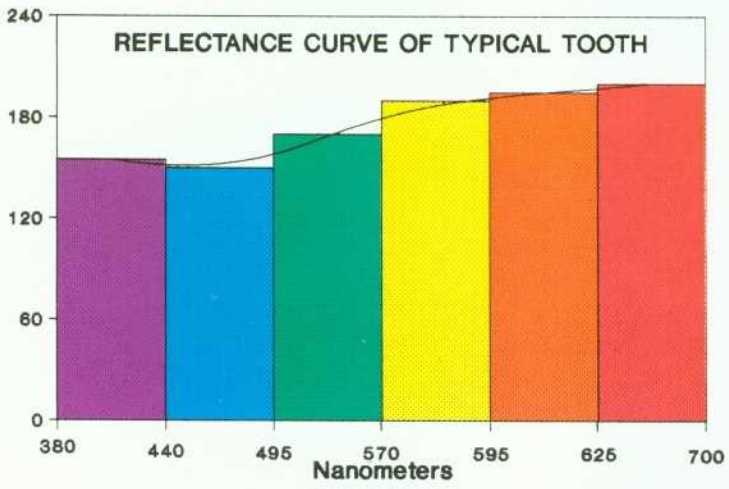


Fig. 7-13

The apparent color of a tooth will be affected by the color of the incident light. For example, in full-spectrum light a tooth might normally have a reflectance curve such as that shown here.

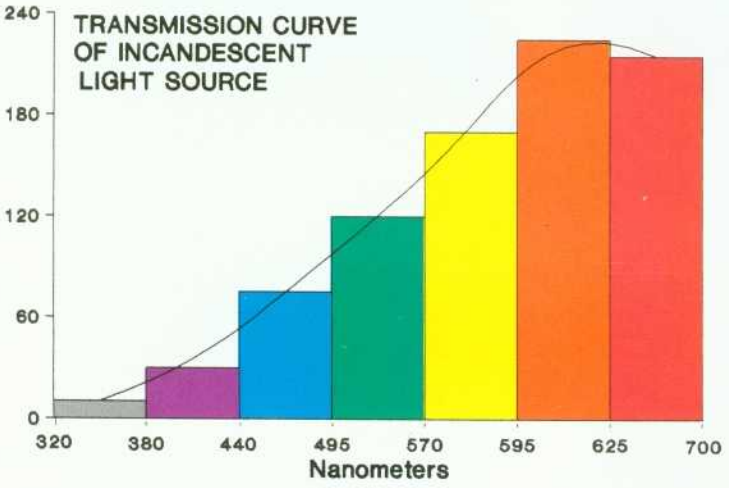


Fig. 7-14

If the source of light changes, however, the apparent color can change dramatically. Here is a normal transmission curve of a typical incandescent light bulb.

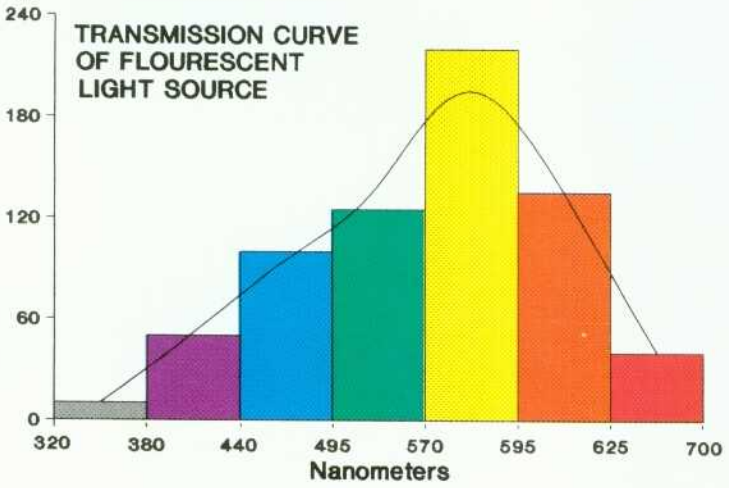


Fig. 7-15

And here is a normal transmission curve of a fluorescent light tube.

Shown here are the two different reflectance curves our tooth would display under these two different sources of light. Even with a constant source of light, the light which actually reaches the tooth can be affected by the colors in the environment at the moment. A dark shade of lipstick, or an intensely colored outfit can easily effect the available spectrum for reflection by the tooth.

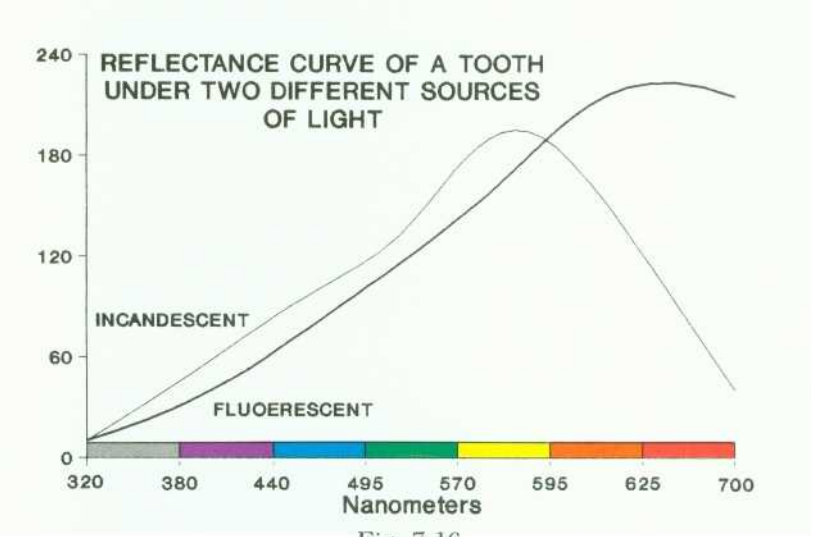


Fig. 7-16

In addition, there are variations in operator sensitivity. Color blindness is no small problem. It is a fact that nearly one in ten dentists in the United States suffers from some degree of color deficiency in the red/green areas. If other color deficiencies are also included, the percentage of visually deficient operators goes up even further. The chances of a male dentist being color deficient is more than ten times that of his female counterpart.

Incidence of color deficiency

	Incidence in Males	Incidence in Females
Caucasians		
Northern European American Australian	8.08 ± 0.26%	0.74 ± 0.11%
Asiatics		
Japanese Chinese Others (e.g., Korean, Philippino)	4.90 ± 0.18%	0.64 ± 0.08%
Other racial groups		
American Indian Mexican American Blacks Eskimo	3.12 ± 0.40%	0.69 ± 0.07%

Fig. 7-17

Fortunately, most of these operators are not color "blind" but only color deficient. Unfortunately, this means that most of them are not even aware of their handicap. In most situations, such a deficiency is of little importance, but in the case of esthetic dentistry, even minor weaknesses in color perception can compromise the intended results.

Obviously, then, it would be to each dentist's advantage to be tested for color sensitivity. Even if a minor deficiency is found, a simple solution may be to have another staff member who is not color deficient confirm all color choices.

Even when the dentist's natural color sensitivity is found to be optimal, however, there is still no guarantee he will make consistent color judgments. The eye can suffer from a decrease in sensitivity from nerve fatigue, the same as any other sensory organ. For this reason, it is important to avoid staring at the tooth and shade guides when taking a shade. Instead, short glances should be employed, with the first impression being considered the most accurate.

One other important point should be made here. During the fusing procedure, the area is isolated. If many laminates are being fused in place, the isolated teeth will have time to begin to desiccate. After only a few minutes of drying, the appearance of the teeth begins to change. The dried tooth becomes markedly whiter, and its surface more opaque.

Fig. 7-18

To demonstrate this, we took a patient with perfectly matched anterior teeth and placed a rubber dam, exposing the maxillary right central incisor for 20 minutes. When the rubber dam was removed, the difference in appearance was clearly evident.

Obviously, any shade decisions must be made while the natural teeth have not desiccated. On more than one occasion, a laminate has been placed in the mouth, and although the shade created in the laminated tooth was perfect, the neighboring teeth had lightened by the time the procedure was completed. If this is anticipated, the patient should be warned in advance that the laminated tooth will appear a bit dark for one day, but that it will match when the unlaminated teeth re-hydrate.

METAMERISM

Most evidence points to the fact that the eye is a tristimulus colorimeter. Like the color television, which is capable o£ producing thousands of colors from only three basic color phosphors, the eye can discern a nearly infinite range of color using receptors for only three wavelengths. Also like the color television, these three receptors seem to have their greatest sensitivity around the colors of red, green, and blue. While this design may be conservative for the number of required receptors for color vision, it does lead directly to the problem of metamerism.

Metamerism is the effect that is achieved when two samples of color appear to match in one type of light, but do not match in another. Simply put, the eye is incapable of distinguishing between certain combinations of light stimuli. Both spectral curves shown here are perceived as yellow-green. So under full-spectrum lighting, the surface which reflects light centered around 540 nm would be indistinguishable in hue from one which reflects two loci of reflectances with one centered around 490 nm and the other around 650 nm.

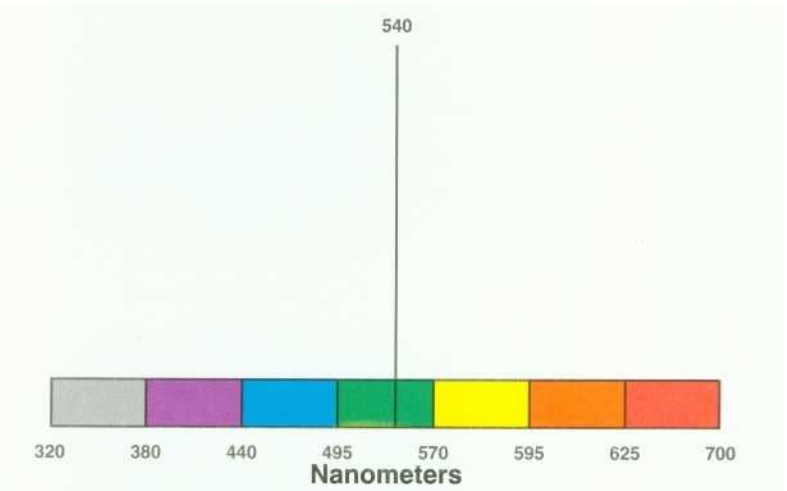


Fig. 7-19a

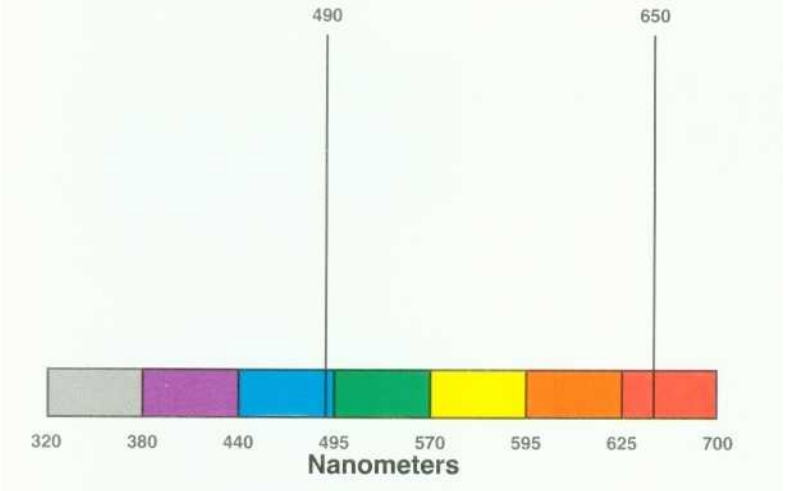


Fig. 7-19b

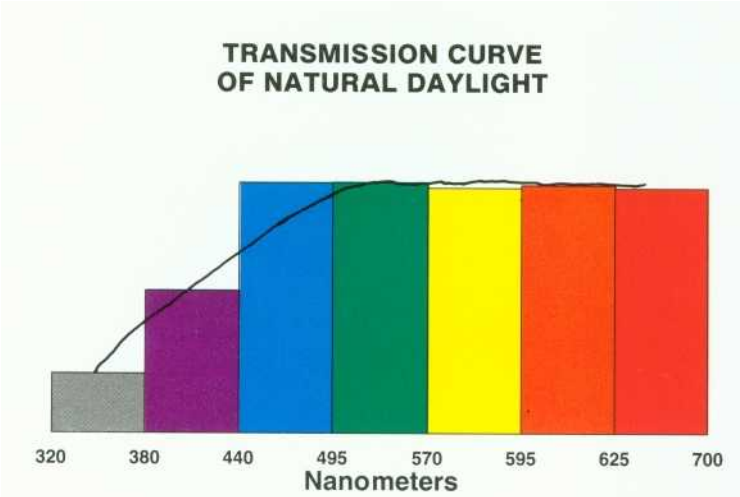


Fig. 7-20

When the lighting source changes, however, the perceived color of the objects also changes. Sunlight on an average day produces a spectral distribution similar to the illustration here.Contrast this with the curve shown on Figure 7-14 for typical tungsten light. As can be seen, when our sample is illuminated by a tungsten source, there is very little light in the 490 nm range available for reflection. When that happens, the samples no longer match. The sample represented by curve A appears red-yellow in tungsten light, while sample B continues to appear yellow-green.

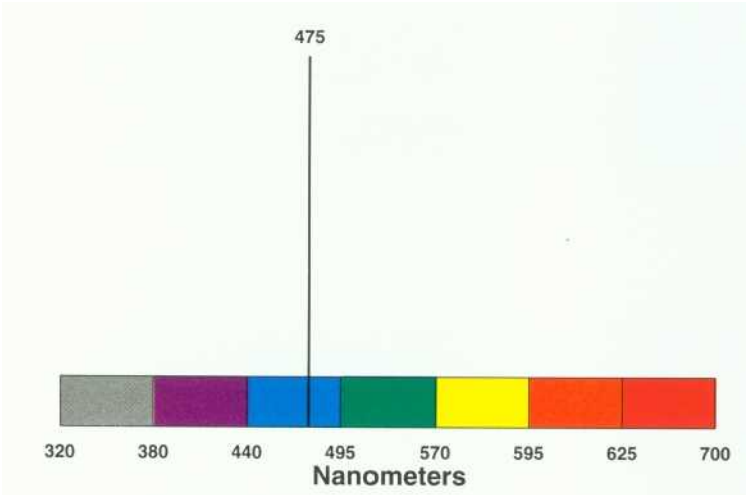


Fig. 7-21a

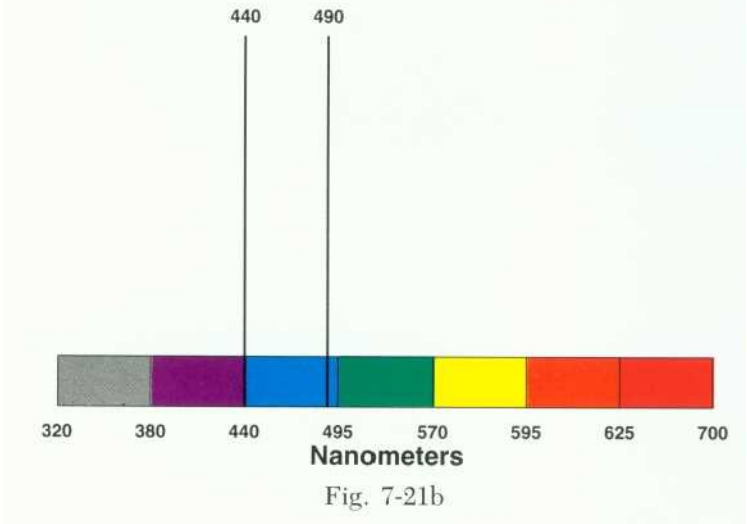


Fig. 7-21b

This example is by no means unique. A nearly infinite number of combinations can be computed which create metameric pairs. This pair, for instance, demonstrates one of the many pairs that would appear to be blue under full-spectrum light, but which would not match under other light sources. In this case, we have a metameric pair because the eye cannot distinguish between a pure blue hue at 475 nm and the combination of 440 nm (reddish blue) and 490 nm (greenish blue).

The pair shown here would be seen as yellow. Unfortunately, metamerism is a common illusion in our field. One factor that complicates this even further is the fact that our vision is most acute in the yellow color range a color range of particular importance in dentistry. In other words, not only are we unable to accurately determine a non-metameric color match, but our eyes have been uniquely designed to be most sensitive to this error in the yellow range.

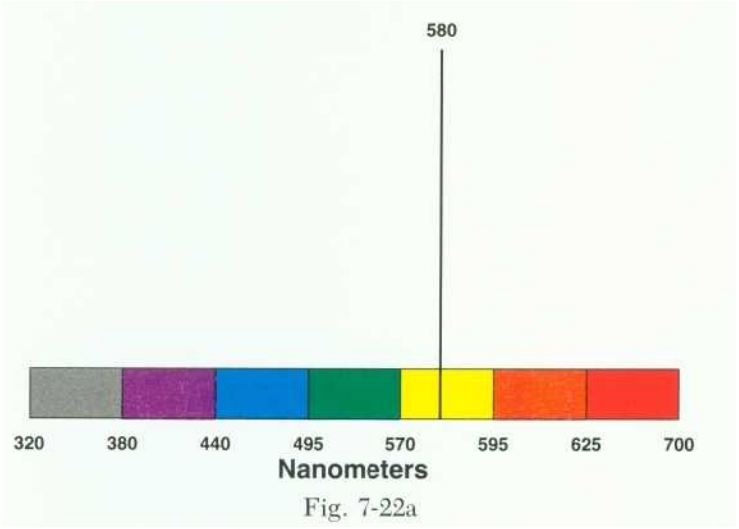


Fig. 7-22a

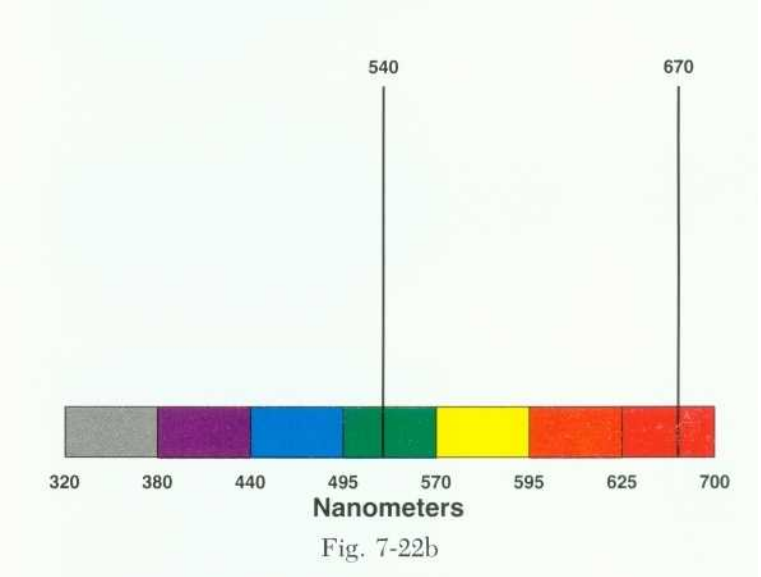


Fig. 7-22b

Fig. 7-23

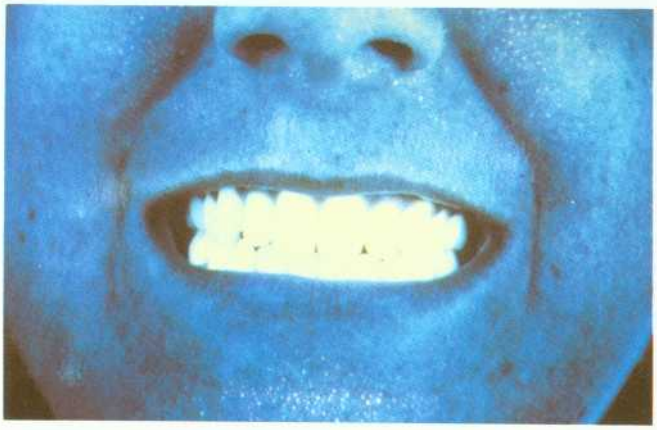


Fig. 7-24

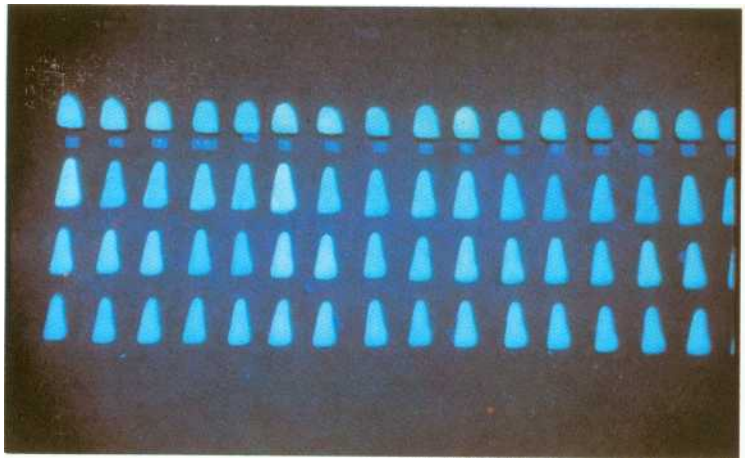


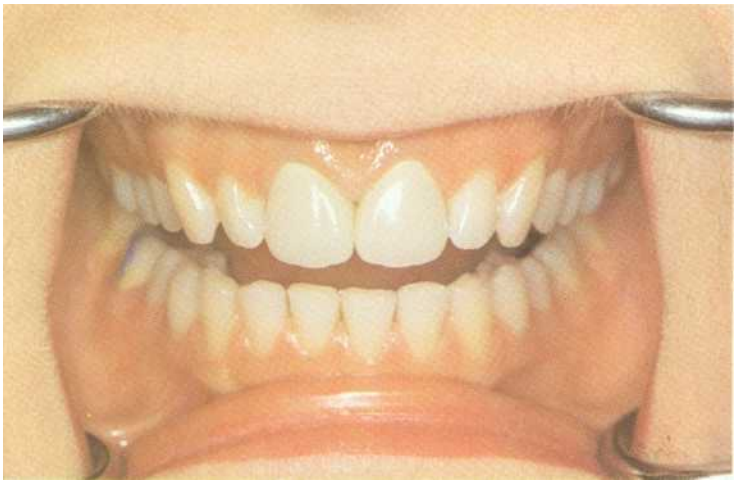
Fig. 7-25

Still another type of metameric pair can be created as a result of the fluorescent nature of teeth. It is well recognized that when natural teeth are exposed to ultraviolet light they seem to glow. Figure 7-23 shows a model under natural full-spectrum lighting. The same teeth are seen in Fig. 7-24, but this time the source of light is an ultraviolet bulb.

The apparent glow of the teeth is due to their own natural fluorescence. Early attempts to achieve natural looking fluorescence in porcelain involved the inclusion of small amounts of radium into the porcelain mixtures, but that practice is no longer used. Instead, certain fluorescing rare earths are incorporated into the porcelain.

Tooth fluorescence is not uniform across all shades. Early this century, when several dentists made a careful study of the fluorescent properties of teeth, it was noticed that certain teeth were more fluorescent than others. Usually teeth with the lighter shades were the most fluorescent. This led directly to the development of dental porcelains with variable fluorescing properties. One such example is found in Austenal's Microbond Natural Ceramic.

This figure shows the various shades of Microbond Natural Ceramic under ultraviolet light. The bottom row shows the various incisal porcelains, the next row up shows the main body porcelains, the next row shows opaquers, and the top row shows the actual shade guide used when taking shades. It is clear that an effort has been made to match the degree of fluorescence of the porcelain to the anticipated natural fluorescence of the teeth.



These findings are of direct importance to porcelain laminates. This figure shows a patient with non-fluorescent porcelain covering both maxillary central incisors. The photograph was taken in natural light. Clearly, the dentist and laboratory technician have done a creditable job of creating a natural appearance, and the match between enamel and porcelain is good.

Fig. 7-26

When this same patient is exposed to increasing amounts of ultraviolet light, however, the shade match falls apart, and the distinction between the natural teeth and those covered by porcelain becomes obvious. You can judge the quality of light in this photograph by the skin tones. Obviously the lighting used in this example could easily occur both in natural lighting, such as during a hazy day, or in man-made lighting, such as in a disco, on stage, or in front of a camera flash.

Fig. 7-27

When under extreme ultraviolet conditions, the porcelain covered teeth actually seem to turn black.

Fig. 7-28

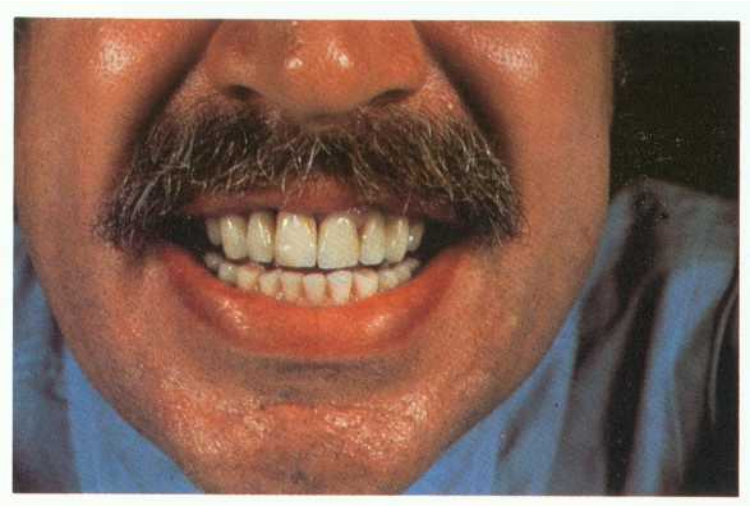


Fig. 7-29

This type of metamerism is easily avoided. When a fluorescent porcelain is used in place of the non-fluorescent one, the shade match can even carry over to situations with intense ultraviolet light. Here we see a model in natural light with porcelain restorations covering the maxillary left central and lateral incisors.

Fig. 7-30

When seen even under extreme concentrations of ultraviolet light, the shade match with the natural teeth continues. Clearly there is a distinct advantage to creating the porcelain laminate veneers out of a variable fluorescing porcelain. There also can be some advantage to using a luting agent that displays variable fluorescence.

SOLUTIONS TO THE PROBLEMS OF DETERMINING THE CORRECT SHADE

Some have suggested that the solution to perfect shade matching (i.e. eliminating the creation of a metameric pair) lies in the use of a full-spectrum light source during shade selection. Unfortunately, this is simply insufficient. As can be seen in Figs. 7-19 through 7-22, it is not uncommon to create metameric pairs which match perfectly in full-spectrum light, but which do not match when the lighting changes.

Further, even so called "full-spectrum" lights can vary in the amount of ultraviolet light produced. Once again any single source of light used during shade selection will not insure a consistent color match when ultraviolet light is present in varying degrees.

The advantage of a full-spectrum light is that with it the dentist can be sure that light from all parts of the visible spectrum are present during the shade matching. Ideally, this light can serve as a sort of median for all the possible emissive spectra from all the possible light sources. As such, it may minimize the metameric discrepancies that our patients will experience.

Perhaps a full-spectrum light, combined with a few partial spectrum lights could provide a solution. If a shade matches when under a full-spectrum light, as well as under two or three widely divergent light spectra including an ultraviolet band, then at least to a human eye it is highly unlikely that the color match will be metameric.

Another possibility is to use a colorimeter. For simplicity in manufacturing, the colorimeters in the past have mostly been of a tristimulus variety. This may seem charming at first. After all, if the colorimeter sees exactly the same way that the eye does, then it will surely be able to tell if the color match is metameric. Unfortunately, this is only partly true. A tristimulus colorimeter is only capable of measuring color in the same method used by the eye. In some light it cannot distinguish between some color pairs, while in others it will readily detect the difference. In short, a tristimulus colorimeter is fooled as often as the eye. A tristimulus colorimeter, used to take at least four readings of a shade using four light sources of varying wavelengths, including ultraviolet, might perhaps eliminate metameric pairs. Unfortunately, there is no such unit available today.

Perhaps an easier solution would be a full-spectrum colorimeter, one which can determine the exact reflective spectra of the tooth being matched. Such a machine is being developed by Bertin and Cie. of France under the direction of Dr. Francois Duret. It is designed to work in conjunction with a microcomputer.

Fig. 7-31

It consists of a portable sensor for measuring the color of teeth, a fiber optic link, a printed circuit board for an IBM PC, and software.

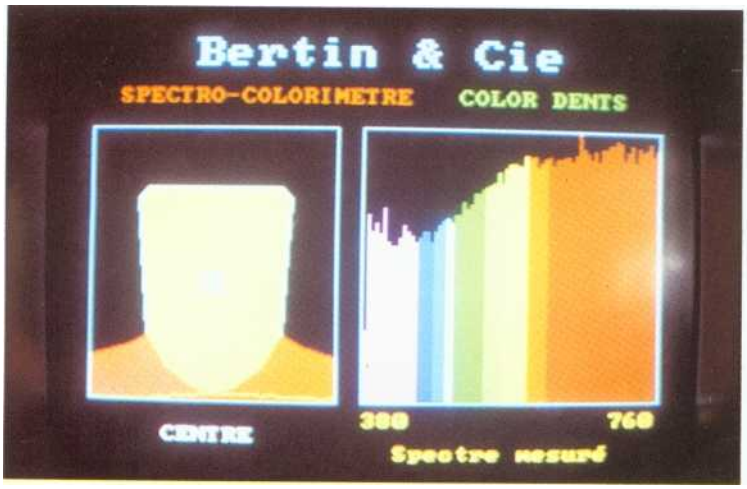


Fig. 7-32

Shade is taken by placing the sensor tip against the surface being measured while the sensor shoots out a bright flash of full-spectrum light. The computer than analyzes the reflectance and presents a read-out as shown here.

Through the computer software, a shade match is then obtained for various manufacturer's porcelains and pigments.

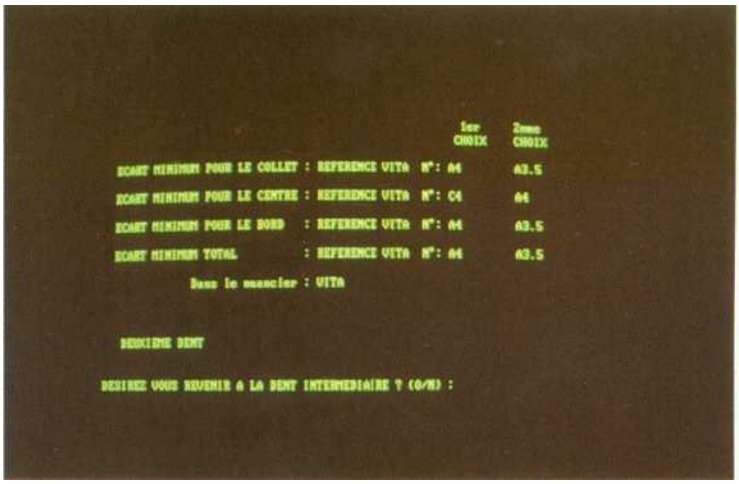


Fig. 7-33

Even this sophisticated equipment, however, does not at present analyze the fluorescence of the tooth, nor does it measure other qualities, such as the perceived translucence of the tooth. It is possible to build a machine capable of these things, but for now it is up to the dentist to become sensitive to these aspects of shading and color matching so as to best create the intended effect.

FURTHER PROBLEMS IN CREATING PERFECTLY MATCHED SHADES

Even with a perfect understanding of color and its manipulation, a few color problems still remain for the dental operator. These are centered primarily around the physical properties of the materials. Unfortunately, there are shade variations between different batches of the same porcelain, and the porcelain from which the laminates are made is usually not even the same porcelain used for the shade guide. Usually the shade guides use a high fusing porcelain, while the veneers are made from a medium fusing porcelain. In addition, there can be variations in shade between two copies of the same shade guide.

On top of this, changes are sometimes made in the shade guide, so that a given shade number one year, may be different than the same shade number in another year.' Even then, the shades the porcelain manufacturers present do not cover the full range needed to perfectly mimic the shade of teeth, often exhibiting deficiencies in the red-orange range.[2]

The problems are not confined to the porcelain, however, since it is common to have slight variations in shade between various batches of the same composite. Age also can change the shade of a single batch. Therefore, the shade numbers of composite resin must serve only as a guide to the shade of the composite contained within the tube.

Then, too, the shade of the composite coming from the tube is not the same shade it will be after it is cured. Thus if a porcelain laminate is placed on a tooth with the composite luting agent in place, and even if the shade match is absolutely perfect, it probably will not match exactly when it is cured. The following figure shows eight brands of luting composite disks that have been fully cured.

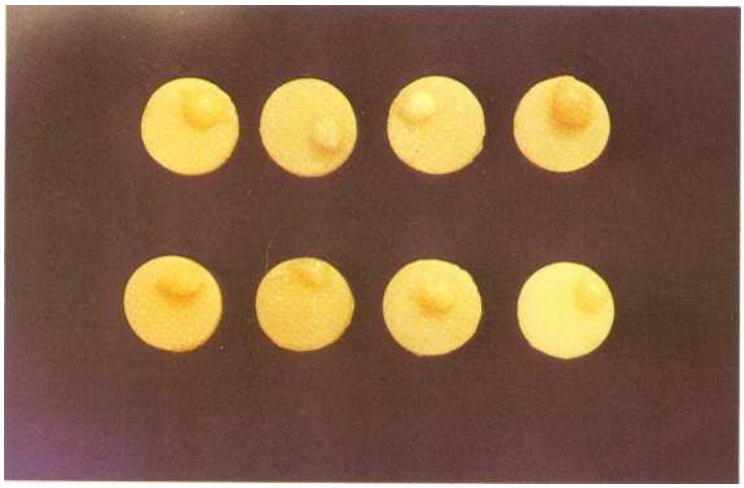


Fig. 7-34

On each disk a small amount of the original composite has been placed, but in the uncured state. As you can see, the shade change which occurs from curing is different from brand to brand not only in magnitude, but also in direction.

The result is that the dentist needs to learn the color characteristics of each material being used. Since the shade of the laminate fused into place will change during the curing process, the dentist must develop a feel for the direction and degree of change so this change can be anticipated in the shade selection of the luting agent.

CLINICAL TECHNIQUE FOR SHADE MATCHING

With all these problems, it may seem that taking an accurate shade is a virtual impossibility. Actually, the procedure is quite simple. The dentist merely needs to be aware of the potential

problems and to try to minimize their effect. Since the light source is one of the major potential problems, the dentist should try to take shades in a room free from wall coverings and decorations highly saturated with color. If the patient is wearing bright colors, they should be offset by using a relatively neutral colored apron. Perhaps the best choice would be a pale blue apron, since this color has been shown to be most restful to the operator's cones. Obviously, the patient's lipstick should be removed as well.

During shade matching, it is best to utilize several light sources to minimize the chances of metameric pairs. At least one of these sources should be "balanced" full-spectrum lighting such as the Esthelite Shade Matching Unit (Efos, Inc., Mississauga, Ontario) (Figs. 7-35, 7-36).

Fig. 7-35


Fig. 7-36

In addition, just as the incorporation of varying light sources can improve the final match, so can multiple viewers. The dentist, the assistant, and the patient should all collaborate on a final shade evaluation. Dentists must remember to remove all tinted glasses before matching colors. It also is important to note that having looked into the composite curing light, the orange protective glasses, or shields, will disrupt a dentist's color perception for quite a few minutes.

Remember, of course, that teeth rarely consist of a single shade throughout. The commercially available guides are merely that, guides to assist in the evaluation and description of a tooth's total color. Teeth should be observed on the basis of layers of color with pockets (or islands) of characterization.

The minimum evaluation should describe at least three layers (gingival, body, and incisal), each with its particular shade and specific demarcation lines. It should be noted at this time that in doing six anterior veneers, it is unlikely that each tooth will be shaded identically; the dentist should therefore take an extra moment to describe the individual shade patterns for each tooth separately though contralateral teeth may be mirror images.

CONTROLLING COLOR DURING ENAMEL FUSION OF THE PORCELAIN LAMINATE

Once the porcelain laminate is returned from the laboratory, there are two basic methods for controlling the final color of the restored tooth. One technique utilizes translucent pigment mixtures and involves a two-step system that neutralizes unwanted shades and then adds the wanted shades. The second technique is more direct and involves masking unwanted shades with opaque pigments of the desired shade. Both techniques have their place. The neutralization/addition technique is properly used when the shade of the porcelain laminate itself is not exactly correct, while the "cover-up" technique is more effective in adjusting the shade of an overly dark tooth.

Neutralization / Addition

When adjusting the shade of a tooth, knowledge of the nature of complementary colors can be extremely useful. If, for instance, the porcelain laminate appears a bit too bright at try-in, all we need to do is to paint the inside of the veneer with a bit of its complementary color.' This will have the net effect of slightly darkening the veneer.

This same technique is used for the selective removal of colors. If a veneer is too yellow, for instance, we can remove the yellow portion of its shade by adding violet.

The one thing complementary color pigments cannot do is make the shade brighter. The addition of a complementary color always decreases the total brightness of the veneer.

We also can augment the existing colors in the veneer by adding pigment on the inside of the veneer. This process is often referred to as characterization. The ability to add this color under the translucent shell of the veneer is one of the characteristics of the porcelain laminate that allows us to create restorations with tremendous vitality. Unlike conventional porcelain crowns, which have to be stained on the surface, any chairside staining will increase, rather than decrease, the lifelike appearance of the restoration.

In the following example, we have taken a set of normal shaded laminates and applied additional pigment in the intaglio.

Fig. 7-37

The pigment in this case is normal laboratory stains that have be mixed with a silane and allowed to dry. The silanated pigment is then picked up by a brush which has been barely moistened with unfilled light-cured resin. If the brush is too moist, the pigment tends to flow uncontrollably on the laminate. More commonly, premixed characterizing stains such as Porcelite Shade Modifiers (Kerr, Romulus, Michigan), or Durafill Color VS (Kulzer, Irvine, California), are used.

Fig. 7-38

Fig. 7-39

In this example, an extreme amount of pigment has been placed into the intaglio of these veneers in order to show the degree of variation that is possible using this characterization technique.

Fig. 7-40

This view shows the external appearance of the laminates after this characterization.

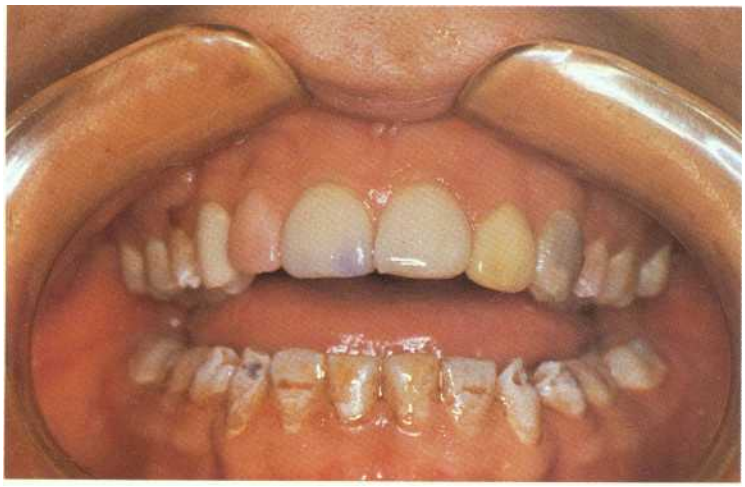


Fig. 7-41

While such a drastic change in appearance is not usually the object of our characterization efforts, this illustration dramatically shows the inherent power in this coloring technique.

Along a more practical line, let us show you the amount of staining which normal characterization involves. Here is a normal looking laminate placed on a tooth. Now let us begin to characterize it.

Fig. 7-42

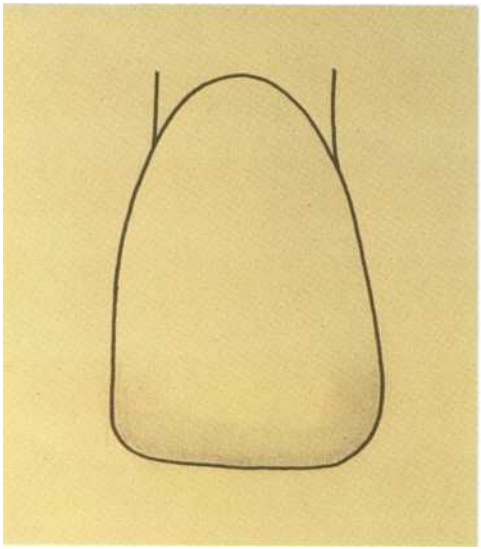


Fig. 7-43

If the dentist wanted to give the tooth a more youthful look, he could accomplished this by creating an illusion of greater incisal translucency. This is done by adding a thin band of grey along the incisal edge.

This thin band of grey is then seen through the laminate as a shadowy translucent effect.

Fig. 7-44

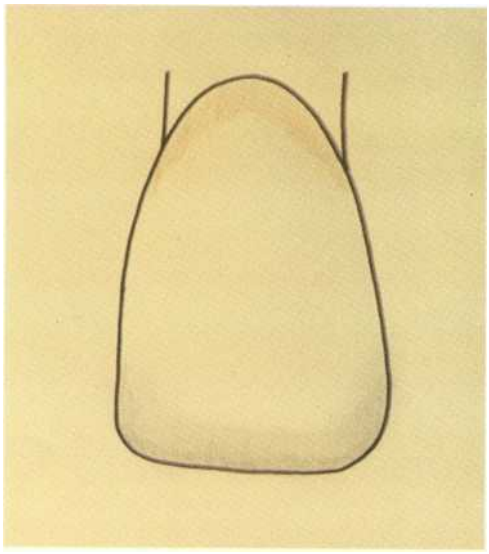


Fig. 7-45

In contrast, a look of increased age could be created through a slight increase in color at the gingival margin. This is usually a yellow or, preferably, orange band.

Fig. 7-46

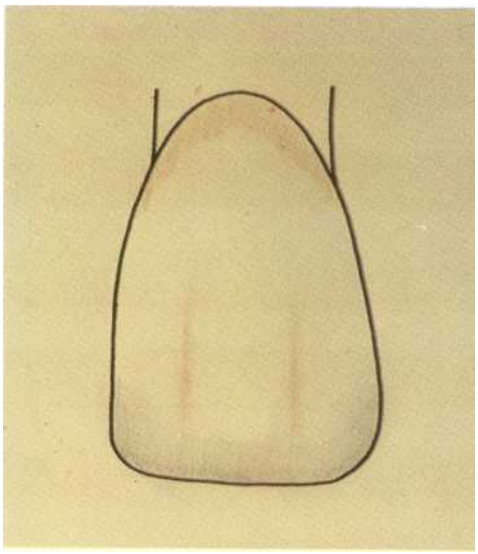


Fig. 7-47

If the facial aspect of the laminate appears too flat, it is possible to accent the variations in the thickness of the laminate by adding either grey or orange stripes.

Grey would be used if the dentist merely wanted to increase the perception of the surface contour without giving an appearance of increased age. If the desired effect was to simultaneously age the tooth, then orange or brown should be used.

If the dentist wants an increased appearance of separation between the teeth, grey or orange should be applied to the lateral aspects of the veneer. Similarly, areas that mock decalcifications, stains, cracks, and other effects can be readily created through this method.

Fig. 7-48

The "Cover-up" Technique

At times, the porcelain laminate is exactly the correct shade, and yet when it is placed on the tooth with a luting agent, the underlying color of the tooth shows through. This could be corrected with an intensely opaque laminate. The trouble with this approach, however, is that the final restoration will lack the appearance of vibrancy and vitality of enamel. A much better method is to use a translucent laminate and to cover the tooth shade with opaque composite.

In chapter 5 we have described an experiment that was used to determine the most effective method of handling this situation. In the experiment, the Type VI (double preparation) technique was employed to mask a tooth whose entire shade was vastly out of range of the desired result. A modification of this technique can be used for smaller areas that are darkened or discolored.

If a tooth is basically the correct shade, with a small but extremely dark or discolored area, two distinct methods are often employed to control the final result. Both techniques use the double preparation technique.

In one method, the tooth is prepared normally in whatever preparation type the dentist feels is appropriate. The impressions are then taken and a laminate prepared. At the time of fusing, the stained area of the tooth is then further reduced, and an opaque luting agent is used to fuse the veneer.

When this procedure is followed, the luting agent should be both opaque, and the desired ultimate shade for the tooth. Often this will mean modifying the basic set of luting composites by adding shade modifiers and opaquers. Several products have been specifically formulated for such an occasion. Kerr Porcelite Shade Modification Kit and Kulzer Durafill Color VS Shade Modifiers are examples of two such products which work well with this technique.

Alternatively, the tooth could be prepared as usual, and before the impression is taken the discolored area could be slightly further reduced. The discolored area could then be bonded over with an opaque mixture of lightly filled resin to bring the discolored area up to the value of the surrounding tooth. An impression can then be taken, and the procedure can continue.

An important thing to remember here is that it is not necessary to make the opaqued area exactly the shade of the rest of the tooth. It is more important to make it of approximately equal value because the entire facial surface will be covered with porcelain, modifying and blending everything underneath. Since the eye is more sensitive to value than hue or chroma, differences in value will be most easily seen in the finished case.

Since the eye cannot see color in dim light, it is easy to clinically separate the quality of value from that of hue and chroma. This can be accomplished by squinting the eyes until color perception is lost. At that point, any spots on the tooth exhibiting a large difference in value from the neighboring areas can be easily discerned.

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2. Sproull, R.C.: Color matching in dentistry. Practical applications of the organization of color. J Prosth Dent 29(5):556-566, 1973.
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Chapter 8 CLINICAL EVALUATION

VISUAL STANDARDS

As with any other dental procedure, specific standards must be created to evaluate our success (or failure) with porcelain veneers. It is important to remember that this field is in its infancy. Therefore both the standards that are used and the criteria for success will be in a constant state of flux. As both the technique and the materials are improved, standards will rise.

The first and perhaps most important post-operative evaluation is that of the appearance. The completed restoration must be esthetically pleasing to both the dentist and the patient, and the shape of the teeth, individually and as a group, must be in harmony with the face and the rest of the dentition. The visual impact must be one of healthy, strong, and (when appropriate) young teeth.

There should be no hint that the patient's teeth have been cosmetically restored. The balance of color should consist of a gradient of colors, from yellower gingivally to (where appropriate) blue-translucent incisally. Monochromatic teeth appear patently false. The selected color must harmonize with both the patient's skin tones and the shades of his natural dentition. The veneered teeth may be somewhat lighter and brighter in shade than the patient's natural dentition, but should fit in with his overall coloration.

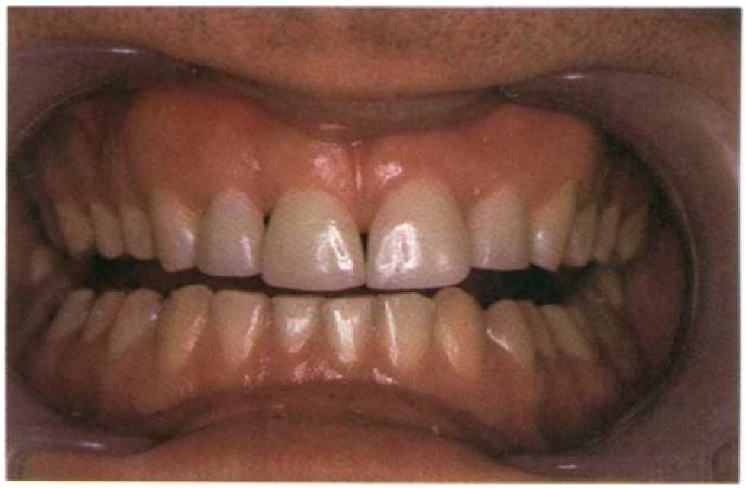


Fig. 8-1

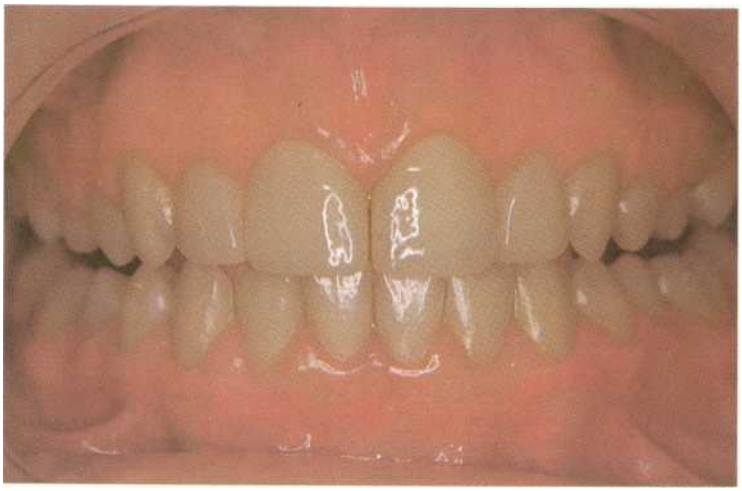


Fig. 8-2

The teeth should be as close to the ideal arch position as possible. None of the anterior teeth should appear malposed at this stage. The two sides, on either side of the midline, should correspond within narrow limits of tolerance.

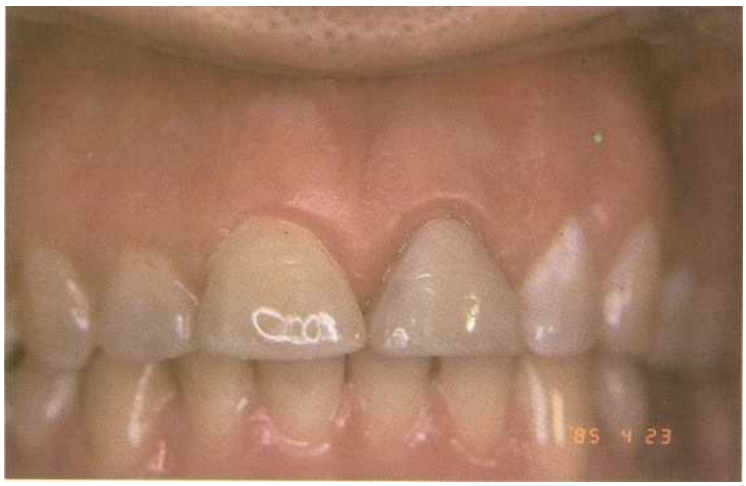


Fig. 8-3

The margins of the restorations must be invisible, not just from a front view, but also from the sides. No segments of the underlying tooth should be visible, and unlike this figure, there should not be any composite fusing material in view.

If there has been an effort made to rejuvenate the patient's smile, the plane of occlusion should reflect this; rather than a reduced flat plane, it should be a slightly convex indicator of youth.

Most importantly, the major concerns of the patient, whether they be diastemas, tooth shape, or tooth shade, must have been overcome and visually eliminated.

TACTILE STANDARDS

Our concerns with the marginal adaptation of porcelain veneers are similar to those with any restorative procedure. The most important difference with respect to most other types of restorations is that any defects can usually be quickly and easily corrected.

All the margins, whether located interproximally, gingivally, or inciso-lingually, must be flush and sealed. There can be no explorer catches anywhere. Any shoulders or ledges must be eliminated and polished to an acceptable emergence angle and confluent emergence profile. Even the slightest inconfluity in the marginal areas will allow food and bacteria to build up and result in caries, periodontal destruction, or both.

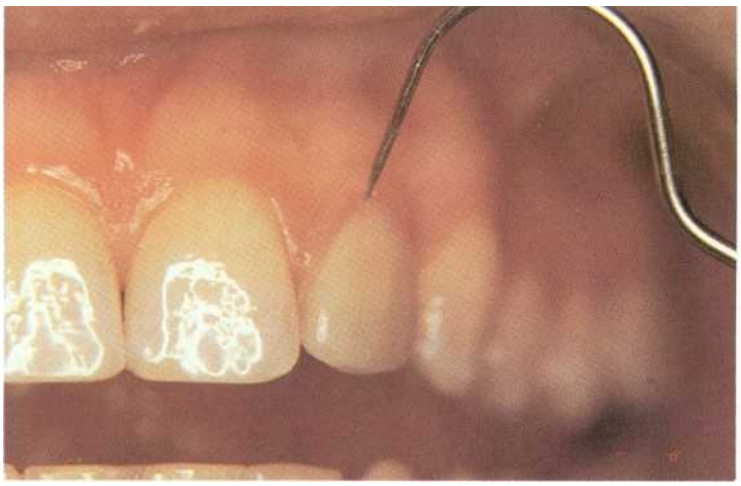


Fig. 8-4

The least visible, and hence the easiest to miss, is the lingual margin, but this is also the location of the greatest patient sensitivity. If there exists the slightest irregularity, or a miniscule gap in the bonding composite, the patient's tongue will find it and constantly return to it, causing irritation. Therefore, after the dentist has evaluated the lingual margins to his own satisfaction, he should ask the patient to make sure the restorations are comfortable to the tongue.

During placement or polishing, flecks of composite material may have lodged themselves subgingivally. These tiny pieces can greatly irritate the periodontium and within days begin to create gingival destruction. Most dentists who have done composite restorations are familiar with this type of problem. The solution is to check subgingivally with an explorer for any bonded or loose chips of excess composite and eliminate them immediately.

Some composite, furthermore, may have become attached to the labial aspect of the veneers. Often composite is found by tactile and not visual means, as its color tends to blend in with that of the veneer. Simply passing a scaler over the porcelain surfaces will identify the location and extent of these composite excesses. The scaler may be used to flick the composite off. Utilizing a sharp scaler is preferable to repolishing the area, as the latter method may damage the laboratory fired glaze of the porcelain.

Fig. 8-6

It is predictable that a sole high contact point will cause the eventual fracture of either the laminate or the natural tooth. The location of prematurities also should be identified in lateral excursive movements, even the most extreme ones, and eliminated.

The choice of structure removal for occlusal harmony is at the discretion of the operator. Each case will be different and should be judged on its own merits. As a general rule, it is preferable to remove the excess from the restoration, except when this interferes with the esthetics. In practice, the dentist often removes a small amount from both the restoration and the natural opponent.

PHOTOGRAPHIC ANALYSIS

Over the last few years, Cosmetic Dentistry has taken great strides forward. The esthetic awareness of both patients and dentists has been heightened. In the past, dentists often complained that no patient could appreciate the artistry of his skills. Today, the patient can not only see the cosmetic changes induced by the dentist, but also demands very high standards.

As appearance has become more important, the photographic recording and evaluation of dental procedures is coming to be regarded as part of the practitioner's normal armamentarium.

It is becoming absolutely necessary to have "before" and "after" records of the dental appearance for legal purposes. A patient who expresses his dissatisfaction by the means of a lawsuit has the upper hand unless the dentist can demonstrate clearly that an esthetic improvement was made. Two factors can contribute to a patient's lack of appreciation. First, he may forget just how bad he looked before treatment. Without reminders of the original state of the teeth, he may feel that the dentist's fees are unjustified. Patients are notorious for becoming accustomed to

The veneered teeth should be cleansable interproximally with dental floss. Any catch on the floss should be eliminated with finishing strips. There should be functional occlusal harmony with all existing teeth. As previously mentioned, there is no contraindication to locating contact points on porcelain, but it stands to reason that the operator will not wish to have porcelain prematurities. Its presence can be evaluated by the use of articulating paper.

If the veneers do contact the lower anteriors during protrusive movements, it is preferable that this be an even, multi-tooth relationship.

better esthetics. Second, cosmetic treatment often involves compromise. The patient who was expecting to look like a movie star and ends up only greatly improved may resent this perceived failure on the dentist's part. Should litigation ensue, the dentist's only means of protection is the photographic record.

Close-up photography (macro-photography) is also essential in self-evaluation. Just as many dentists use loupes to improve their vision in the micro-environment that is modern dentistry, so the close-up slide projected onto a wall screen affords the magnification that will reveal the smallest of mistakes. By examining his own work, each dentist can pinpoint his weaknesses in preparation or finishing, and thereby attempt to eliminate them. In this manner, the success (or failure) of shade matching, characterization, and the creation of illusion are highlighted.

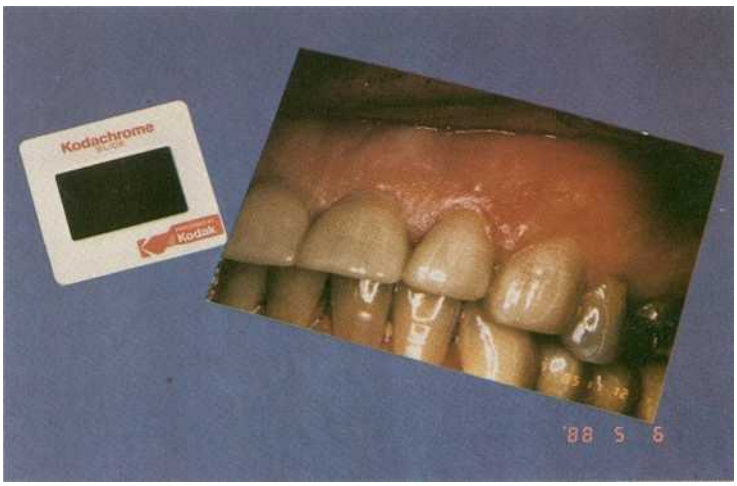


Fig. 8-7

Slides vs. **Prints**

Both slides and prints can provide a photographic record. However, because of their specific limitations, each has a definite use in dentistry.

Print film has more grain than slide film, and as a result, prints are always less sharp than slides. Well exposed slides offer more brilliance, contrast, and color saturation than can be expected from photographic prints.

Slide film has a lower tolerance for varying colors of light, and is thus able to reproduce colors more faithfully. During the printing process, colors may be partially lost or unintentionally introduced; with slides this cannot happen.

Slides can easily be blown up on a screen for presentation at lectures or for self evaluation. Due to the extremely fine grain of slidefilms like Kodachrome 64, even large magnifications are possible without distortion.

Slide film also is less expensive and easier to store than print film. Obviously, the current medium of choice for the photographic storage of dental images is that of color slides.

Standardization

The objective of "before" and "after" records is to demonstrate a changed condition. Thus it is necessary to have some standards whereby the manner of recording does not influence the observed outcome; the conditions under which photographs are taken have to be similar. Film, camera, and lighting should always be the same for comparative images. A single dentist will usually use the same camera and flash unit for an extended period. He must be sure to use the same film as well.

The developers of photographic film realize that photographs are taken under wide variations of lighting conditions. They have therefore created different types of film for varying circumstances. There is, for instance, film created for use with tungsten lighting which compensates for the uneven spectrum of color given off by tungsten bulbs. When this film is used in full-spectrum lighting, the color rendition no longer seems true.

Fig. 8-8

Fig. 8-9

The authors consider Kodachrome 64 the best standard for dental film. Manufactured under very stringent guidelines throughout the world, it is developed only by Kodak under rigorous temperature and chemical controls. Kodachrome 64 also can be used to compare work that is both geographically and temporally separated, thus providing a reliable and standardized comparative evaluation of cosmetic and esthetic dental procedures (Figs. 8-8, 8-9).

If a dentist wished to "cheat" on his slides, in order to embellish the esthetic effects of his work, he would photograph the "before" with Kodachrome 64, showing all the yellow-/brown/red staining of the teeth. Following treatment (or no treatment at all), he would photograph the teeth with Ektachrome 64 for the "after", highlighting the blue and white tones. The difference would be remarkable. The "after" teeth would appear brighter and whiter. The improvement would be due only to the red filtering effect of the Ektachrome, not any dental amelioration (Figs. 8-10, 8-11).

Fig. 8-10

Fig. 8-11

Camera and Lens

There are numerous camera manufacturers and each of them produce many different camera systems. The most ubiquitous type of system is the 35mm\ format, a logical choice for a standard format because of its extensive availability of bodies and suitable lenses.

There are several types of camera bodies, but the best ones for our purposes here fall into the "single lens reflex" (SLR) category. This mean that the camera has been made in such a way that when the user looks through the viewfinder, he is looking through the actual camera lens and sees the exact image that will be projected on the film. In addition, the ideal camera body would have an automatic exposure feature with "through-the-lens" (TTL) metering, which is coupled to the flash unit. The

flash-coupled TTL metering effectively becomes a governor system that reads the amount of light reaching the film from the subject and then terminates the flash output as soon as the film has been adequately exposed. This innovation has made dental photography much less of a mystery to most dentists, since the film exposure is fully automated.

The lens should be a good quality 100mm macro-zoom. The "macro" means close-up, and the "zoom" indicates that there are different levels of magnification available. Automatic cameras have correspondingly coupled automatic lenses; an automatic body with a non-automatic lens works the same way as a totally non-automatic system.

Fig. 8-12

Typical of this type of camera is the Pentax Dental System, although it is only one of many fine systems on the market today. This system includes the "Super Program" body. It has programmed into the body six different "modes" of operation, including the automatic capacity for interacting with the lens as well as a flash unit.

The lens shown here is the Pentax Dental Macro A100mm F4.0 macro/zoom. The "A" denotes that the lens can be coupled with the automated camera body. "100mm" is the focal length, or a measure of the ability of the lens to magnify objects. "F4.0" indicates the widest the lens can open to let in light. The term "macro" is used to differentiate between similar focal length lenses for telephoto (far away) work and macro (close-up) photography. "Zoom" is a feature that allows the dentist to change the magnification of the object without losing his focus. In other words, once a tooth is clearly sighted, if it takes up too much (or too little) of the frame, the dentist can adjust the size of the image without having to refocus.

There is a direct relationship between the size of the " F stop" number and the depth of field focused in the picture. For our purposes, we can consider that the higher the number for the F-stop, the more of the image that is in focus. This depth of field becomes most critical in close-up work, so the dentist almost always wants as high an F-stop as possible. In dental photography, a wide open lens, such as F4, will show perhaps one tooth in focus, and the rest will be blurred. To avoid this situation, a higher number F-stop, such as F11 or F16, can be used. These will put most or all of the teeth framed in the slide into sharp focus.

One way of expressing how close up a lens can take a picture is to cite the ratio of the size of the image on the film to the actual size of the object. For instance, many macro lenses of 100mm will permit a maximum image size of 1:2. On the film, the greatest dimension of the tooth will be 1/2 of the actual life size. This is good for dental demonstration, but not always adequate. The Pentax system includes add-on close-up lenses that clip onto the tip of the Al00mm lens and allow 1:1 and 2:1 reproduction ratios.

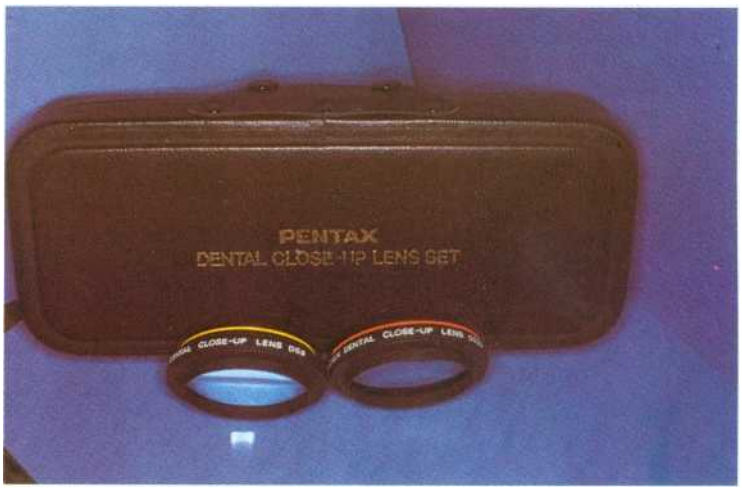


Fig. 8-13

The 1:1 is the most commonly used, but the 2:1 gives excellent close ups of margins and finish lines.

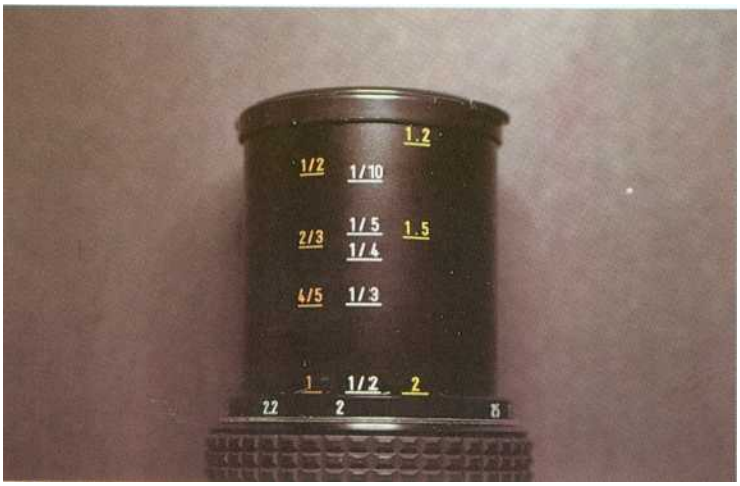


Fig. 8-14

The color coded hash marks on the top of the lens specify to the dentist exactly which magnification he is using. This is particularly handy when he wishes to create a standard magnification of a particular subject at different times.

Fig. 8-15

In normal focusing operations, the photographer sights his object, and then adjusts the lens to fit the distance. In dental macrophotography, it is the magnification that is preset, and the dentist physically moves closer to, or farther from, the object until he establishes the correct focus. Though sometimes a bit awkward, this procedure is readily learned and adaptable to each practitioner.

Along with magnification and focusing, framing is a very important element of dental photography. Obviously, the dentist wishes to avoid as much extraneous material as possible. Cotton rolls, retracting fingers, and drooping lips tend to detract from the clarity and the neatness of an image. Ideally, only relevant subject material should be included and this should be centered in the photographic frame. In practice, it is hard to isolate intra-oral subjects from adjoining structures. Therefore, we must use certain framing techniques to encourage a viewer's eyes to focus on those subjects of interest (Figs. 8-16, 8-17).

Fig. 8-16

Fig. 8-17

Fig. 8-18

In general, there tends to be a visual convergence on the center of an image. Thus the subject should be as close as possible to the center of the frame. When the dentist wishes to point out a condition of a single tooth, that tooth should take up most of the frame; this will result not only in an adequate magnification for demonstration, but also tend to exclude any irrelevant material that might hinder the viewer's attention Figs. 8-18, 8-19).

Fig. 8-19

Fig. 8-20

If a comparison is being made of opposing sides of the jaw, however, both sides should be clearly visible, and, preferably, the midline of the teeth should occur at the horizontal midpoint of the film.

Where the dentist is showing a smile comprising both upper and lower teeth, then the entire anterior segment (cuspid to cuspid, or bicuspid to bicuspid) must be visible and in focus. The intermaxillary line should be at the vertical midpoint of the image and parallel to the horizontal edges of the film. A visually tipped plane of occlusion does not compliment the esthetics. The means of retraction, whether with fingers or plastic labial expanders, do not form part of the necessary picture, and thus should be eliminated.

Fig. 8-21

The "zoom" is especially handy for this aspect of intra-oral photography; if there is too much peripheral material, the dentist needs simply to move in and thus narrow the field of vision of the camera. When the visual coverage is inadequate, one can easily "zoom" out to pick up more perspective (Figs. 8-22, 8-23).

Fig. 8-22

Fig. 8-23

Flash Units

Now that we have a means to record an image and the standards whereby such a slide is comparable, we still have one problem: illumination.

The oral cavity, as every dentist knows, is inherently dark. The only way to ensure that the resultant images are bright and clear is through the use of flash units.

In regular photography, a single light source flash unit is commonly used. While the illumination is adequate, certain shadows will appear, depending on the source direction. Shadows are often desirable in portraits, but usually not in dentistry. Some manufacturers have added a second light source to the apparatus. When these are properly deployed (at 180 degrees to one another), they can eliminate most of the shadowing, but not all.

Fig. 8-24

The best flash for dental photography is the ring flash. This apparatus, which is usually placed at the tip of the macro lens, gives off a truly circular, 360 degree illumination. All the potential shadow areas are eliminated and a clearer, more objective, image is produced.

At other times, such as in full-face photographs, some shadowing is desirable in order to eliminate a flat, featureless look. Thus many dental flash units combine a ring flash with a standard flash unit, with a switch to choose which unit is to be used at any given time.

Both flash units should be of the thyristor type, so if less than the full charge is utilized, the remaining energy can be applied to the subsequent recycling sequence. This feature provides a much quicker re-energizing phase and longer lasting batteries.

Both the flash unit and the camera should have compatible coupled TTL monitoring systems. Rather than rely on the older trial and error method of devising proper illumination, or on the elaborate calculations based upon film speed, lens aperture, and background light, coupled with the technique of "bracketing" (taking 3 or more slides of the same situation to ensure that at least one of them would be correctly exposed), the dentist simply presses the shutter release, letting the camera microchip read the light entering the lens. This control will automatically cut off the flash as soon as enough light has reached the film plane. As a result, a dentist can expect to achieve close to 100 percent success with his exposures, whereas 50 percent would have been considered an enviable situation not long ago.

Intraoral mirrors

From time to time, one would like to capture on film a view that is not visible directly to the outside observer such as the buccal and lingual aspects of molars, and the linguals and incisals of anteriors.

Fig. 8-25

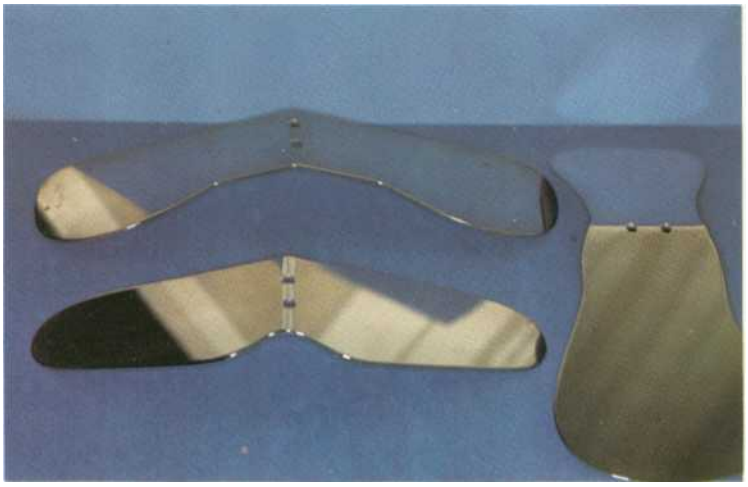


Fig. 8-26

Various sets of intraoral photographic mirrors are manufactured to assist the dentist faced with this problem.

Fig. 8-27

With practice, the practitioner can become adept at utilizing these to capture interesting, but not readily visible, conditions.

Instant Dental Photography

Not all dentists are inclined to become involved with 35mm photography, and for this group of practitioners, an instant system might be suitable for legal protection. The quality of the prints of an instant camera and film are not as diagnostic or as detailed as 35mm prints, but because they can be ready in one minute, they can be an invaluable part of the dental photographic process.

The role of the instant photograph in Cosmetic Dentistry is more geared to internal marketing and patient education than to personal or peer evaluation, or presentation and publication. These prints are easily made in the dental chair prior to and immediately after cosmetic treatment. They are then often given to the patient. In the aftermath of a positive esthetic dental

procedure, the patient may show his friends the change and underscore the description with "before" and "after" photos. The marketing value of this type of photographic testimonial can hardly be overestimated.

For the dentist, taking instant photographs is much easier than pulling the appropriate slides, having them printed, and then forwarding them to the patients. Besides, by the time this cumbersome procedure is completed, the patient will be accustomed to his improved appearance and less likely to show the pictures to his friends.

Unfortunately, the instant photography field has historically been more in tune with family snapshots than with dental close-ups. Recently, however, a number of different products suitable for dentistry have come on the market.

Now there are several complete dental units available. One that gives consistently lifelike results is the Polaroid CU 5 (Polaroid Corporation, Cambridge, Massachusetts).

Fig. 8-28

The CU 5 consists of a camera body, a 75mm lens/shutter, an electronic ring flash (with a power pack that recycles in about 5 seconds), and magnification multipliers. The regular CU 5 body achieves a print size:tooth size ratio of 1:1. With the addition of a magnification multiplier, the ratio becomes 2:1; that is, the apparent size of the teeth on the print is two times their actual size.

The use of the CU 5 is very straightforward. The appropriate plastic anterior extension is placed against the patient's chin, the camera is centered, and the photo taken. Both the exposure and the focusing are predetermined, thereby eliminating any guesswork. The flash functions automatically, but the output can be modified if necessary. Auxiliary staff can be readily trained to use this system.

The only difficulty lies in the process of framing. The operator does not see the image that he is photographing (as in SLR cameras) and thus has to guess the angulation and left-right orientation of the unit. With practice, this uncertainty is minimized. In any case, since the print is ready within one minute, the dentist can easily retake an exposure that he does not consider adequate.

These prints also can be used to enhance laboratory prescriptions. When appropriate, by giving the technician a visual interpretation of the the pre-operative condition, the dentist can improve his communications.

Fig. 8-29

The unit was designed to be used as a planning and communication tool. In the normal mode of operation, a still picture of the patient is taken using the video camera and the image is sent to the color monitor. Once on the screen, the image can be manipulated in many ways. Spaces between teeth can be filled, teeth can be lengthened or shortened; tooth shade can be changed; teeth added or removed. In short, any esthetic changes the dentist or patient can imagine can be shown on the screen. The images can then be printed on paper or even saved on a disk for later recall.

ELECTRONIC IMAGING

Recently, yet another "high tech" instrument has entered the field of cosmetic dentistry. Known as an imaging computer, it can be used to help plan and communicate projected cosmetic changes. The basic unit consists of a video camera and a digitizing pad connected to a desktop computer. Often the unit also comes with a printer or an instant camera.

The changes are made using a digitizer, which is a sort of electronic sketchpad. It looks like a thick plastic clipboard and is connected to the computer by a wire. In its simplest function the dentist "sketches" on the pad using an "electronic pen", which looks like a pen with a nylon tip at the writing end and a wire coming out of the top. Wherever the "electronic pen" touches the digitizer pad, a corresponding area of the monitor screen is drawn over. Thus the "pen" acts as a paintbrush painting the video screen.

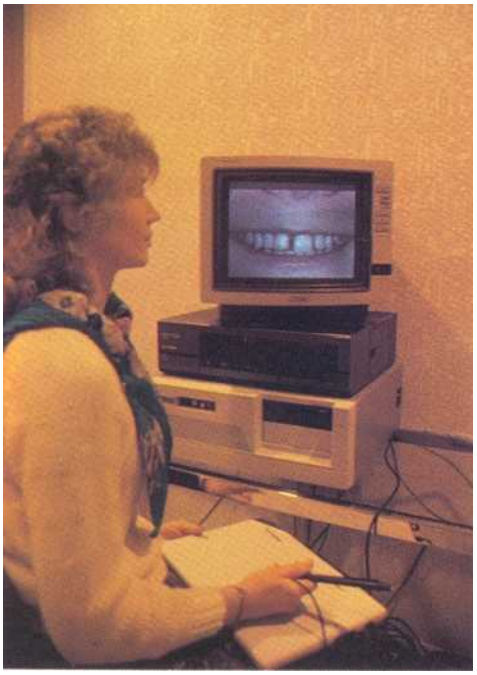


Fig. 3-30

Colors can be chosen from a virtually unlimited supply. A common configuration allows over 16,000 different shades to be used, although if the dentist prefers, the choices of color can be condensed into those of any given standard shade guide. These colors can be painted over the image in opaque or translucent layers.

The machine is much more than a mere paintpad. While it is capable of painting over the image on the screen with different types of "brushes", ranging from opaque solid to a "spray paint can" of translucent water color, the program also allows much more sophisticated things to be done with the image. For instance, portions of the image can be modified to widen teeth in order to fill in gaps. Individual teeth can be rotated on the screen, or "orthodontically" moved. Multiple images can even be overlaid, allowing the dentist to put the teeth of a celebrity, for instance, into the mouth of his patient.

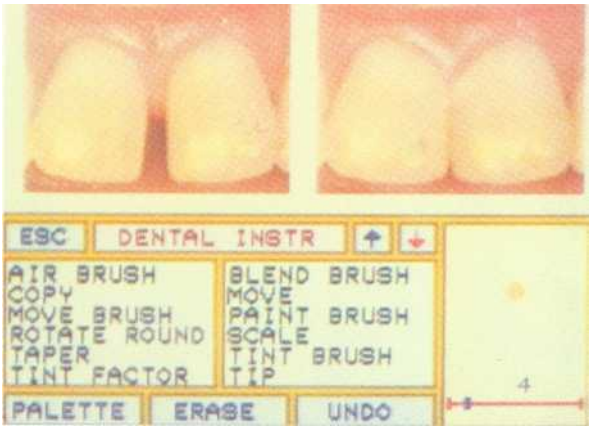


Fig. 8-31

Fig. 8-32

He can also superimpose x-rays over a picture of the patient.

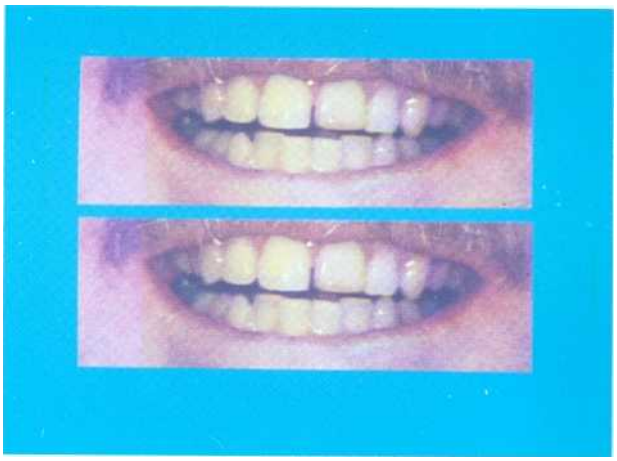


Fig. 8-33

Here is an example of a sophisticated application of the equipment using the PreView system (InstruMed, Carpintaria, Calif.). In this example, we are going to show one of the ways that the computer can close up a patient's diastema. First, a "before" picture is taken of the patient's teeth.

Fig. 8-34

Using one of the computer's built in functions called "taper polygon", a polygon shape is superimposed on the screen around the narrow central incisor.

Using the sketchpad, the polygon is moved to exactly outline the tooth (Figs. 8-35, 8-36).

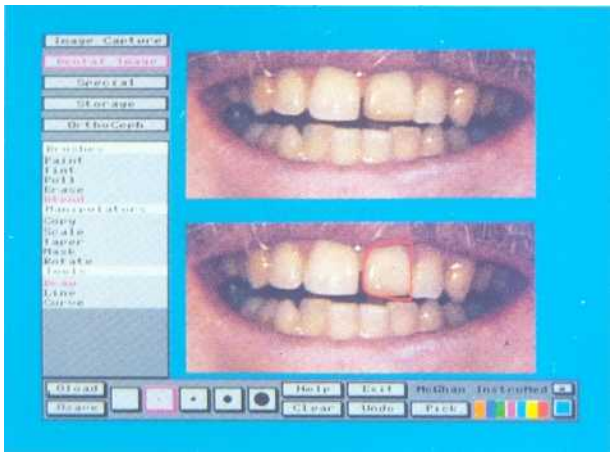


Fig. 8-35

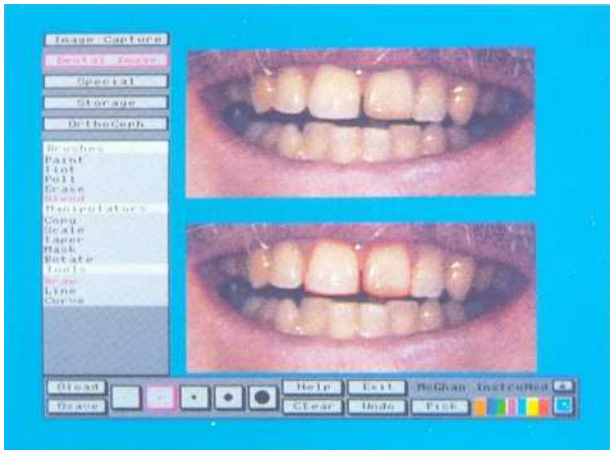


Fig. 8-36

Then the same method is used to move the polygon to the shape the dentist desires ...

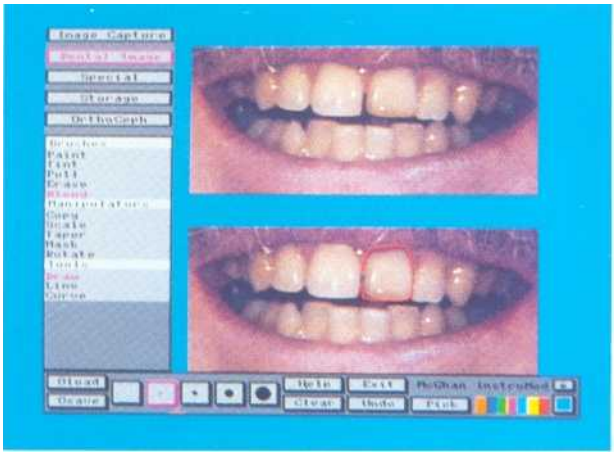


Fig. 8-37

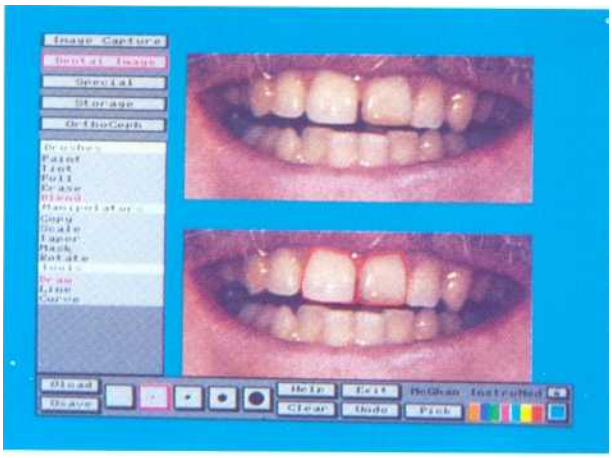


Fig. 8-38

and the computer automatically changes the shape of the tooth to the new outline (Figs. 8-38, 8-39).

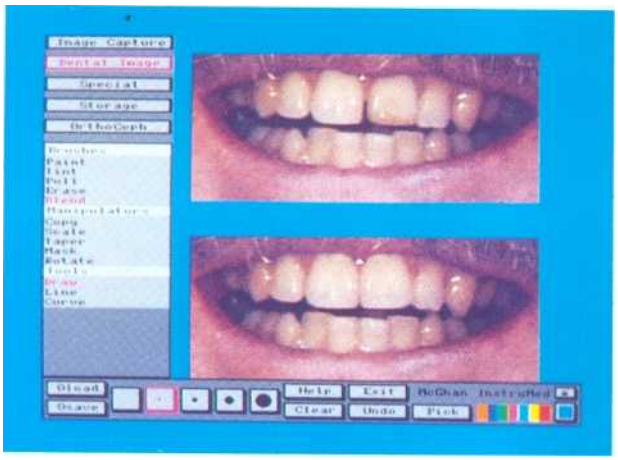


Fig. 8-39

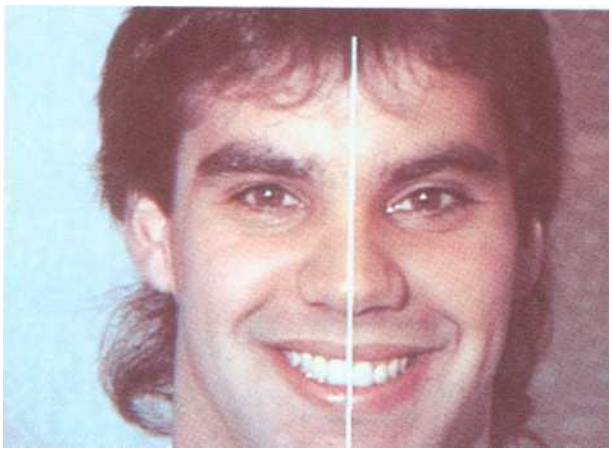


Fig. 8-40

Naturally, it is easy to zoom in on any portion of the image to see the fine details, and then zoom back again. Marking facial midlines, demonstrating the golden proportion, bleaching teeth, making darkened fillings match the teeth, and virtually any other feasible esthetic consideration can be demonstrated and visualized on the screen, so patients can easily appreciate any limitations of treatment before the work is performed.

In short, using the computer, it is possible to show the patient whatever changes the dentist has in mind before the procedure is undertaken. Perhaps more importantly, the patient also can clearly communicate the changes that *he* has in mind. This allows a more complete communication than ever before. In this way the patient's expectations can be aligned with procedural reality.

In addition, the cosmetic dentist can include information during the consultation regarding the use of make-up to maximize the effect of the teeth. On the screen, various shades of make-up can be applied and removed without ever touching the patient. The patient can, for example, see the apparent tooth shade changes that occur by simply changing lipstick. The patient also can see how other facial distractors can be minimized, and thereby highlight the full beauty of their smile.

Using the same instrument, it also is possible to create side-by-side comparisons of various appearances. The screen can easily be split into two or more sections. Often this technique is used to create before-and-after pictures of the suggested changes so the patient can appreciate the full impact of the anticipated changes.

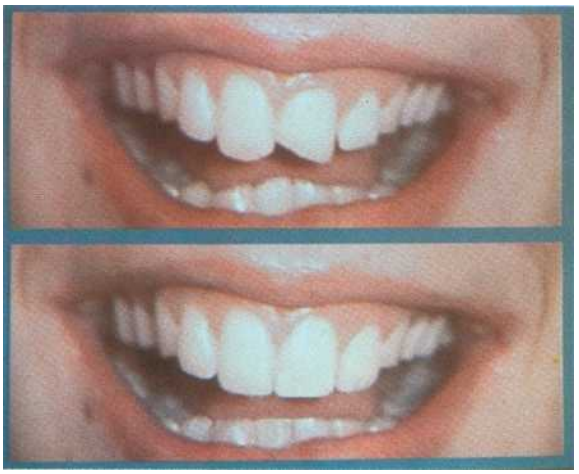


Fig. 8-41

With an attached printer, whatever is shown on the screen can be printed into a Polaroid quality print in less than a minute. It also is possible to combine the actual "before" picture with one that is taken after the completed treatment, as shown here. This can then be given to the patient or placed in the patient's chart as part of his permanent record.

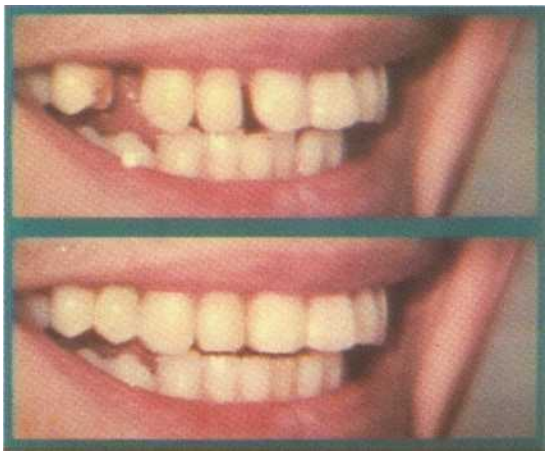


Fig. 8-42

The major limitation of the video imager comes about because it provides only a two-dimensional image. It cannot be used, for instance, to indicate to the dentist the limits of enamel reduction, or to automatically demonstrate the effect of the rotation of a tooth. It also will not give the dentist or patient an appreciation of the thickness of the teeth after the bonding procedures.

Sometimes a given view of the patient will obscure certain details that are extremely pertinent to the treatment plan, but this is not usual. It also is possible to do things on the screen that are impossible in real life. It would take little effort, for instance, to place a third eye in the middle of the forehead. The operator must, therefore, be constantly aware of what is possible in reality, making sure he does not overstep those limits.

Still, even with these limitations, it is usually possible to quickly see how good or bad a given treatment plan is without having to go through the mess of working with wax on a plaster model. In fact, in less time than it takes to take and pour an impression, the entire procedure can be finished with the imaging machine.

This has great implications for time planning, since it essentially allows the dentist to accomplish the entire data acquisition, analysis, planning, and consultation, all at the same visit something simply impossible by any other means.

Chapter 9 Advanced Clinical Considerations

CREATING ILLUSIONS

Many times the underlying tooth structure or the existing spacing is such that porcelain veneers cannot adequately create an esthetic smile. In these cases, various illusions can be of great assistance.

The teeth most commonly requiring the use of esthetic illusions are the anteriors. Since their perceived appearance is greatly dependent on the light reflected by the labial surfaces, their visual width and length can be modified by altering the quality and direction of these reflections. Due to their different shapes and angles of presentation, each of these teeth must be modified in its own individual manner.

Illusions in the Mesio-distal Dimension

The central incisor. The central incisor is the most prominent tooth in the mouth. Even slight discrepancies of size and shape will skew the total facial appearance of the patient. It is particularly challenging to match a porcelain veneer on a single central incisor with an adjoining natural tooth. As with full crowns, in many cases both centrals should be treated simultaneously to obtain the best results.

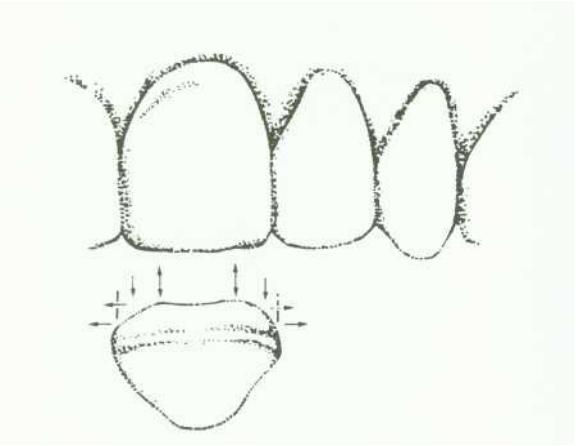


Fig. 9-1

Examination of the labial anatomy of the central incisor reveals two developmental grooves (lines) that run inciso-gingivally and that divide the tooth into three usually equal sized lobes. These lobes are rarely obvious as individual entities, though they do form an integral part of the overall presentation of the tooth. When noticeable, they are most prominent at the middle third of the labial surface.

To narrow the appearance of the central incisor, the developmental lines should be moved closer together. This decreases the amount of light reflected directly back at the observer (due to the lateral angulation of the tooth structure between the interproximal contact point and the developmental line on the ipsolateral side). In fact, the angulated contour of the proximal surface tends to deflect light, making this part of the tooth appear darker. This change serves to make the tooth appear more narrow since darker areas of tooth structure are usually perceived as being smaller than their true dimensions.

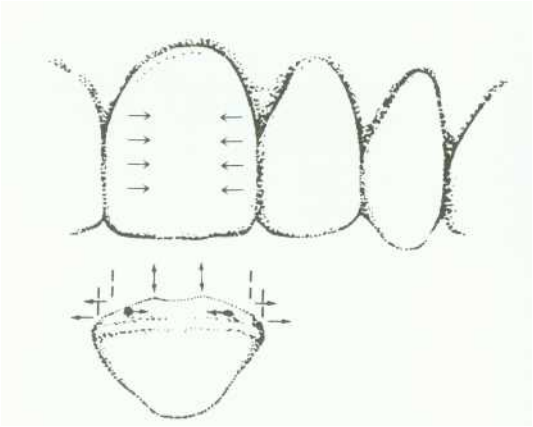


Fig. 9-2

The developmental lines can also be accentuated further toward the gingiva than usual to increase the "long" appearance of the central and to add further to the illusion being created.

Where the central should be widened, just the opposite needs to be done. The developmental lines, and hence the lateral prominences, should be more widely separated.

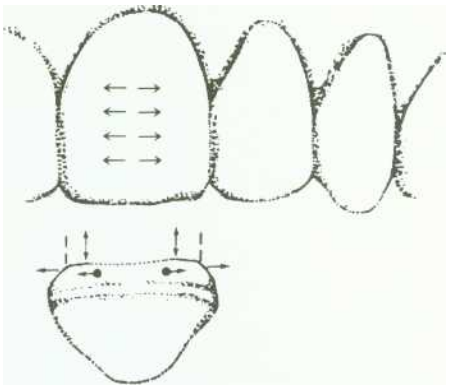


Fig. 9-3

The creation of a relatively flat central area will increase the amount of light reflected directly back at the observer and this, in turn, will give the illusion of increased width of the tooth. The angulated proximal surface will be concomitantly decreased in width, and therefore less light will be deflected laterally. The proximal area will appear brighter and thus larger. To further highlight the mesio-distal bulk of the tooth, the developmental lines should be shortened and restricted to the middle third of the labial surface.

The lateral incisor. There is generally a greater acceptance of size variability of lateral incisors than central incisors in dental esthetics. Still, the dentist must on occasion deal with esthetic illusions for this tooth. One common situation calling for esthetic illusions of the lateral incisors is found where a patient has a very square face and large teeth and the lateral incisors are similar to the central incisors in actual size .

It should be noted that when viewed in sagital section, the labial aspect of the lateral incisor generally has more curvature than that of the central incisor, and there usually is a distinct absence of developmental lines and prominences. Also, because of the roundness of the arch, the lateral incisor is usually not facing directly forward, but is slightly rotated relative to the central incisor.

The seeming width and length of the lateral incisor can be effected using the same techniques as for the central incisors, with the additional aspect of rotation to simplify the job. To narrow the appearance of a lateral incisor, we often wish to increase the rotation in order to deflect more light away from the

observer. To widen the lateral incisor, the labial surface has to be made to seem flatter or at right angles to the observer, and thus more reflective. This illusion can be accomplished by creating a slight decrease in the degree of rotation relative to the central incisors.

The cuspid and bicuspids. The labial surface of the cuspid is smooth and rounded. Crisp developmental lines, if visible at all, are faint and of little concern or use in the fabrication of veneers. There are, however, three developmental lobes, and the middle lobe is by far the largest. This produces a ridge on the labial surface (the labial ridge), slightly to the mesial of the vertical midline of the crown. Distal to the labial ridge, in the cervical third of the crown, there is often a concavity. It is the absence of this concavity that often gives cuspid veneers a "boxcar" appearance.

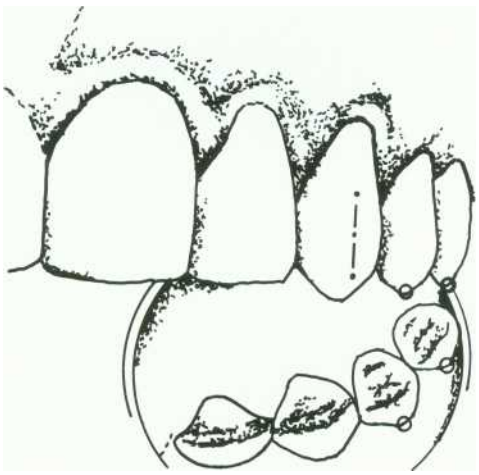


Fig. 9-4

The cuspid normally presents only its mesial aspect to the frontal observer, although people with wide smiles and/or high lip lines will exhibit the entire surface to view. Thus, while we are primarily concerned with the esthetics of the mesial portion of the cuspid, the distal can contribute to, or detract from, the overall cosmetic value of a restoration.

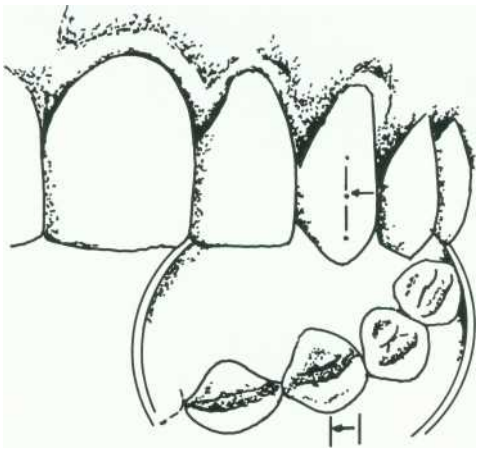


Fig. 9-5

To narrow the appearance of a cuspid, the labial ridge should be moved mesially, thereby reducing the mesial proximal area. The decreased reflectivity of the diminished area will make the cuspid appear smaller. Since the proximal area is almost completely perpendicular to the observer's line of vision, it is difficult to change the angulation and thus cause light deflection. Therefore, the entire illusory process depends on the reflective surface area caused by manipulating the position of the labial ridge.

If there is a need to visually widen the cuspid, the labial ridge is placed more to the distal. This step increases the area available for light reflection on the mesial proximal surface, thereby magnifying the apparent size of the cuspid.

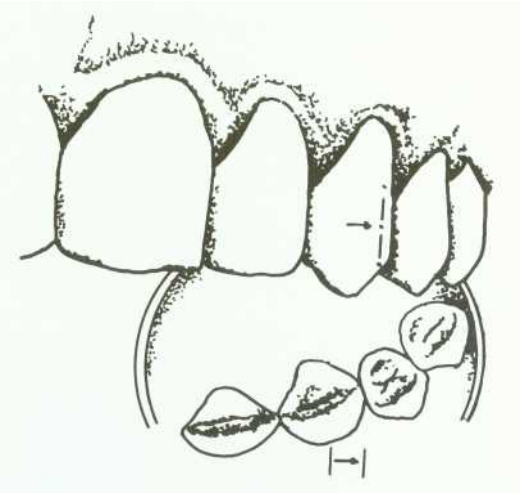


Fig. 9-6

The distances that the labial ridge should be moved are very minimal, as even half of a millimeter in either direction will greatly influence the perception of the size of the cuspid.

When veneering the bicuspids, a similar technique can be used to increase or decrease the apparent tooth magnitude, but in observance of the lesser frontal visibility of these teeth, even less displacement of the labial ridge is required.

Illusions in the correction of the labial silhouette. In general, the accepted frontal view of cuspids and bicuspids indicates that the labial surfaces of these teeth are parallel. Rotated or malposed teeth can destroy this harmony and reduce the esthetic value of a person's smile. On occasion, inadequate veneer planning will create cuspids that are well related to the anteriors, but in total disharmony with the remaining posterior teeth. In extreme cases, this can give the patient an edentulous appearance distal to the cuspids.

The laboratory, and ultimately the dentist, must ensure that this does not occur. The laboratory will therefore require impressions extending at least two teeth beyond the most distal veneer. The dentist should check for parallel silhouettes both on the model and intraorally.

If a bicuspid is in a lingual position in relation to the arch, it is a relatively easy procedure to ask for a thickened veneer that will restore the ideal outline. The same tooth in buccal version raises a different type of problem. It might be easier to restore the other teeth to correspond to the one in slightly incorrect position, or perhaps there could be some labial reduction required of the tooth in question. The decision must be made by the practitioner in each individual case based upon clinical factors and the underlying concept of maximal tooth conservation.

Illusions in the Inciso-gingival Dimension

The visual length of a tooth is as important to its appearance as its visual width. The apparent length, too, may be manipulated utilizing light reflection. In this type of illusory procedure, the technique for all the anteriors is essentially the same, and thus will be discussed together.

In order to shorten a tooth, we must reduce the amount of reflected light that reaches the observer. There are several means of achieving this.

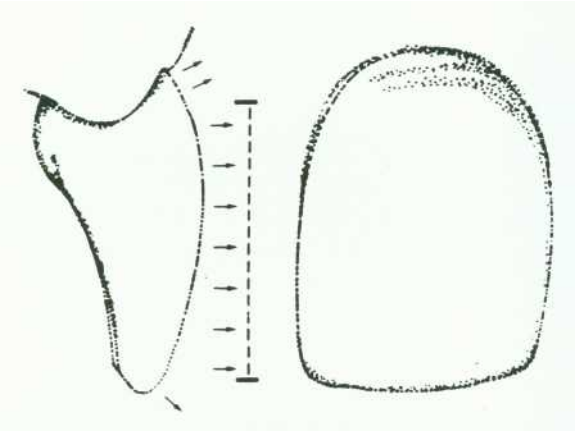


Fig. 9-7

The labial contour of an anterior tooth exhibits a certain roundness.

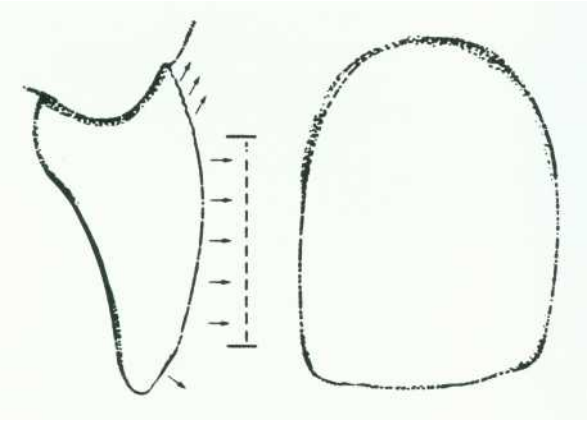


Fig. 9-8

The more accentuated this roundness, the more the gingival and incisal portions of the enamel (or porcelain) are likely to deflect light rather than reflect it. The less labial surface available for the direct reflection of light, the smaller the tooth will appear. Therefore, placing the inciso-labial angle (the line nearest the incisal edge where the curvature of the labial surface takes a more pronounced lingual direction) further from the incisal edge tends to shorten the appearance of the tooth.

Similarly, locating the gingivo-labial angle (the line nearest the gingival margin where the labial curvature becomes more lingual) further from the gingival margin has the same effect as placing the inciso-labial angle further from the incisal edge.

Teeth occasionally have faint gingivo-labial grooves called perikymata. These wavy structures have the effect of deflecting incident light in every direction, thereby darkening the gingival third of the tooth. This darkening decreases the apparent crown length and can be used very successfully in creating the shortening illusion.

The flattening of the incisal edge of an anterior has the effect of making it more square in appearance. This squareness tends to focus the observer's eyes into the middle of the tooth, also imparting an illusion of decreased length.

It is more common, however, to desire that the maxillary anteriors appear longer. Generally, longer incisors, particularly central incisors, are indicators of youth. (It is not to be inferred from this that areas in which periodontal surgery has exposed root surfaces and made the teeth inordinately long are esthetically desirable; what is being described here as the ideal is the unworn, posteriorly supported, appearance of the late teens or early twenties.)

In increasing the apparent length of incisors, the light-reflecting area must be maximized. The inciso-labial line should be placed as close to the incisal edge as possible, and the gingivo-labial line must be located as far gingivally as the dental conditions allow. This positioning will effectively reduce the labial curvature, directing more reflected light at the observer, and increasing the apparent size of the tooth.

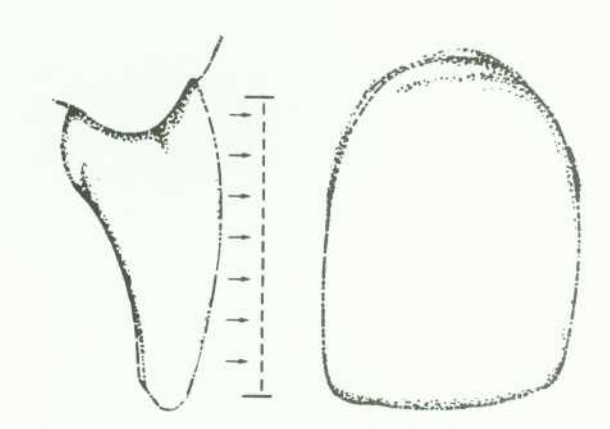


Fig. 9-9

Minimizing or eliminating the perikymata also tends to create the illusion of greater length. A smoother gingival third is therefore desirable in the lengthening illusion.

Lengthening the middle third of the incisal edge and rounding the proximo-incisal angles slightly will make the tooth look more rectangular, and therefore will create a longer appearing tooth.

A combination of these illusion-creating mechanisms will result in a longer or shorter appearing tooth, as the case may be, without actually changing the dimensions.

In most cases, techniques for both mesio-distal and inciso-gingival illusions will be used in concert, in order to achieve a natural, harmonious, and esthetic appearance in the fabrication of porcelain veneers.

DEALING WITH SPACES

Spaces due to misalignment

It is common for the cause of a diastema to be the misalignment of one or more of the teeth. When that is the case, the patient should be encouraged to seek an orthodontic solution. Unfortunately, the patient is often already all too aware of the possibility of orthodontics, but has ruled it out because of the nature and length of treatment. If that is the case, it may be possible to use porcelain laminates to give the patient "instant orthodontics".

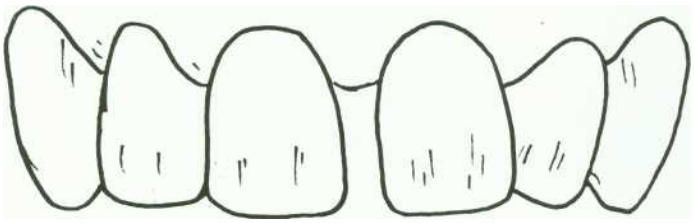


Fig. 9-10

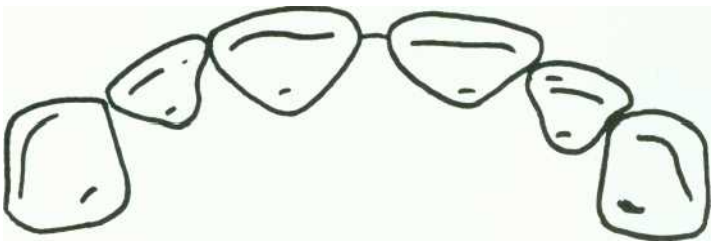


Fig. 9-11

In the case illustrated here, the patient has a diastema because the maxillary left central incisor is moved to the distal. To complicate matters, it is rotated over the mesial aspect of the upper right lateral incisor. The right anterior segment is normal.

After carefully analyzing the case and measuring the sizes, the maxillary left central and lateral incisors as well as the left cuspid should be trimmed back in the areas indicated (Figs 9-12, 9-13).

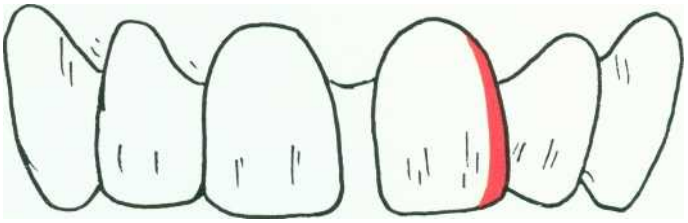


Fig. 9-12

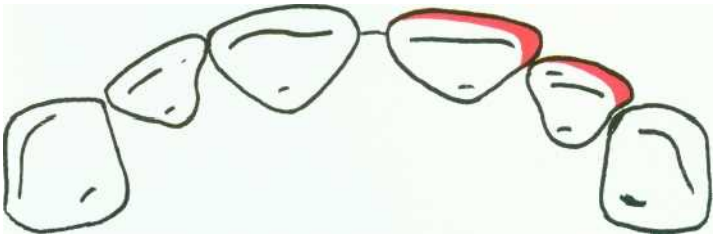


Fig. 9-13

After modifying the teeth, the new appearance from the facial view will look like this.

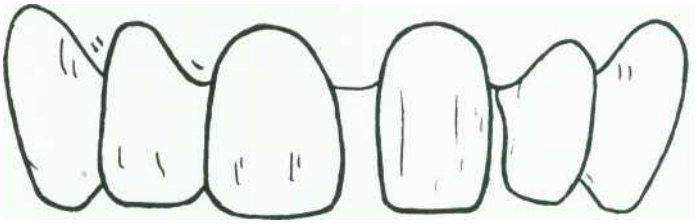


Fig. 9-14

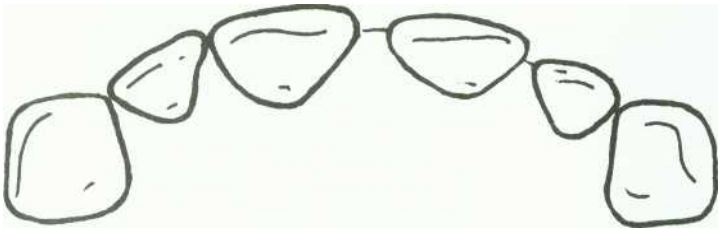


Fig. 9-15

From the incisal view, it is easy to see that any overlap of teeth will thus be eliminated.

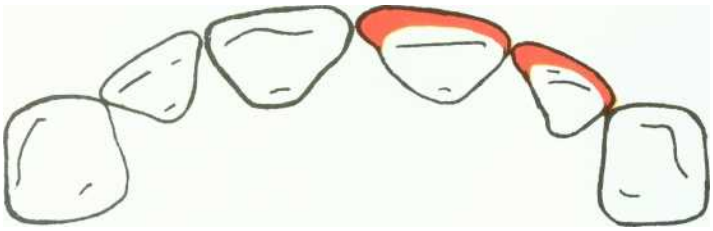


Fig. 9-16

Laminates should then be fabricated for both the left central and lateral incisors to give an appearance of proper alignment. By making the laminates thicker toward the mesial aspect, it will make the teeth appear as if they are not rotated.

Fig. 9-17

The final appearance from the facial aspect should look like this.

Fig. 9-18

Spaces Due to Size Discrepancies

When the diastema is caused by teeth which are simply too small for the space allotted, the usual solution is to widen the teeth. This is most easily accomplished by creating laminates that cover the existing teeth as well as the spaces (Figs. 9-18, 9-19).

Fig. 9-19

Fig. 9-20

In this case, five laminates were used to cover the upper incisors and the upper left cuspid (Figs. 9-20, 9-21).

Fig. 9-21

Fig. 9-22

It is also possible, although far more difficult, to successfully add only a sliver of porcelain on the proximal surfaces of the teeth adjoining the spaces to fill in the void. Such was the technique used in this case.

Fig. 9-23

The shape and position of the central incisors in this case were ideal for such a technique. In addition, there was very little variation in the shading of the central incisors from the incisal edge to the gingiva margin. It was therefore possible to create these "veneers" for the unprepared central incisors. A blend of porcelain with slightly greater opacity than usual was utilized.

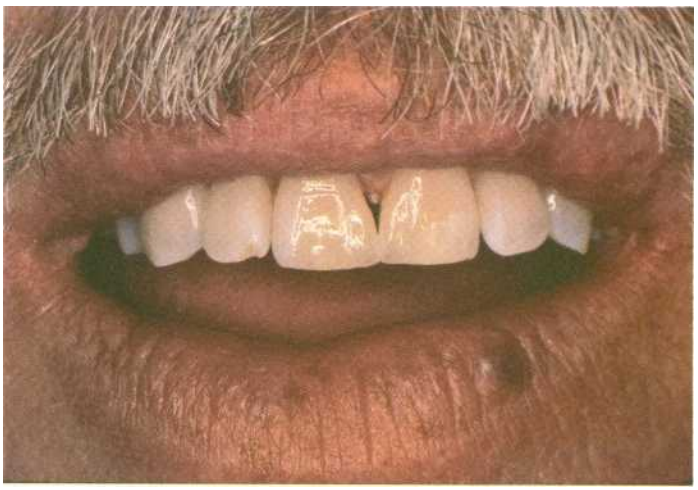


Fig. 9-24

The appearance improved dramatically after the porcelain slivers were fused into place.

It should be noted, however, that conditions are seldom so ideal. The difficulties created by variations in shading over the surface of the tooth can be perplexing. There are usually slight variations in the apparent surface texture between the porcelain, composite luting agent, and tooth. In addition, the finish line of the porcelain is clearly visible on the labial surface of the finished tooth. This can cause an immediate esthetic problem that will become increasingly more apparent. All things considered, while the apparently conservative nature of this approach is charming, it is usually a second-choice treatment alternative when using porcelain.

OVERCOMING TETRACYCLINE STAINS

One of **the greatest difficulties** with tetracycline stained teeth is that the tooth structure underlying the finished porcelain veneer is so highly variable in color. Often the operator's efforts at masking the darkly stained portions simply render the lighter areas far too bright and white for a truly esthetic result.

Obviously such a situation calls for a Type VI (double) preparation. In addition, the technique of external bleaching can be utilized just prior to fusing the veneer. Under normal conditions, the external bleaching of vital teeth is often followed by a complete or partial color relapse, as the oral environment affects the cleansed enamel lattices, but such relapses requires the access of oral fluids to the bleached prisms. Where this access is not possible, such as under the fused porcelain veneer, the bleached enamel remains stable.

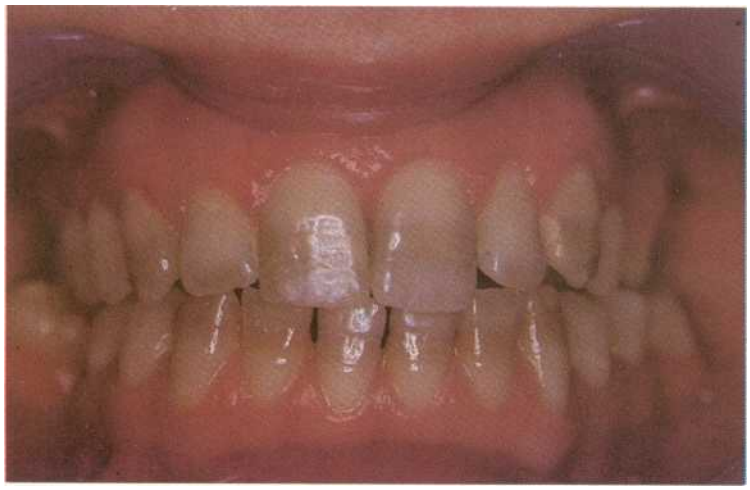


Fig. 9-25

In the case shown here, the pumiced enamel was partially etched to provide better penetration of the bleach. The darker areas were bleached for up to 5 minutes, the darker areas being exposed for the longest periods. Following this extra step, the fusing process was resumed from the beginning (the initial etch). The only other departure from the standard veneer technique was the placement of an opaquer on the darkest enamel surfaces during the fusing process.

Fig. 9-26

As can be observed, the resulting veneers not only are an improvement on the originally severe stains, but also have a very natural, non-striated appearance, without being excessively bright or opaque. The prisms are blocked by resin, and the danger of color relapse has been eliminated.

RE-ESTABLISHING ANTERIOR OCCLUSAL FUNCTION

Many of the early articles on the subject indicated that porcelain veneers should not be placed in areas of occlusal stress. While it can be certainly stated that there must not be any prematurities on the veneer, there is no contraindication to allowing full, normal occlusion on either single or multiple veneers. The thin porcelain veneer is a very fragile item. However, when it is fused to a tooth or baked onto a metal coping, its strength increases dramatically.

One of the less indicated areas for the placement of porcelain veneers is the lower anterior region. On occasion, however, circumstances dictate that porcelain veneers be used, as shown in this case.

Fig. 9-27

Three porcelain laminates were placed to cover the patient's remaining three mandibular incisors. A Type III preparation was used and the incisal edges of the laminates were placed in full function.

Fig. 9-28

Fig. 9-29

After 18 months of constant occlusal stress and function, the veneer had neither delaminated nor fractured. Instead, because of the fact that it was occluding against an unglazed surface of a porcelain fused to metal full crown, the porcelain on both the laminate and the opposing crown showed wear. The forces at work are evident from the amount of wear that the mandibular central exhibits.

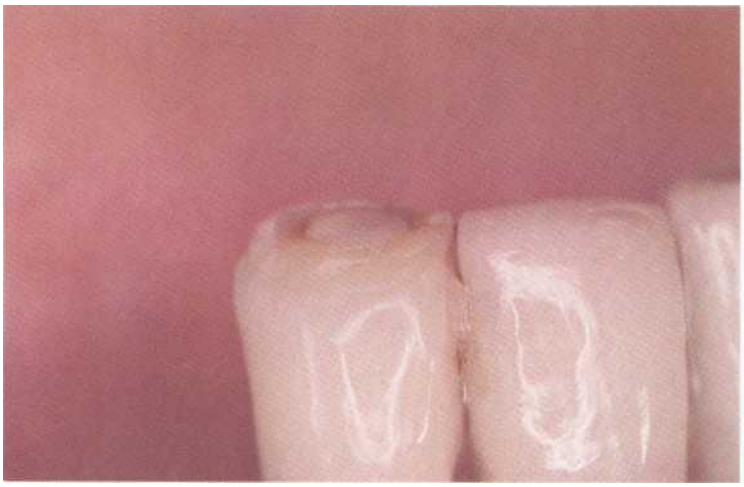


Fig. 9-30

This is a demonstration of just how strong the clinical bond between the enamel and the veneer is, showing that the veneer truly becomes a physical and functional part of the tooth. Notice the complete lack of crazing or cracking of the porcelain in this extreme close up view.

TRANSFORMING CUSPIDS TO LATERALS

For a patient congenitally missing laterals, the dentition first presents itself with space where the missing laterals would normally be. Traditionally, the dentist may take one of two orthodontic directions. One is to open enough mesio-distal space between the centrals and cuspids so a lateral pontic can be inserted. The other is to close the lateral space entirely. This latter approach always brings with it certain esthetic liabilities: the cuspids are almost always larger, darker, and more conical than lateral incisors. This is the situation that this patient found herself following treatment by an orthodontist.

Fig. 9-31

The only reshaping or preparation undertaken was the removal of the incisal 1/2 mm of the cuspids' points. Veneers were made with a particular reference to the size of the centrals. The laboratory was asked to add certain hypocalcification spots on the laterals to further aid in the camouflaging of the veneers. Note that these lines, if naturally formed, will occur at similar levels on the laterals, but on the centrals,' their position will be further gingival (corresponding to the earlier development of the central). The buccal aspect of the first bicuspids will recreate the cuspid illusion, and thus the esthetics of the upper anteriors is restored.

Fig. 9-32

Naturally, if the patient is to wear a retainer, it must be fabricated to fit over the porcelain veneers on the labial surface .

Fig. 9-33

Two points of caution should be made here. The first is that while it is possible to alter the shape and size of the crown using laminates, it is not possible to make the gingival margin of the tooth narrower, nor is it possible to move the gingival margin in a more incisal direction. If the gingival border of the cuspid is correct for a cuspid, it will not be correct for a lateral. It will be wider and more apical than that of an ideally placed lateral incisor. Sometimes the patient must be warned in advance that the final appearance of the "converted" crown will be imperfect at the gingival margin. Still the potential improvement in appearance is so great that few patients object to this imperfection.

The second point of caution has to do with occlusal stresses. It is not uncommon with missing lateral incisors for the lower cuspid to nestle just distal to the cusp tip of the maxillary cuspid. In such cases, if a porcelain laminate were used to create the shape of a lateral incisor, the disto-incisal corner of the laminate would be placed in a position of undue stress where the porcelain was unsupported by tooth structure.

In such cases, either the maxillary laminate must be made shorter than the esthetic ideal, or the mandibular cuspid must be shortened.

MOVING THE MIDLINE

It is often necessary to do full orthodontic treatment in order to realign teeth. This is particularly true in the case of centering the midline. If the discrepancy between maxillary and mandibular midlines is small, however, it may be aligned cosmetically.

Fig. 9-34

The patient shown here had two 7 year old Mastiques that had chipped and percolated.

Fig. 9-35

The two central incisors required retreatment, and it was suggested that the laterals be veneered as well. This made it possible to extend the tooth size discrepancy over more teeth and thus make it less visible.

Fig. 9-36

The maxillary midline was aligned with that of the lower incisors (as well as that of the face), and the laboratory was asked to fabricate veneers with that starting point in mind.

TOOTH/JAW SIZE DISCREPANCY

Often the orthodontist is called upon to correct malocclusions complicated by dental size discrepancies. Where the teeth are too large, treatments such as serial extraction or interproximal reduction may be undertaken to improve the dental appearance.

A far more difficult situation is that of microdontia. Typically the dentition and, in particular, the maxillary anteriors, are too small both in terms of facial size and arch width. In the past, the only method of dealing with this problem has been to apply full coverage crowns. The amount of healthy dental structure that had to be removed was an unfortunate but necessary sacrifice.

The treatment of microdontia by fused porcelain veneers is a recent and very welcome addition to the armamentarium of the dentist. This is a conservative and highly esthetic mode of dealing with the problem of undersized teeth.

Fig. 9-37

As always, the first step in treating this problem is to evaluate of the appropriate size of the maxillary anteriors (as described in chapter 4). In the case shown here, the mesio-distal space required for the centrals and laterals corresponded to the arch distance available between the mesials of the cuspids.

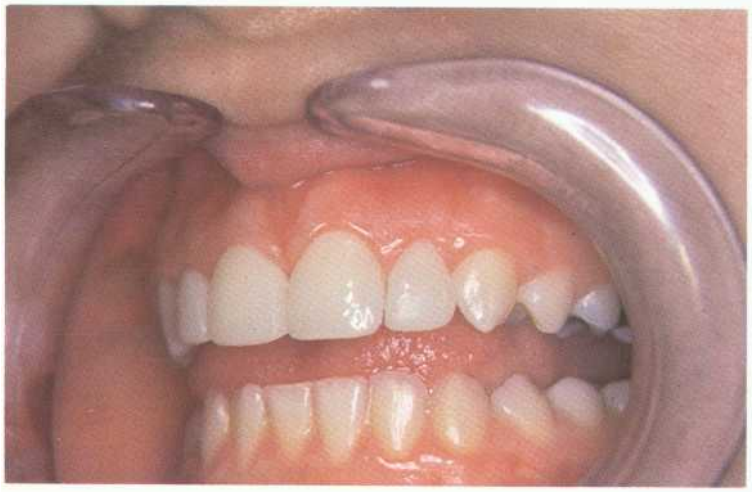


Fig. 9-38

Next, establish the face-related shape of the central incisors. In this case, there was no need for preparation of the teeth, and thus maximum conservation was possible.

Fig. 9-39

These three views of the left lateral incisor are from the same case after the two central incisor veneers had been fused in place. Notice that this tooth required absolutely no preparation.

Fig. 9-40

This view of the laminate prior to fusing shows the degree of extension required to create a tooth of correct size.

Fig. 9-41

This is a view of the tooth immediately upon placement of the veneer. Notice that even though there was no tooth reduction along the margins, the gingiva is undisturbed without any blanching. At the same time, notice the smooth, esthetic gingival margin presented by the finished case.

It also should be noticed that the shade selected is slightly lighter than the color of the cuspids. This is the most natural condition, and every attempt should be made to maintain it.

In the case just depicted, the face size/dental arch relationship allowed the operator to close all the existing diastemas. For other patients this might not be possible. The dentist must then decide, in consultation with the patient, where the interdental gaps will occur, and then this information must be clearly communicated to the laboratory.

Fig. 9-42

PEG LATERALS

Peg laterals combine the two esthetic problems of undersized and incorrectly shaped teeth. As such, they are ideal for porcelain lamination. Here is an example of just such a problem.

Fig. 9-43

The dramatic improvement in facial harmony which two porcelain veneers can create is clearly evident in these two full face photographs (Figs. 9-43, and 9-44).

Fig. 9-44

STAINED RESTORATIONS

Since the earliest days of composite restorations, dentists have faced the prospects of temporal staining and deterioration. Part of the problem lay with the weaknesses inherent in the materials that were utilized, but most of the culpability was the patient's. Habits such as smoking, drinking coffee and tea, and poor oral hygiene were (and are) greatly responsible for the esthetic failures of anterior restorations.

It was frustrating to replace these fillings, knowing full well that the patient's habits were going to remain, and soon begin undoing these newer restorations. Staining and discoloration (staining is defined as the extrinsic diet and habit induced darkening of composites while discoloration implies the internal yellowing that occurs due to chemical changes and reactions within the composite) have been reduced as better materials have been developed, but they have not been eliminated.

When the restorations become an esthetic handicap and/or the patient is unable or unwilling to control his habits, then often porcelain bonded veneers are the best solution.

It is important to replace all redecayed and greatly stained restorations before the placement of veneers. Failing this, the veneer could be undermined both curiously and cosmetically. The opacity of the veneer and fusing materials can eliminate minor color variations.

Both the phenomena of polymerization shrinkage and the coefficient of thermal expansion are of sufficient concern when dealing with an attachment to teeth that they have been the subject of numerous investigations. These investigations date back to the early search to find methods of attaching materials to tooth well enough to avoid leakage. This research has shown that composite bonded to etched porcelain or etched enamel will attach with sufficient strength to avoid later degradation due to the initial polymerization shrinkage or the subsequent thermal expansion or shrinkage. When chemical attachment is added to the physical attachment (the fusing process), the strengths become even more formidable.

In the case of attaching materials to dentin, it is only with the most recent generations of dentin bonding materials that the initial bond strength of composite to resin exceeded the forces created by polymerization shrinkage during cure. Thus, if attachment to dentin is required, not all "dentin bonding agents" will be adequate for the job.

While not always necessary, the authors advocate the use of these dentin bonding materials whenever dealing with etched porcelain over exposed dentin. Further, since porcelain fused to enamel exhibits markedly higher bond strengths than even the best obtainable to dentin, the prudent dentist will always try to end all porcelain restorations on sound enamel.

Using this technique with porcelain laminates in place of repeated composite placements, the operator can now be assured of color stability for a number of years. The porcelain does not stain or discolor with time. The underlying restoration is not open to intraoral fluids; thus staining is eliminated as a potential problem. Discoloration may continue, but its pace is slow; the veneer's opacity tends to mask small changes.

Some concern has been expressed about having a thickened layer of composite beneath the porcelain veneer. These concerns center around four main areas: compressive strength, tensile strength, polymerization shrinkage, and coefficient of expansion.

In fact, none of these characteristics need be of great concern when dealing with composite resin that has been either bonded or fused to porcelain or enamel. The compressive strength (over 34,000 psi) and tensile strength (over 5,000 psi) of composite resin is sufficient for any proper application of etched porcelain.

Fig. 9-45

Fig. 9-46

In the case depicted here, no unusual steps needed to be taken. In some cases, however, the degree of enamel destruction is so great that dentin bonding procedures must be incorporated. This is simply accomplished by using GLUMA, Scotchbond 2, glass ionomer cement, or some other similar material under new composite restoration (Figs. 9-45, and 9-46).

Chapter 10 THE LABORATORY PRESCRIPTION

By the time the dentist is about to write a laboratory prescription for the fabrication of porcelain laminates, much care and thought will have already been invested. Many factors and considerations will have been taken into account in the determination of the final shape, color, and size of the veneers. But at this stage the element of control will be removed from the dentist's hands and transferred to the laboratory technician.

The technician, who has been selected by the practitioner for his ability and conscientiousness, will endeavor to produce ideal veneers. His limitations, however, include the quality of the impressions and the information that he has been given about a patient he is unlikely to ever see.

In some ways this is actually the most difficult step in the fabrication of porcelain veneers; a technician is requested to create a supremely compatible esthetic restoration at a distance, often with three or four words being his only clues indicating the desired result. A prescription that reads "make porcelain veneers for maxillary teeth 1 x 6, shade B2" is unfortunately all too common. It is not surprising that remakes sometimes become necessary, with the undesirable side effect that dentists and technicians see each other in an adversarial light. If a readily understandable means of communication existed, whereby the dentist could and would describe the desired result in detail, then complications and misunderstandings would be greatly reduced.

The more information that can be provided to the laboratory, and more clear and specific this transmission of information is, the easier the resulting veneers will be to place in the mouth. It is with this in mind that the authors have created a guide to a specific prescription for porcelain veneers.

First, the patient's name is entered on a form which specifies the mold to be used as a guide in the fabrication process. The guide mold details the general shape and size of the maxillary anteriors (established in accordance with the Trubyte system described in chapter 4). This measurement helps the technician understand the general shape the anterior veneers should take.

It has often been remarked that one major problem with existing laboratory prescriptions has been that too little space is provided to enter all the required information for a comprehensive cosmetic description. If all the details are described in the small area usually designated for this purpose, the result is sometimes indecipherable.

It is for this reason that on the new form three separate areas are set aside for the various aspects that are to be incorporated into the final porcelain product-one each for shade, surface texture, and characterization. In this manner, clear instructions about the specific features of each tooth can be communicated without the risk of misunderstanding.

The new form also provides a specific reference to the degree of masking required to reduce or eliminate the existing stains on the teeth. The form also draws attention to the presence of short teeth and specifies which ones should be lengthened.

Porcelain veneers can easily correct diastemas, but the patient does not always want them eliminated. The form asks the dentist to indicate which spaces will be eliminated and which will be left open.

The next area of the prescription questions whether illusions are necessary, and if so, for which teeth. This is deliberately kept separate and distinct from the shading section. The final color of the veneers must correspond after all the other modifications have been made. Thus, if there is any illusion creation, this must not affect the final cosmetic harmony of the anterior teeth.

The dentist also is required to indicate whether the labial dimension of any particular tooth is to be increased.

Depending on the type of preparation or non-preparation that has been performed, the technician should be instructed which teeth are to have incisal edges in porcelain.

There are at least two major theories that apply to the gingival margin of a porcelain veneer; some practitioners utilize a flame or knife-edged finish, while others prefer one closer to a butt joint. This, too, can be clearly indicated.

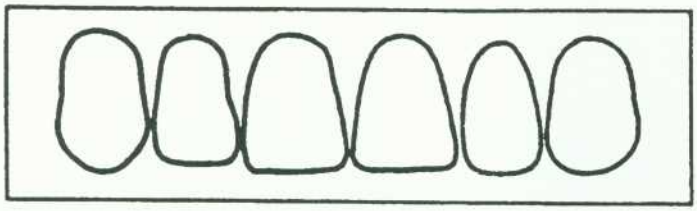
Perhaps the greatest asset of the suggested laboratory prescription is that it can serve to guide the dentist in the creation of a detailed and complete picture he might not otherwise always provide. All the information is necessary and important. In fact, this proposed form may be only a starting point, to which each dentist will add his own specific notations and requests.

LABORATORY PRESCRIPTION©

PATIENT_____ Sex_____ Age____

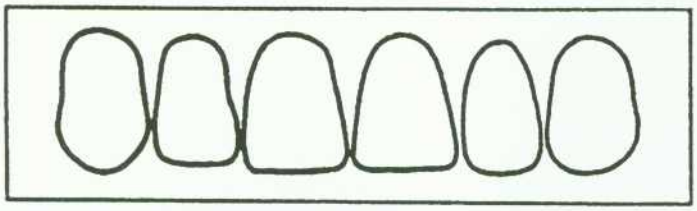
GUIDE MOLD_____ Tooth shape: square__ tapered__ ovoid__
square tapered__ tapered ovoid__
square tapered ovoid__

FINAL SHADE:

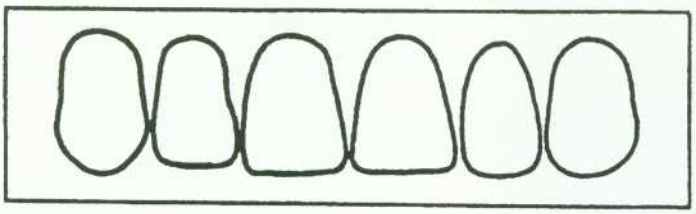


MASKING DEGREE: severe__ moderate__ minimal__ none__

SURFACE TEXTURE: lobes, perikymata, mammelons, developmental grooves



SURFACE CHARACTERIZATION: hypocalcification, craze lines, translucencies



SHORT TEETH: lengthen_____

DIASTEMAS: close between_____ leave open between_____

SPECIAL NOTES:
Illusions: make the following teeth:
wider_____
narrower_____
longer_____
shorter_____
occlusal view:
increase labial dimension_____
porcelain incisal edge on _____
gingival margin of veneers: flame____ butt___

ADDITIONAL REQUESTS:

Chapter 11 LABORATORY PROCEDURE FOR PORCELAIN LAMINATE VENEERS

There are two basic approaches to the laboratory fabrication of porcelain laminate veneers. The first and most popular of the two methods utilizes an investment model onto which the porcelain is baked directly. After processing, the investment model is eroded away from the porcelain laminate using a sandblaster. This method was first proposed (and subsequently patented) by McLaughlin. The second method uses a stone model of the teeth against which platinum foil is swedged. The porcelain is then built up on the platinum foil much the same as when making a porcelain jacket. After the final porcelain firing, the platinum foil is removed from the intaglio of the veneer. This method was first developed and subsequently patented by Greggs.

Each of these two methods has its proponents and detractors. In the end it is a personal decision as to which laboratory technique is employed.

Regardless of the laboratory method selected, a detailed impression including embrasures and sulci is always required. This should be accompanied by an accurate bite registration and detailed prescription. From this stage on the two methods differ markedly.

Fig. 11-1

Fig. 11-2

Many laboratories believe that if the original impression material is other than a vinyl polysiloxane or a polyether, it is preferable to make an index of the master model with a vinyl material to produce the refractory model. Problems can occur if VHT or other similar investment material is used with a water-based impression material, such as alginate or agar hydrocolloid.

INVESTMENT MODEL TECHNIQUE

Andre Dagenais, R.D.T. and Carl L. Lee-Young

If the investment model technique is employed, the technician first fabricates articulated, die-stone master models.

The impression is then repoured using a suitable high temperature investment, such as Whip-Mix VHT Investment (Whip Mix, Lexington, Kentucky), to produce a refractory model. This model need only contain the teeth being veneered and their immediate two neighbors.

Fig. 11-3

Next, the refractory model is degassed in two steps:

Step 1: Hold the model in a regular burnout oven at 600 degrees Celsius for 20 minutes.

Step 2: Then place the model in a porcelain furnace, and bring the temperature to 990 degrees Celsius under full vacuum.

Fig. 11-4

After cooling, the degassed refractory model should be soaked in distilled water for two to three minutes. Keeping the model wet allows for easy application of the porcelain.

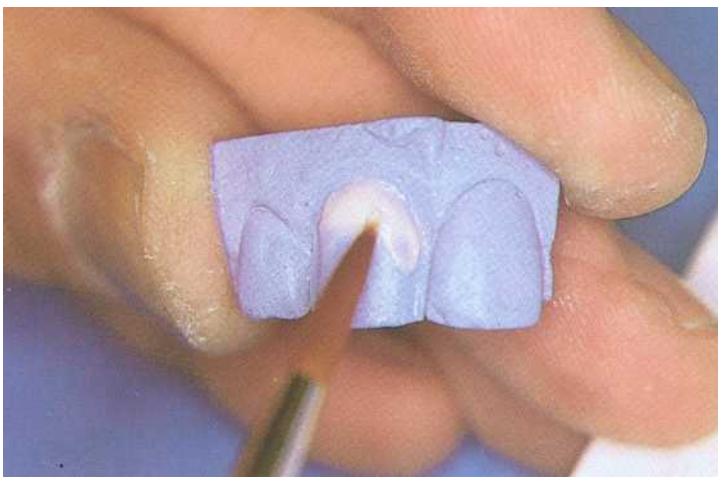


Fig. 11-5

The margins may be marked with a ceramic pencil (Whip-Mix, Lexington, Kentucky). This marking will remain visible after firing and will help keep sight of the margin.

A thin layer (0.2mm-0.3mm) of body porcelain is applied to the full extent of the area to be covered and slightly beyond. This will serve as the base of the veneer. It is sometimes easier to visualize the thickness of the porcelain if a drop of food coloring has been added to the porcelain before applying it to the model. Once fired, the food coloring burns out leaving only the unadulterated porcelain behind.

Fig. 11-6

The utilization of a sonic condenser, such as the CeramoSonic (Shofu Dental Corporation, Menlo Park, California) will give optimal results. When doing multiple units, be careful to establish adequate separation between teeth before firing.

Fig. 11-7

Next, dry the model for five minutes in front of the open muffle of the furnace .

Place the model into the oven and fire it to 985 degrees Celsius under full vacuum at a rise of 45 degrees per minute. At 950 degrees, release the vacuum and immediately remove the model to bench cool.

Once cooled, the base-bake will look like a "slurry" bake on a metal restoration . It will have a high glaze and usually will exhibit some cracking due to the porcelain shrinkage. The model should then be resoaked before further porcelain application.

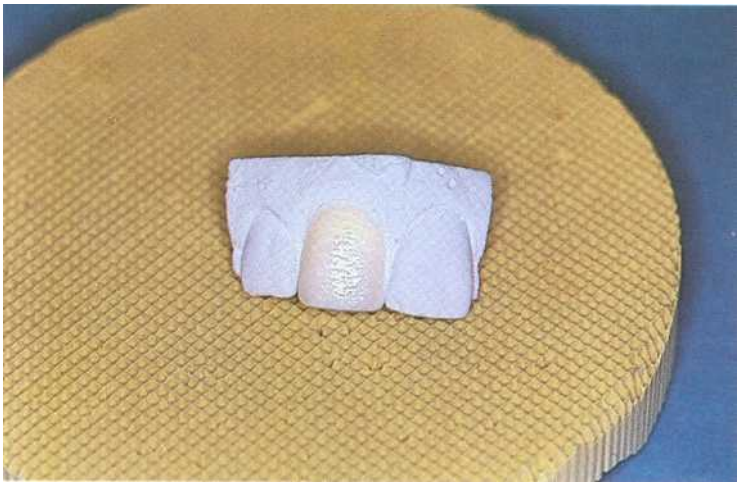


Fig. 11-8

Next, the body porcelain is applied to the full contour desired. The second layer should overlap the first so as to end on the model. Failure to do this will often result in a peeling away of the porcelain from the model along the margins.

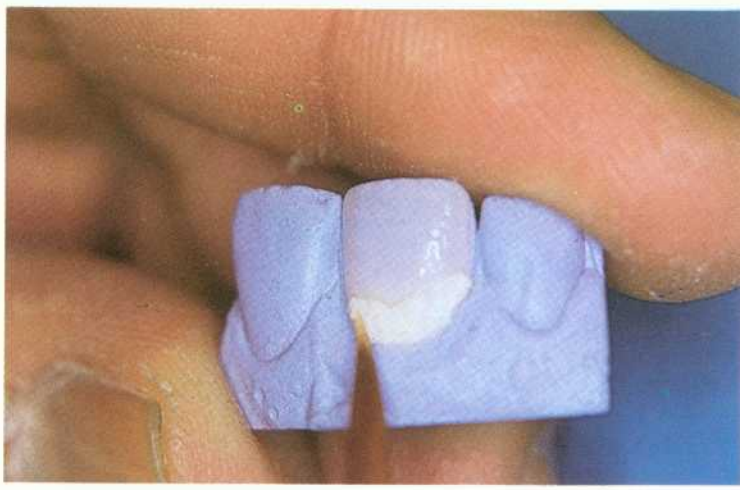


Fig. 11-9

Fig. 11-10

Condense well. When making multiple units, cuts must be made between each tooth before firing in order to keep the units from fusing together.

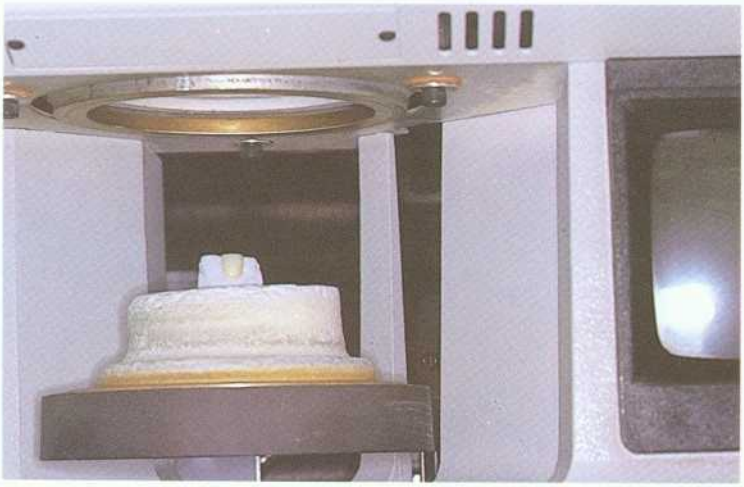


Fig. 11-11

Once again dry the model in front of the open furnace muffle for five minutes.

Bake the porcelain at the manufacturer's recommended temperature at full vacuum. Release the vacuum 35 degrees below the peak temperature. Once the peak temperature has been reached, immediately remove the model and allow it to bench cool.

The model should then be resoaked before adding any further porcelain. Correct the body shape with the addition of body porcelain where required. Again, any additions to the marginal areas should extend over the present margins and end on investment material. Correct the incisal areas with the addition of incisal porcelain as desired.

The final build-up is performed to ready the veneer for firing. The same firing cycle is employed as in the second bake, but at five degrees lower.

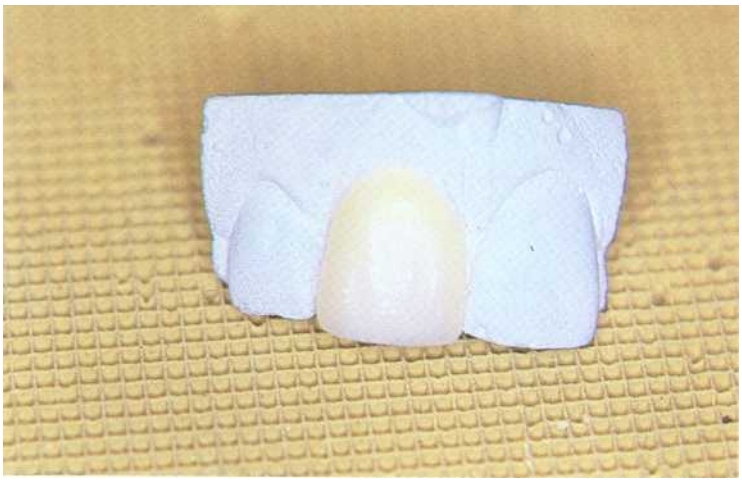


Fig. 11-12

The case' is allowed to bench cool. After the cooling, it is ready for separation and grinding.

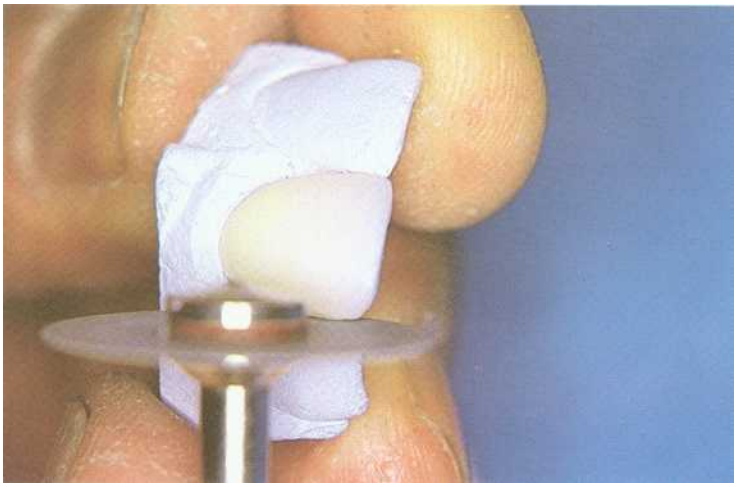


Fig. 11-13

The finishing is begun with a diamond disk. The general contours are imparted at this stage.

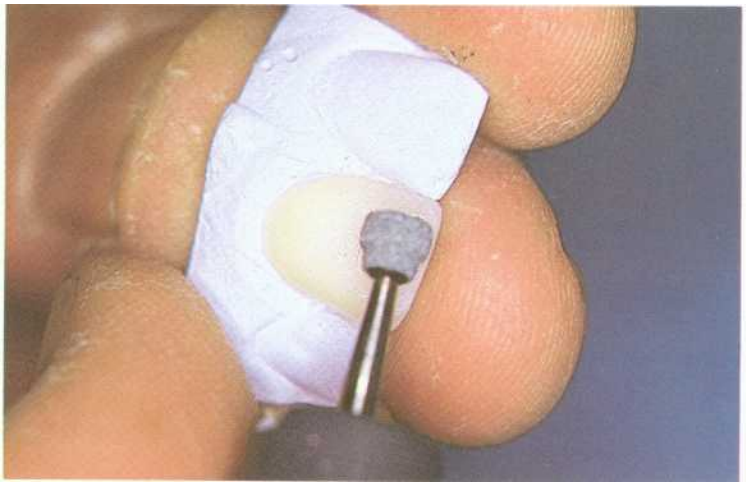


Fig. 11-14

The finishing is continued with a green stone. This step will reduce surface roughness and create the rounded features of the final product.

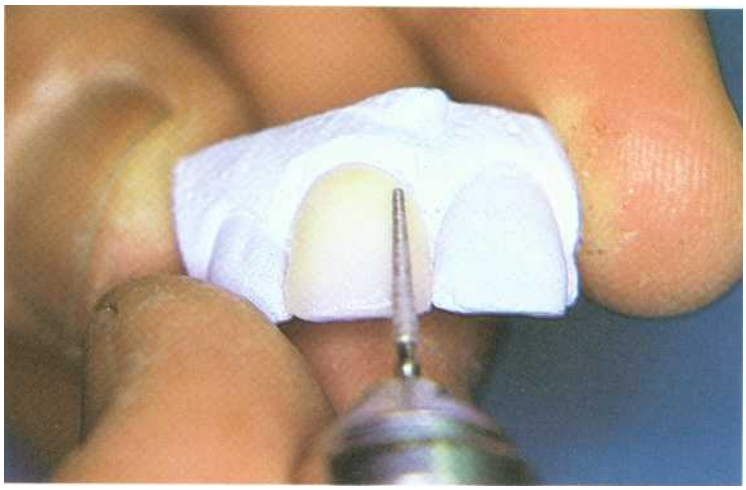


Fig. 11-15

Fine diamond burs create the highlights, depressions, and grooves that characterize the veneer and give it its lifelike appearance.

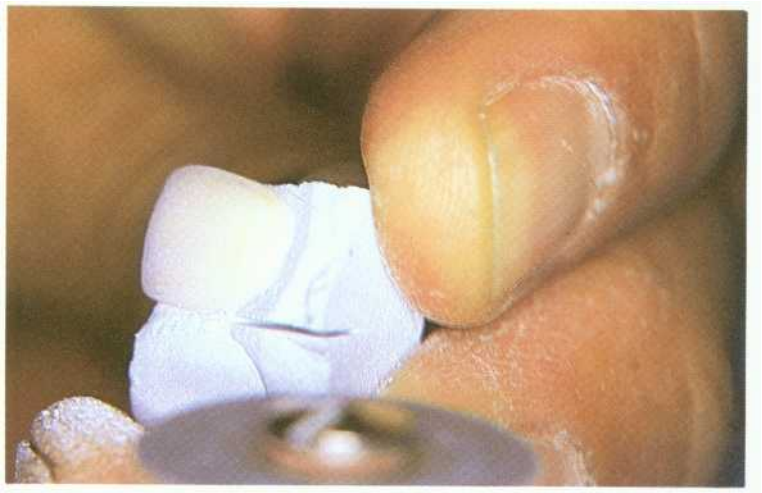


Fig. 11-16

The case is separated into single die units using a slim separating disk (Figs. 11-16, 11-17).

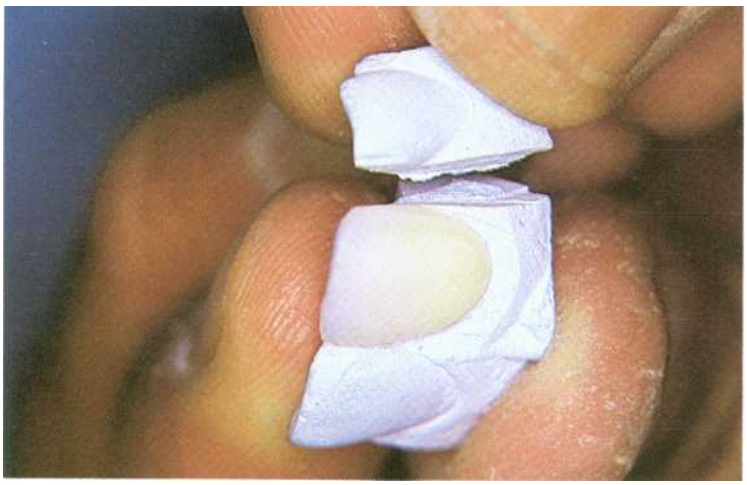


Fig. 11-17

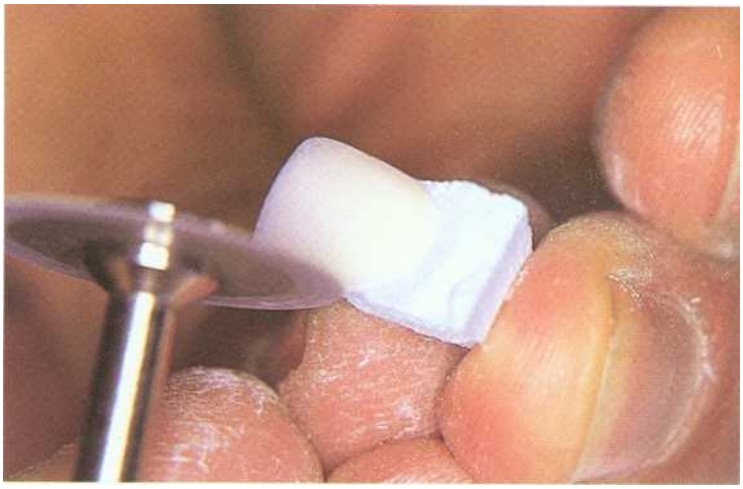


Fig. 11-18

Once separated, further finishing, particularly toward the proximal, may be readily accomplished.

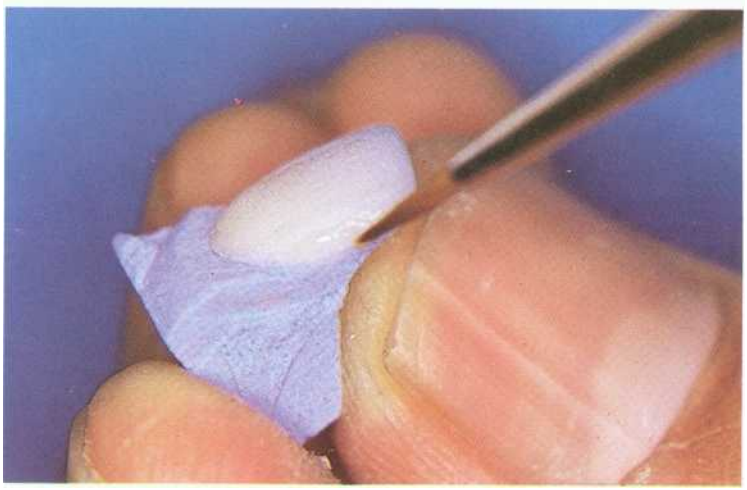


Fig. 11-19

Small proximal discrepancies and contacts may be adjusted by adding a mixture of 50 percent body porcelain and 50 percent glaze. Natural glazing provides the best results.

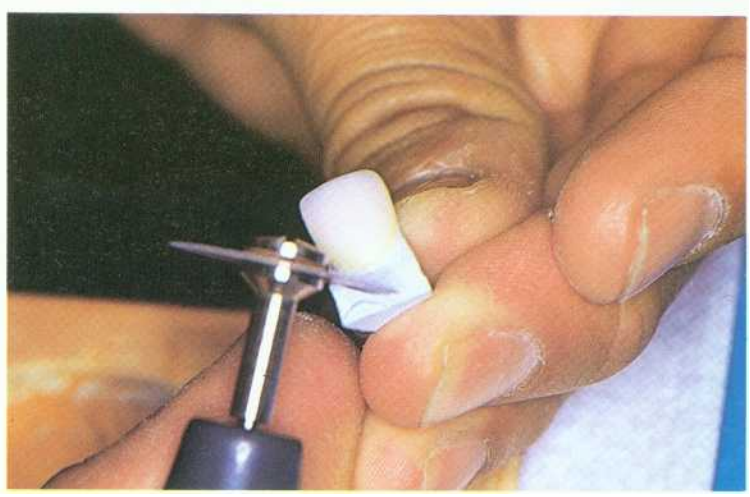


Fig. 11-20

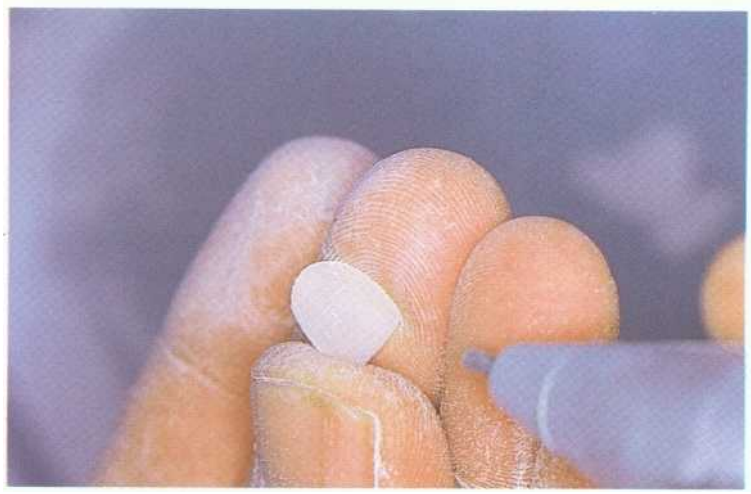
The bulk of the refractory material is cut off using rotary instruments (Figs. 11-20, 11-21, 11-22).

Fig. 11-21

Fig. 11-22

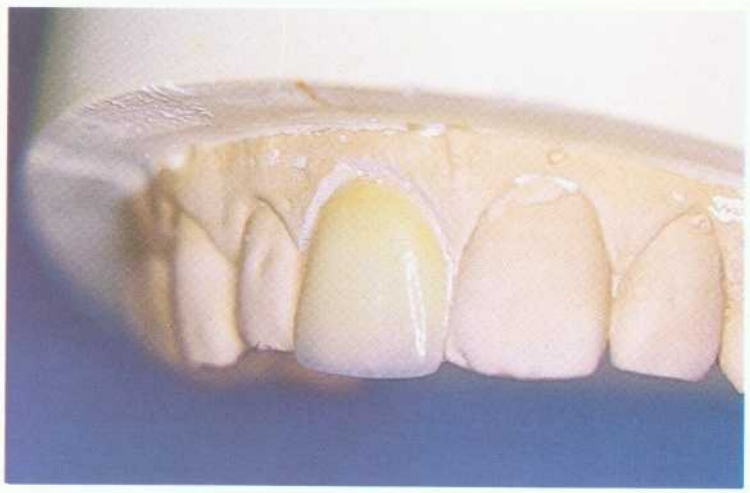
The remainder is sandblasted with a micro-blaster using glass beads.

Fig. 11-23



It is important to be especially careful with thin areas on the veneer and with the margins.

Fig. 11-24



The veneer is reseated on the master model in order to verify the fit. The veneer should be checked for mesio-distal, facial, and inciso-gingival contour, as well as for esthetic integrity.

Fig. 11-25

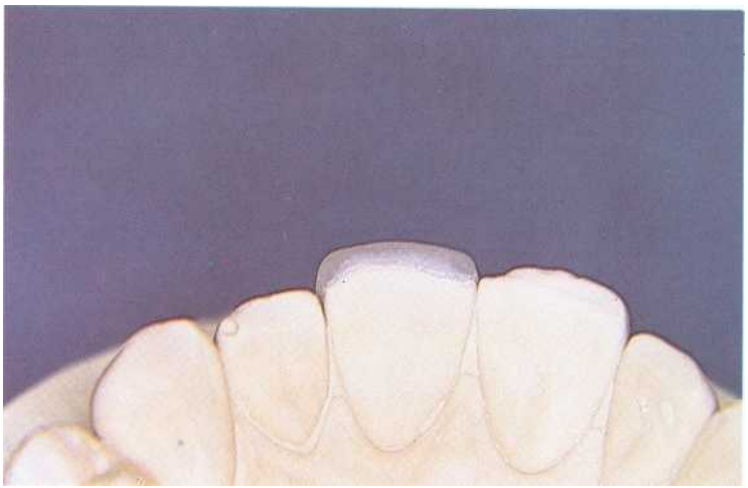


Fig. 11-26

The lingual must also be checked for fit and adaptation. The incisal extension of the veneer is also evaluated at this time.

Fig. 11-27

Overextensions are removed with a diamond disk or small diamond burs.

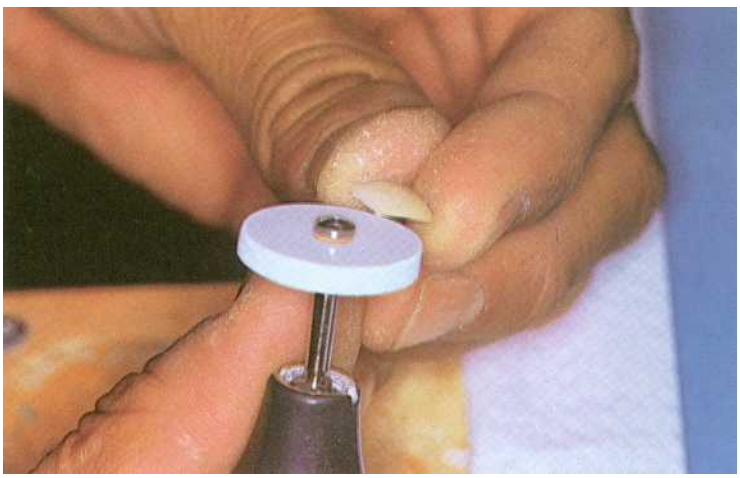


Fig. 11-28

The final adjustments are accomplished with the fine polishing wheels, such as Ultra wheels and Ultra polishing wheels (Shofu Dental Corporation, Menlo Park, California). It is important to support the veneer while doing adjustments. Mandrels must be straight and vibration-free. At this stage, the veneers are quite fragile, and care must be exercised not to fracture them inadvertently.

Fig. 11-29

The finished veneer is checked on the master model.

Fig. 11-30

The finished veneer is placed on a plastic plate. Using a plastic eye-dropper, a drop of 18 percent hydro-fluoric acid or a hydrofluoric acid mixture is placed on the lingual aspect of the veneer. Depending on the porcelain used as well as the concentration of the acid used, the veneer should be allowed to stand approximately two and one half minutes. Obviously, the technician must exercise great care when handling the acid.

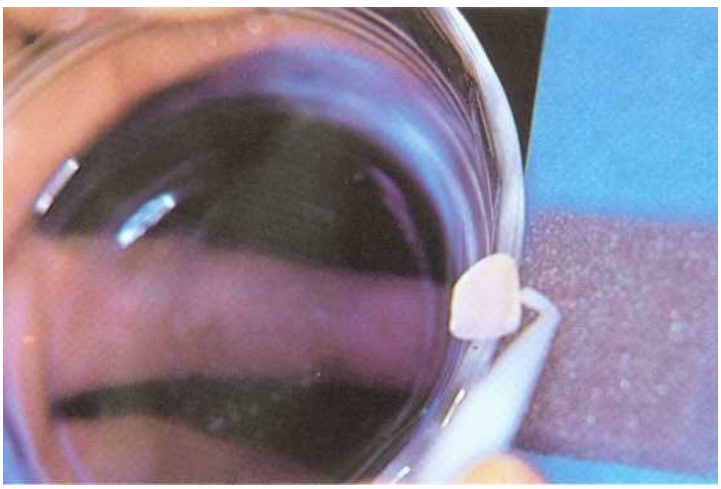


Fig. 11-31

With the help of a plastic instrument, the veneer is pushed into a container of water and washed thoroughly.

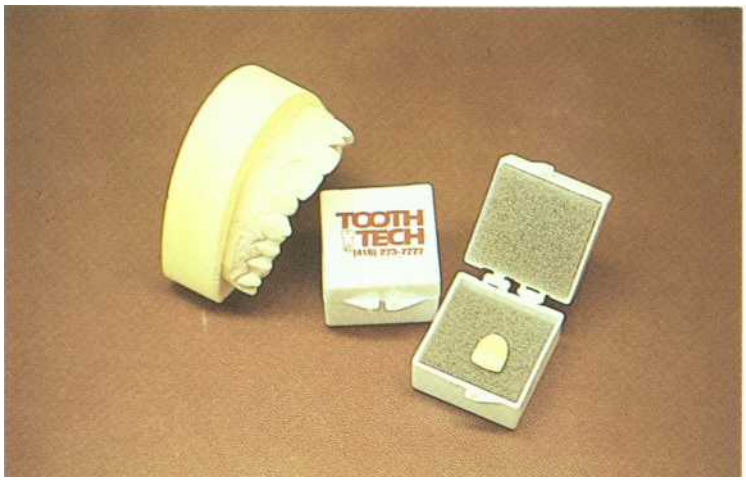


Fig. 11-32

The finished and etched veneer, along with the master model, is ready for delivery.

PLATINUM FOIL TECHNIQUE

Thomas Greggs, C.D.T

The laboratory fabrication of porcelain laminates using a platinum foil technique necessitates the use of individual removable dies on a master model made of hard die stone.

The working model is poured using hard die stone leaving a minimum of 3/8 inches of working area between the gingival margin and the base. All the dies of teeth to be veneered, and the adjacent teeth should be pin indexed. A base is poured and allowed to completely dry.

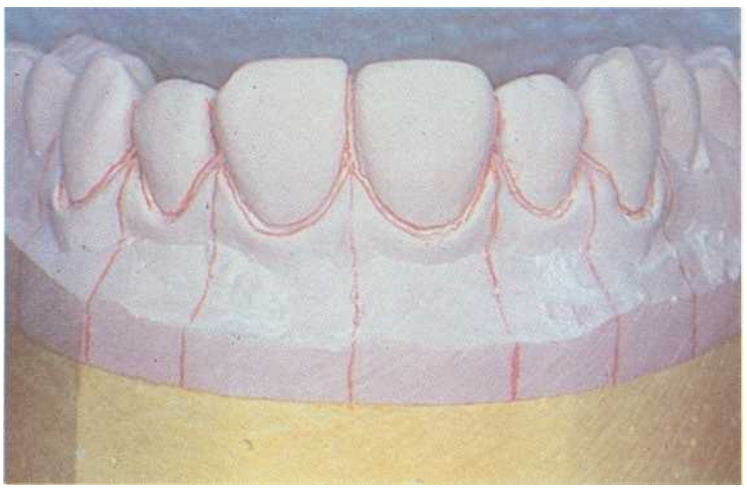
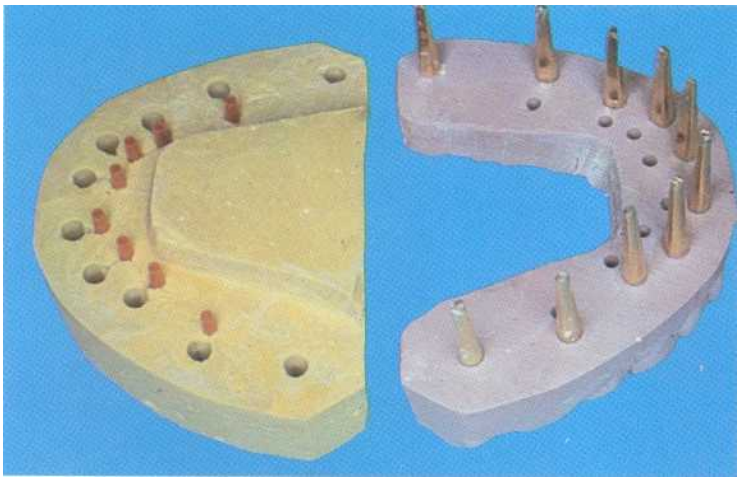


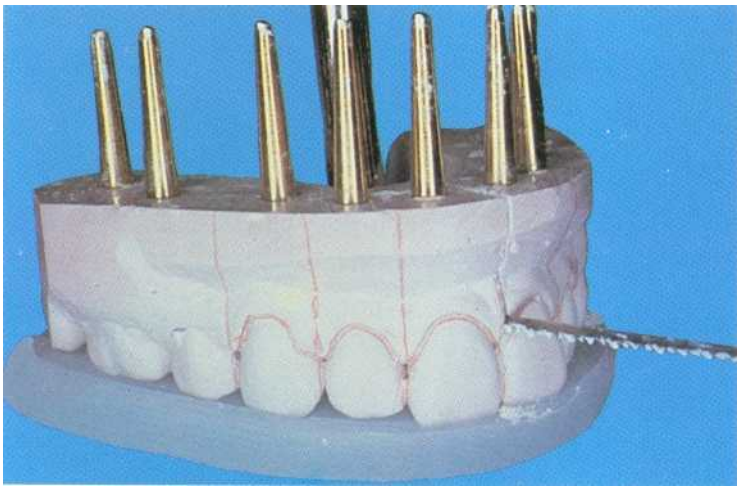
Fig. 11-33

The outline of the labial gingival margins of all teeth to be veneered are indicated with a sharp red pencil. Other red lines are drawn from the embrasures to the model base on both the labial and lingual surfaces to direct the sectioning of the base. The sectioning lines should be parallel to the dowel pins. (Film for Figs. 11-33 through 11-67 courtesy PVS System, Cercom International, Armonk, N.Y.)



The entire model is dislodged from its pin indexed base by selective tapping on the pinned model.

Fig. 11-34



The incisal edges of the pinned model are placed on a base of soft white wax to serve as a cushion while the model is sectioned. The model is first sectioned in half by cutting between the central incisors from the base up to the embrasure. When the saw blade reaches the embrasure, the saw should be removed and the two model sections are then carefully snapped apart. The interproximal surfaces must not be cut with a saw. This process is continued for individual dies until all dies have been separated.

Fig. 11-35

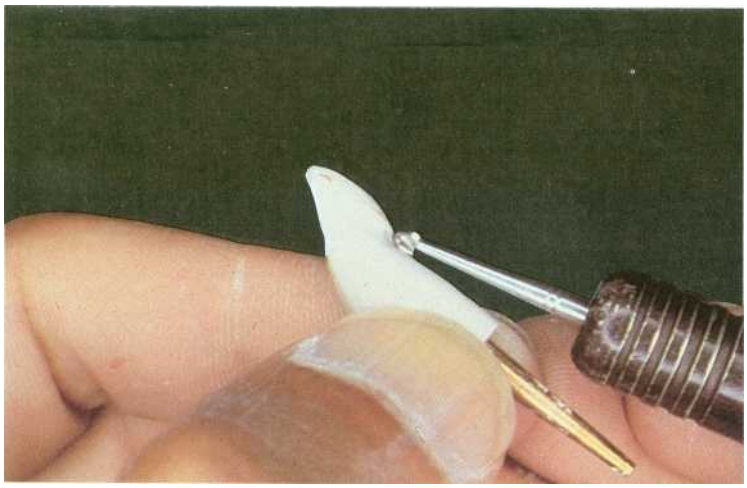


Fig. 11-36

The marginal area of each die is exposed with a #8 round bur, undercutting the gingival margin one quarter of the bur diameter. Proximal margins should be undercut with less depth; approximately 1/16 the bur diameter.

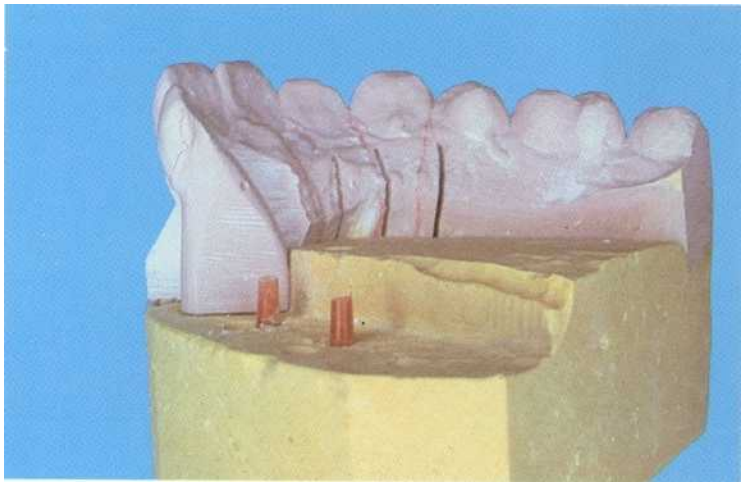


Fig. 11-37

Unless a prepared gingival margin exists, the gingival undercuts are placed either at the red outline, or 0.2mm beyond. A large bud bur should be used to trim the excess stone in order to create a smooth cylindrical shape for easy access to the labio-gingival working surface.

Fig. 11-38

All flaws and undercuts are filled with block-out material to facilitate effective foil removal. The dies should then be coated with surface hardener for increased durability.

The platinum foil matrix serves as a substructure for the porcelain veneer buildup, as well as a heat-conducting matrix that brings the porcelain to a uniform maturity during the firing cycle. Platinum foil thickness commonly used for veneering measures 0.00085 to 0.001 inches in thickness. Handling characteristics of each manufacturer's platinum foil may vary due to differences in pliability and rigidity. To assure consistent handling characteristics and predictable results, platinum foil specifically designed for porcelain veneering procedures is recommended (Cercom International, Armonk, N.Y.).

Instruments of the highest quality are extremely important in the proper placement of the foil. Suggested instruments include scissors with straight, delicate blades; molding tweezers with a straight, pointed tip; foil removal tweezers with a serrated tip for an optimal grip during the removal of foil; and an orangewood stick for consistent burnishing results.

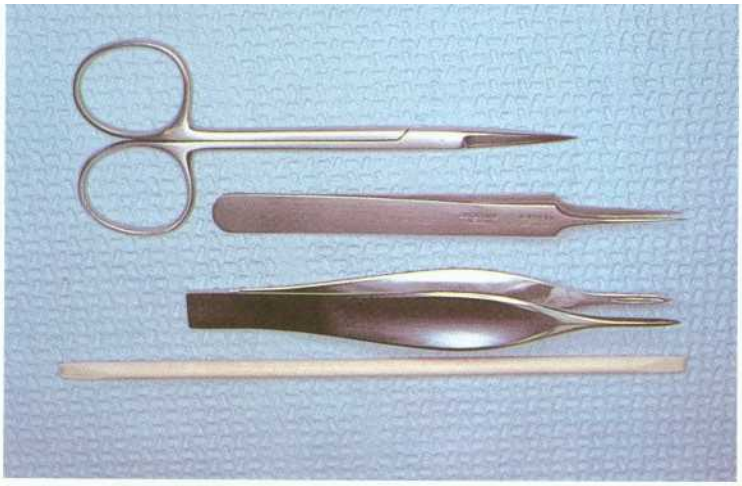


Fig. 11-39

The platinum foil is cut into the specified shape using a template designed for veneering techniques. The platinum foil should then be placed over the labial surface with the tab portion below the gingival margin. Any excess foil mesial or distal to the preparation is trimmed.

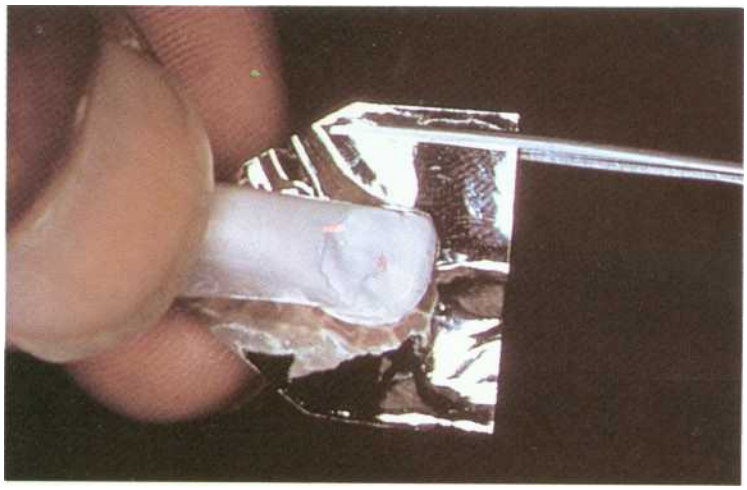


Fig. 11-40

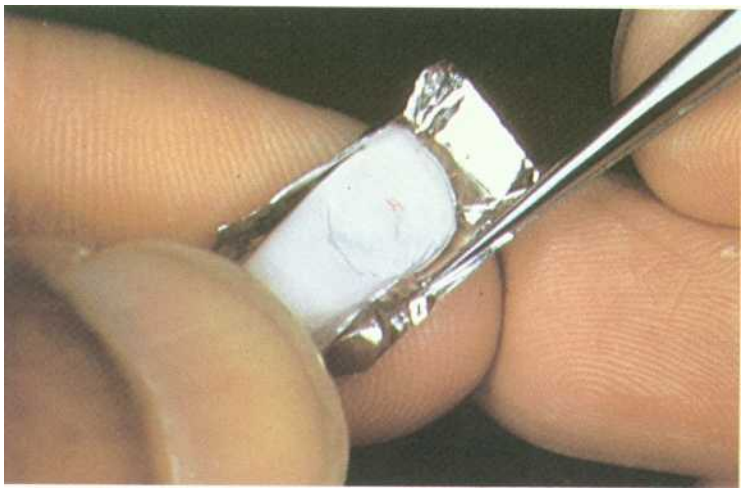


Fig. 11-41

The foil is held firmly in place and wrapped around the mesial and distal margins of the die using the straight, pointed-tip tweezers.

Fig. 11-42

The platinum foil is folded over the labio-incisal edge and carefully burnished from its center toward the proximal corners using an orangewood stick. This will create little incisal "wings" in the foil.

Fig. 11-43

Excess foil is burnished diagonally from the incisal wings to the middle third of the tooth to create a labial ridge. The foil ridge should be creased using the straight, pointed-tip tweezers.

The triangular tab of foil which extends apically and the gingival margins of the preparation are then burnished to secure the foil to the die.

Fig. 11-44

Excess foil at the incisal wings is cut using scissors, leaving a 1 mm extension. The straight, pointed-tip tweezers should be used to grip the edge of each incisal wing. The tweezers are then turned 180 degrees, folding the foil wing in half.

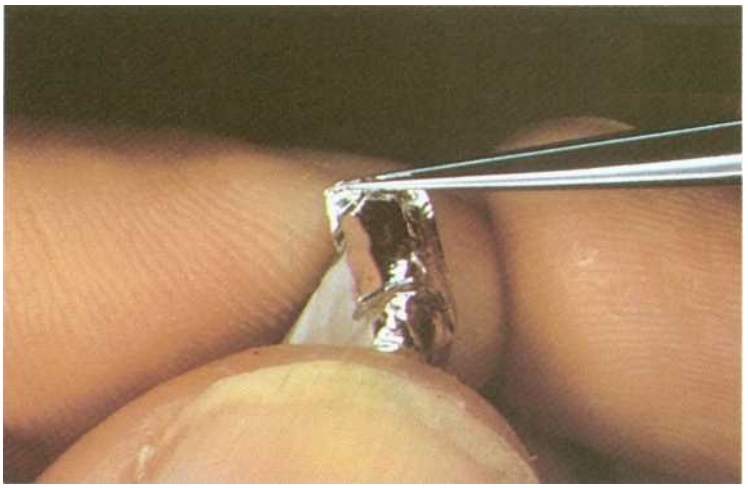


Fig. 11-45

Fig. 11-46

Next, the labial ridge is burnished toward the center of the preparation, flattening the excess foil into place. This procedure will strengthen the labial portion of the foil.

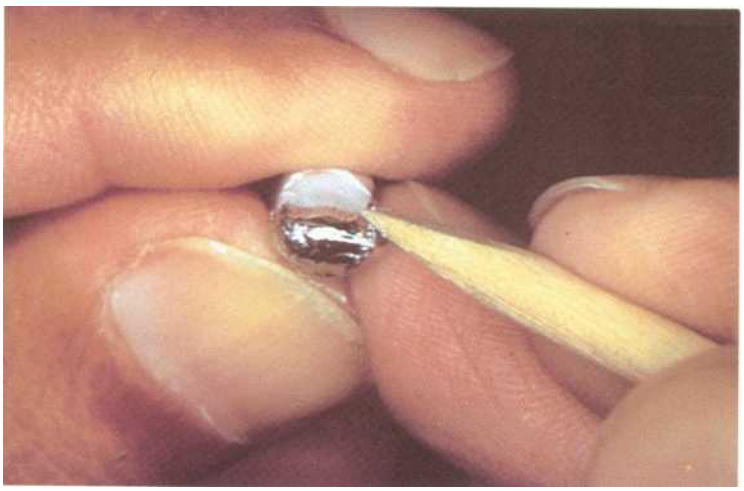


Fig. 11-47

The foil is secured incisally by flattening the foil at a 45 degree angle from the incisal wings toward the lingual midline.

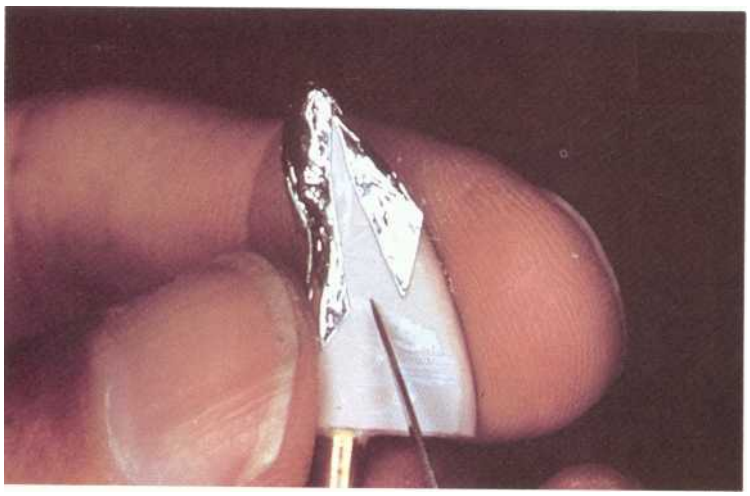


Fig. 11-48

All excess foil beyond the mesial and distal margins and the lingual-incisal edge should be cut using a #11 scalpel.

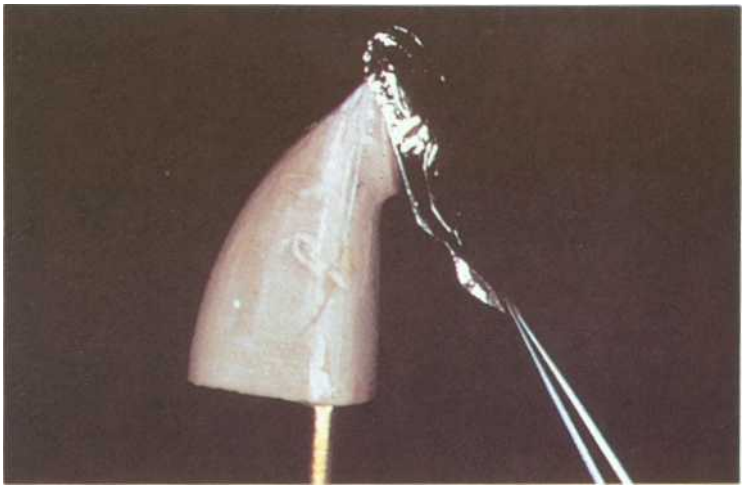


Fig. 11-49

In order to remove the foil from the die, the tab portion must be gently lifted in a hinge-like movement from the gingival margin toward the incisal edge.

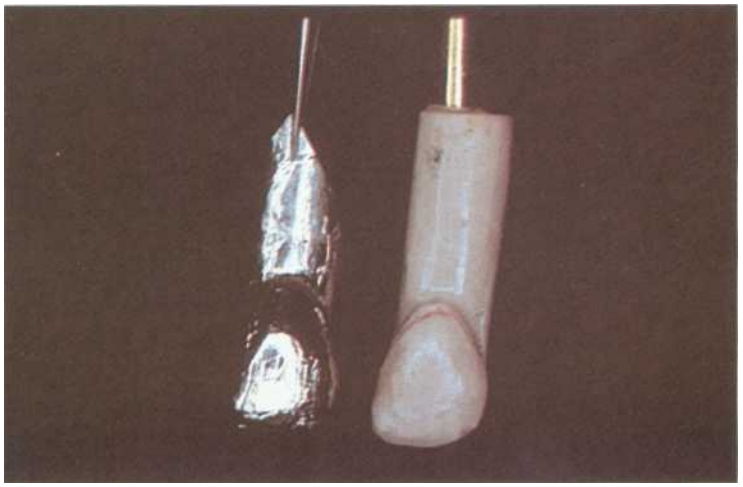


Fig. 11-50

The completed foil matrix represents a duplicate of the shape of the die to which it was applied. When all foil matrix procedures are carefully followed, the matrix will not bend or change shape.

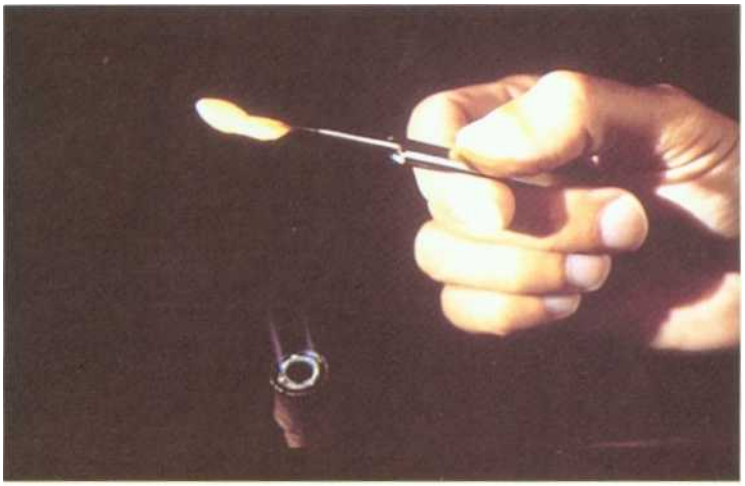


Fig. 11-51

The foil matrix is then held above a cone-shaped flame of a bunsen burner, or a vertical torch flame until the foil is bright orange. This procedure decontaminates and anneals the foil to a dead soft state.

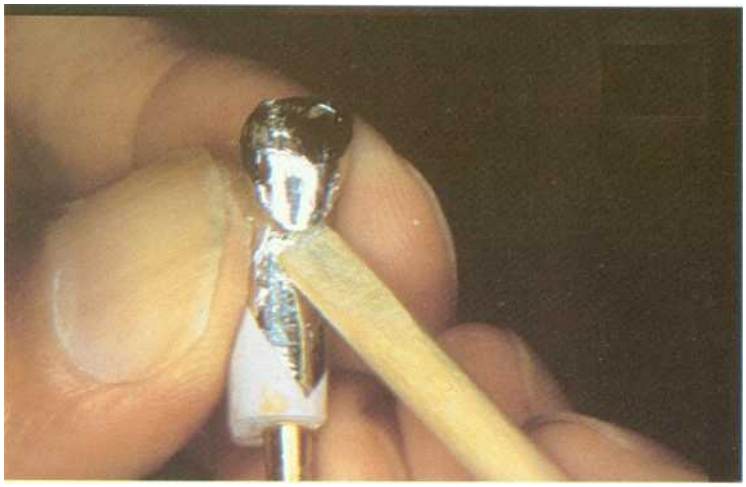


Fig. 11-52

The annealed foil matrix is placed on the die by positioning the matrix at the incisal edge and carefully lowering it into place using a hinge-like movement. The foil should be lightly re-burnished onto the die.

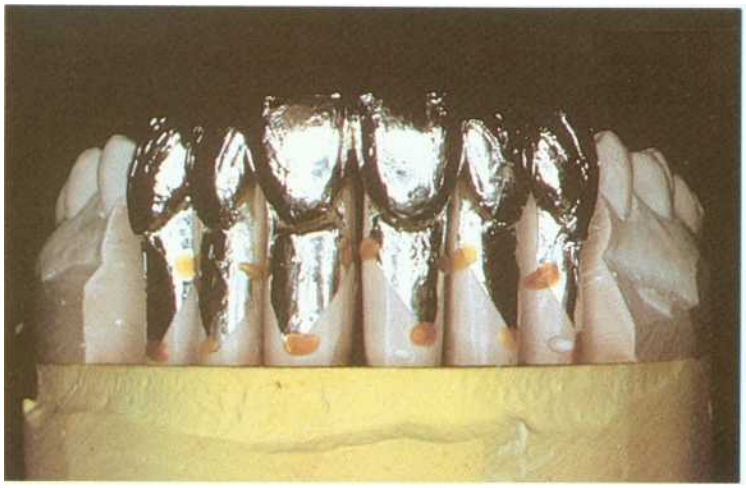


Fig. 11-53

The foil is secured to the die with a dot of sticky wax at the mesial, distal, and apical locations on the tab portion of the foil. The dies should then all be returned to the pin-indexed base for the porcelain buildup and evaluation.

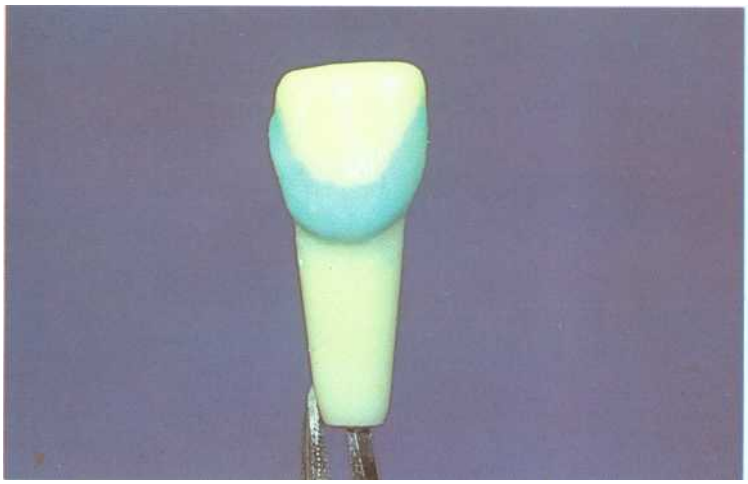


Fig. 11-54

Porcelain specifically formulated for veneering techniques is recommended for optimum esthetic results. Body porcelain one shade darker than the prescribed shade is applied from the gingival margin to just below the middle third of the labial surface. The gingival porcelain should be extended into the proximal curvatures to create a visual trapezoidal effect.

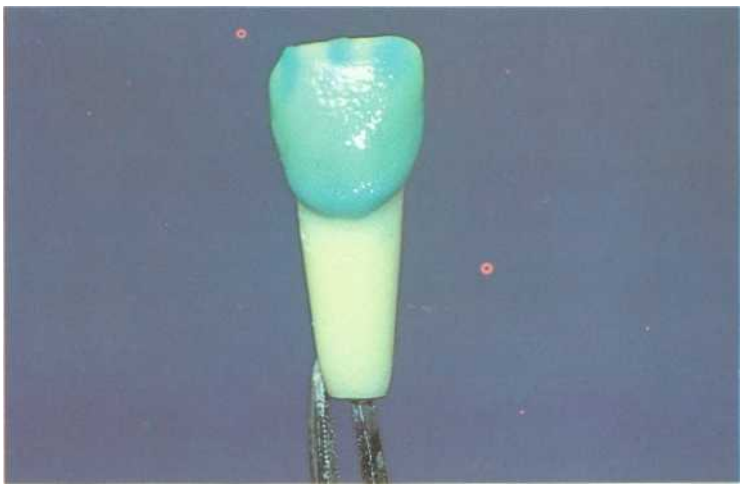


Fig. 11-55

The prescribed shade of body porcelain is applied, feathering it slightly over the darker gingival shade. The build-up procedure is continued from the middle third to the incisal third with feathering strokes. Three lobes of the prescribed body shade porcelain should be placed to create a mammelon effect. In both interlobular areas there should be a small amount of gingival porcelain shade for visual contour.

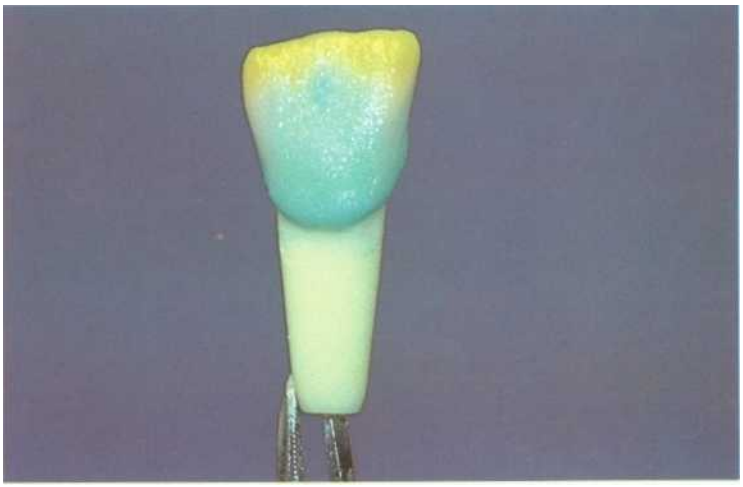


Fig. 11-56

Incisal porcelain is applied to the desired length of the restoration. The incisal build-up should extend over the incisal edge to the lingual-incisal line angle. The porcelain build-up should terminate at the lingual-incisal line angle unless the lingual surface has been prepared by the dentist.

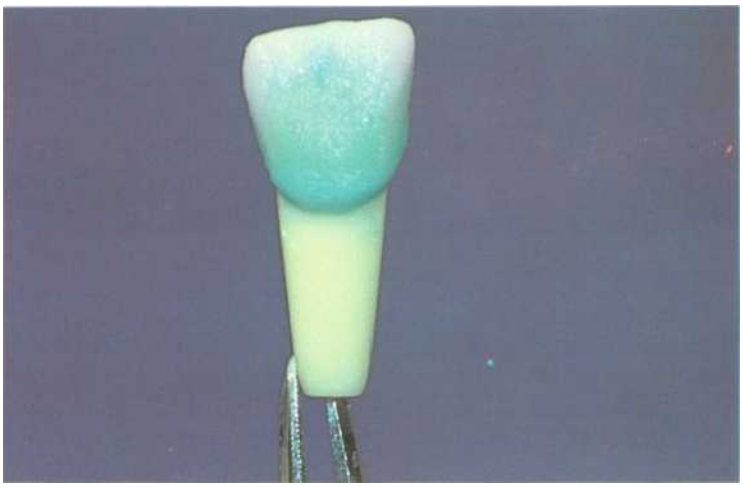


Fig. 11-5

Enamel porcelain is selectively applied from the incisal edge to the middle third of the tooth to create the translucent effect naturally found in this area. Either a brush or an instrument is used to form the labial anatomy, and light vibration is carefully employed to condense the porcelain.

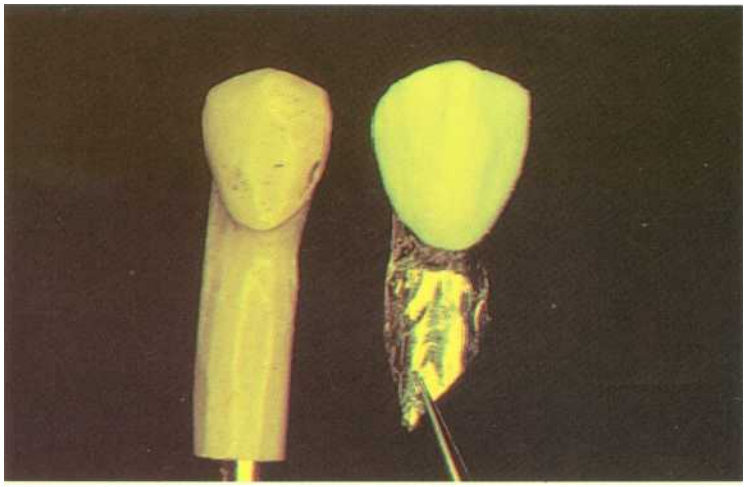


Fig. 11-58

The foil is then lifted by the tab portion at the base of the die in a hinge-like motion, lifting it away from the labial surface of the die, up and off the incisal-lingual edge.

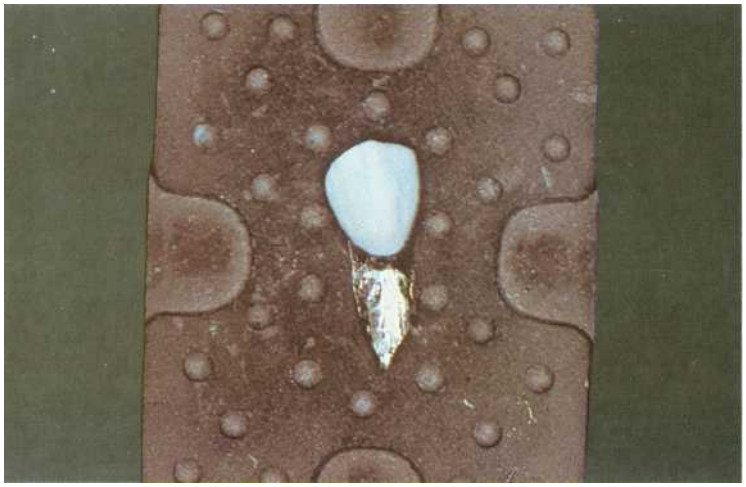


Fig. 11-59

After bench setting for five minutes on a saggar tray, the porcelain with the foil matrix is fired.

FIRING CHART

Procedure	First Bake	Second Bake	Glaze
Predry Time	5	5	0
Predry Temp. °F	72	72	NA
Entry Time/Min.	1.5	1.5	0
Entry Temp °F	950	950	1200
Air Fire °F	1100	1100	1730
°F/Min.	75°F/Min.	75°F/Min.	75°F/Min.
Vacuum	26-29	26-29	
Fire to °F	1750	1740	
°F/Min.	75°F/Min.	75°F/Min.	75°F/Min.

Fig. 11-60

This chart shows the firing instructions for PVS porcelain, by Cercom International, Inc.

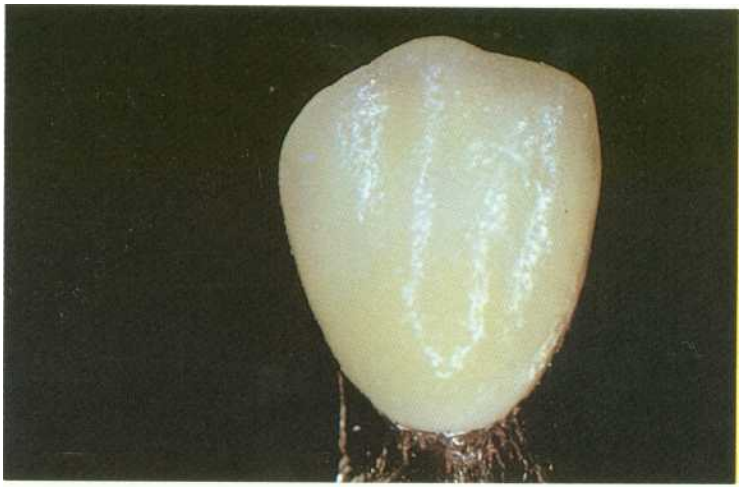


Fig. 11-61

The porcelain is fired to its full maturity on its first bake and should have a lustrous, stippled appearance. Color definition and natural translucency are readily visible as a result of the four stage porcelain buildup.

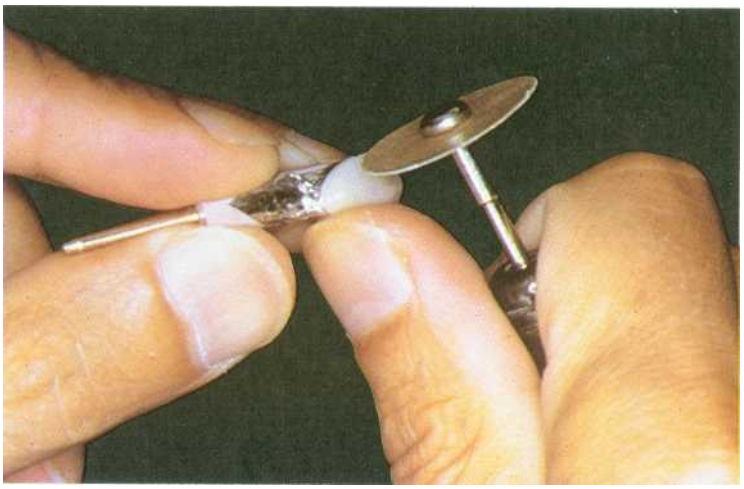


Fig. 11-62

The foil matrix and the covering porcelain are returned to the die for finishing and contouring. A medium grit sandpaper disk is recommended for trimming the margins and contact points. Further finishing should be accomplished with microfine friction-grip diamonds (15 to 45 grit) and a high speed handpiece. Marginal areas are contoured with sandpaper disks. Flame-shaped diamonds can be used for facial contour.

Fig. 11-63

Each die is replaced in the master model successively, until all contact points are adjusted.

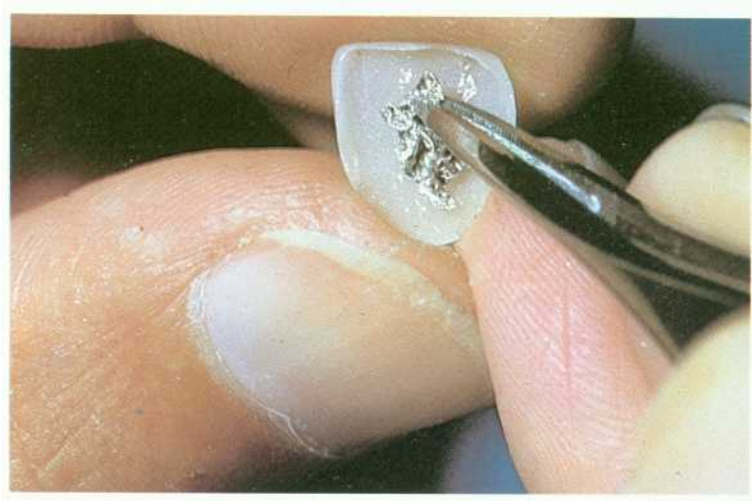


Fig. 11-64

A slurry mix of glaze is applied in a thin layer on the porcelain surface to seal microporosities and create a vital luster. Stains may be applied at this time to add definition and character. Stains are allowed to dry prior to the final glaze firing (1700 degrees F).

The serrated-edge tweezers are used to remove the platinum foil. The foil is gripped and peeled from the inner face of the veneer revealing a smooth, glass-like surface. The inner surface of the veneer must be etched to create a surface suitable for fusing to the tooth.

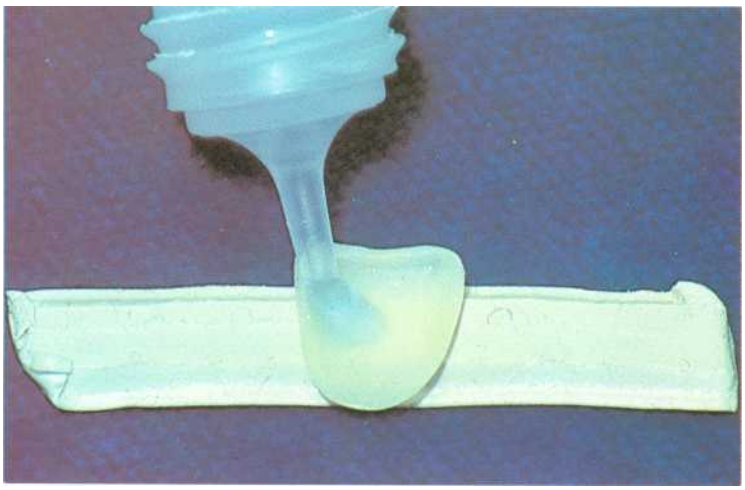


Fig. 11-65

The veneer is placed on a Mortite strip. A suitable etching gel is thoroughly spread within the concave inner surface of the veneer for the manufacturer's recommended time.

A neutralizing solution is prepared and the veneer with Mortite strip is submerged in the neutralizer.

After the veneer is cleaned in a soapy solution, the veneer intaglio is air abraded with aluminous oxide and cleaned again before final placement on the master model.

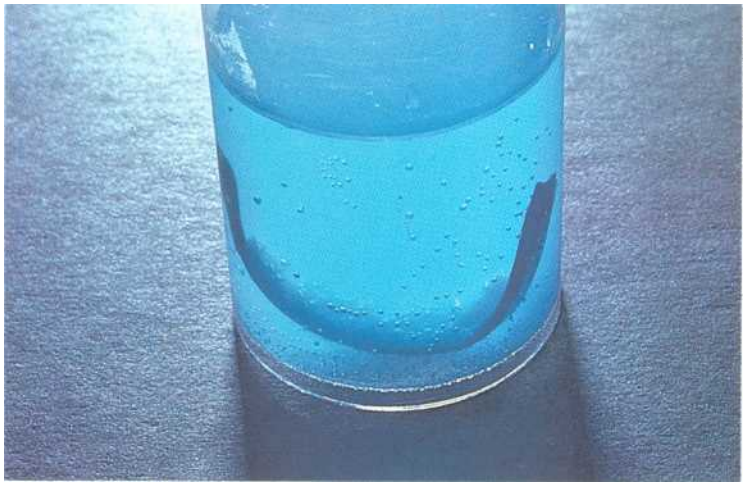


Fig. 11-66

When all the steps are carefully followed, the resultant porcelain veneers rival traditional crown and bridge prosthetics in esthetics, fit, durability, and longevity.

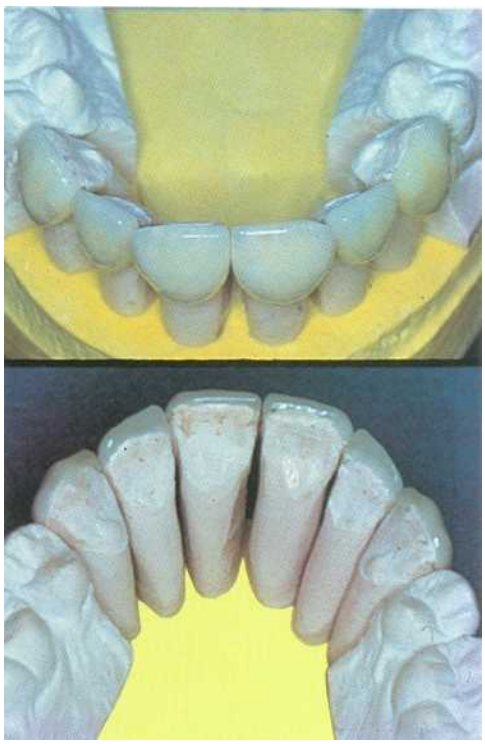


Fig. 11-67

Chapter 12 PORCELAIN INLAYS AND ONLAYS

Bonded (fused) porcelain veneers were such an instant success that it was not long before work began to extend the technique to the posterior region. Once again, clinical success was almost immediate. While it is not within the scope of this text to fully describe and discuss porcelain inlays and onlays, this chapter will provide a very brief introduction on the subject.

The most obvious advantage that the patient derives from posterior porcelains is the excellent esthetic potential that they offer. Using porcelain, a truly cosmetic restoration can be fabricated that to all intents and purposes is indistinguishable from natural tooth structure. The desire for an increased natural appearance is a sentiment that dentists hear more and more every day. Obviously, the gold inlay/onlay is no longer being accepted as a "cosmetic" treatment modality.

Not surprisingly, the most common request for porcelain inlays is in the maxillary bicuspid region. Amalgams give the teeth a grayish appearance when seen through enamel walls, and are even more unsightly when seen as part of the buccal surface .

Fig. 12-1

Fig. 12-2

These teeth are readily visible in most smiles, and occasionally the amalgam-clad occlusal surfaces themselves contribute to the overall lack of esthetics.

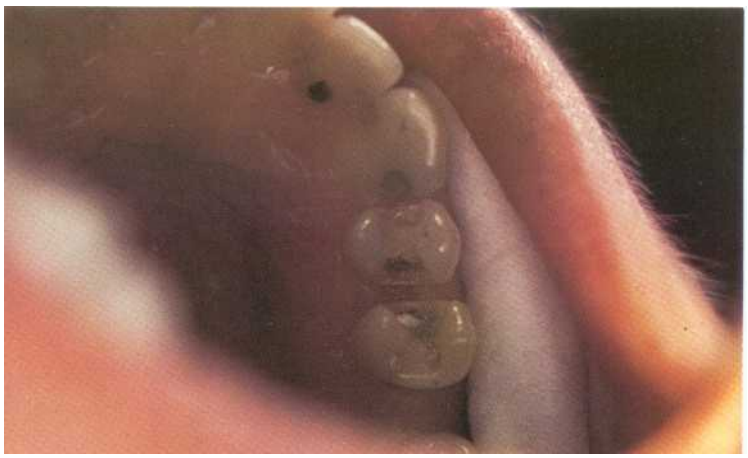


Fig. 12-3

Thus it is easy to see why porcelain inlays and onlays are popular with patients. In this case, for instance, the procedure was strictly an elective cosmetic process. The offending amalgams were removed, taking care to conserve as much enamel and dentin as possible.

The teeth were then temporized normally except for the choice of cement. During temporization it is important to avoid using any cement which contains eugenol, since eugenol can interfere with the subsequent bonding procedure.

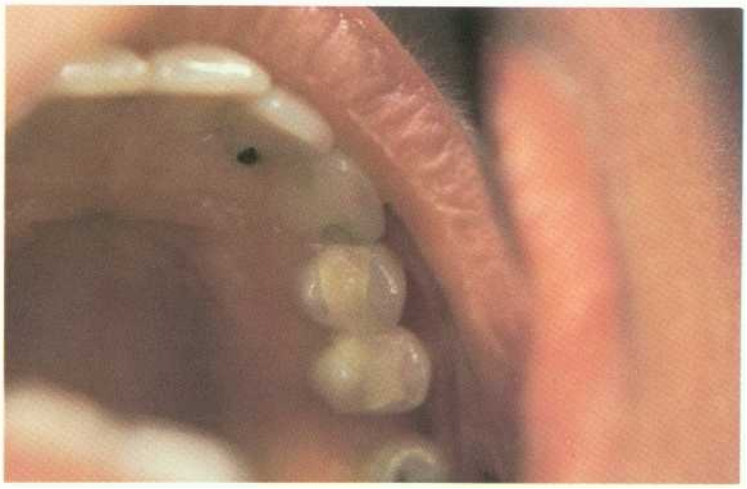


Fig. 12-4

In these photographs of the completed case, the gray tone of the bicuspids has been replaced by a natural, healthy appearance. Also note the shade incompatibility on the mesio-buccal of the second bicuspid. In this case, a variability of luting composite shades would have been very helpful.

Fig. 12-5

The occlusal surfaces of the inlays demonstrate the artistry that the laboratory technician can and should apply in the fabrication of these restorations.

Fig. 12-6

The list of reasons to employ fused porcelain inlays and onlays goes beyond simple esthetics. Porcelain restorations are much more conservative than complete coverage of full crowns. In the case of porcelain inlays/onlays, the only parts of the tooth that need to be removed are the decay and the access zone. In the replacement of amalgam restorations, only the old amalgam is eliminated; if there is no recurrent decay, all the healthy enamel and dentin can be maintained.

When composite resin is used as the complete filling material for posterior restorations, the overriding concern is that the composite will wear faster than the surrounding tooth structure. When porcelain is utilized, this is no problem. In fact, the porcelain wears more slowly than the adjacent dental structures.[1]

In many ways, the porcelain inlay is proving superior even to the gold inlay. The major weakness of the gold inlay is found at the margin; the cement is much weaker than either the tooth or the inlay. With this weakness, the gold inlay often failed because of marginal leakage and recurrent caries. Though current cements are much improved, none can match the integrity of a porcelain fused to enamel interface.

Additionally, evidence is mounting that a porcelain restoration which has been fused to the tooth structure increases the tooth's resistance to fracture.[2]

It may come as a surprise to some that, as with several of our state of the art "high tech" modern dental techniques, the porcelain inlay is not at all new. Porcelain has been used in Class V inlays since the last century. These simple inlays were even routinely etched on their inner surface by hydrofluoric acid, but were held in place with zinc oxyphosphate cement. The needed additional retention was afforded by placing a groove in the axial walls of the tooth midway between the pulpal floor and the enamel margin. A similar groove also was cut into the porcelain inlay.

But simply being able to produce a porcelain inlay was not enough. In a Class V facial restoration, not only must the cement fulfill all the usual requirements (such as low film thickness, high adhesive strength, lack of toxicity, etc.), but also it must have superior esthetic qualities. Clearly, the early use of zinc oxyphosphate to cement porcelain inlays resulted in esthetic restoration outlined by an unesthetic ring. In addition, the need for a cement of minimal solubility is much more stringent with porcelain than with a burnishable material like gold.

These two problems were so severe that the porcelain inlay never really achieved widespread acceptance. Still, the potential of a dental restoration composed of porcelain was clear, and several dentists kept the torch lit over the next century.

Accuracy in manufacturing was a crucial issue, since this would minimize the demands upon the luting cement. Many manufacturing techniques were developed and discarded over the years.` These included compressing porcelain powder into a mold and subsequently firing the porcelain, injection molding of molten porcelain, platinum and gold foil used as a matrix, utilizing preformed blocks of finished porcelain cut from denture teeth as a matrix, as well as other innovative approaches. Over time, the approach which seemed to come closest to the ideal involved the use of an investment model. Still, until recently even this technique was not usable for Class 11, 111 or IV restorations.

It was not until 1986, when McLaughlin patented a technique utilizing a full statue of the tooth made of refractory material, that the laboratory phase of porcelain inlays and onlays became a routine procedure.'° A second method has also been patented by Greggs. This second method uses a platinum matrix instead of the refractory model".

With the resolution of the laboratory difficulties, the remaining problems with porcelain inlays and onlays centered around the cement. Since porcelain fusing with composite resin was so successful in the anterior regions, it seemed an obvious step to utilize the same techniques to hold porcelain inlays and onlays in place. As a luting agent, composite could easily solve the mechanical and esthetic problems, leaving only the possibility of pulpal damage from the luting resin and poor adhesion to dentin to be solved.

In addition, the ideal handling characteristics of a luting resin for inlays still had to be delineated since they are different from those of veneers. Both chemical and light cured materials have significant drawbacks in this application. A self curing composite takes about four minutes to set in the mouth. This length of setting time can create difficulties in keeping the inlay in place and in assuring adequate moisture control. Furthermore, the margins cannot be finished until the set is complete, for fear of disturbing the seating of the restoration. If there is a significant quantity of excess composite interproximally, it can prove very difficult to remove since the material is very hard and the instrument access almost impossible. The color match between the tooth/porcelain/composite is often so good that the flash may be difficult or impossible to identify, at least until it has caused serious periodontal problems.

This would seem to indicate that light cured materials should be utilized; the dentist can seat the restoration at his leisure, eliminate excess material, and cure when ready. Unfortunately, the light from the curing unit does not pass through porcelain very easily. Even a thin layer (1-2 mm) of relatively non-opaque porcelain can diffuse the light to an extent that its curing capacity is severely curtailed. While the readily accessible margins are

usually cured to hardness, the underlying floors of the cavity preparation and the pulpal walls of any boxes will often maintain uncured composite resin. A similar situation exists at any gingival floor of the deeper parts of the preparation. As a result, there have been a number of early failures with porcelain inlays and onlays, and many practitioners have lacked the confidence and clinical assurance to continue with this mode of treatment.

Fig. 12-7

Almost as soon as glass ionomer materials such as Shofu Glass Ionomer Cement Filling Material-Type II were discovered, it was clear that they were suitable for use as a base under fillings in all but the deepest places. In the case of porcelain inlays, these materials are utilized to replace all the dentinal structure that has been removed by decay or access, as well as the filling of the box portions of interproximal preparation areas. Glass-ionomers are well tolerated by gingival tissue, [12] and will bond to dentin." Furthermore, after setting, they can be acid etched for subsequent bonding procedures. [14,15]

By utilizing glass ionomer cement as an etchable base, the practitioner can minimize the thickness of the porcelain which is desirable since unnecessary thickness can often frustrate proper light-curing. The glass-ionomer can be built up to within 1-2 mm of the required occlusal height, and the laboratory fabricated inlay/onlay will complete the remaining vertical dimension. There is little doubt that the stronger curing light units will penetrate this thickness of porcelain as long as it is relatively transparent.

There are still limitations for this approach, however. These include the degree of color change that can be effected with the relatively thin porcelain, the difficulty in temporizing such a small volume of missing dental material, and the extreme technique sensitivity involved. In addition, the bond strength of glass ionomer to dentin is less than that achievable with the newer dentin bonding agents, such as GLUMA (Columbus Dental, St. Louis, Mo.) and Scotchbond 2 (3M, St. Paul, Minn.).

In general, therefore, the most suitable material for the placement of porcelain inlays/onlays is a dual-cure material; that is, a composite bonding material whose setting is initiated by means of a conventional curing light and continues until completion through a self-curing process. These materials are often referred to as "continuous cure" materials because of this unique characteristic. When attaching porcelain inlays using a dual-cure composite resin, the margins can be externally light-cured to eliminate the possibility of leakage, and once curing is thus initiated, all the remaining internal composite fusing material (as well as those margins that are inaccessible to direct curing) set within a short time. There are a number of these dual-cure materials available currently, but unfortunately, they all lack a range of shades that cosmetic dentistry absolutely requires.

Still, there appear to be some very promising materials on the horizon. These combine the properties of dual-cure, multiple shade availability, and true dentin bonding. With their advent, the use of cosmetic inlays/onlays is sure to increase and become a part of every dentist's repertoire. While the future will certainly see changes in the technique for porcelain inlays and onlays, it will also most assuredly see increased utilization of this fine technique.

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Chapter 13 CONCLUSION AND THE FUTURE

It has been less than a decade since the phenomenon of fusing porcelain directly to the tooth was first described. Since that time, the growth and development in the field has been nothing short of meteoric. The technique has already progressed a long way from its first tentative steps.

Possibly of equal importance has been the rapidity with which this new technology has been embraced. In 1987, just four years after its introduction, one survey indicated that over half of the dentists in North America were already performing some type of bonded porcelain procedure.

This is a cause for both excitement and caution. It is cause for excitement because the technique has obviously been shown to fill an important need. Yet it is cause for caution because the science is still in its infancy, and this fact can easily be forgotten in light of its widespread acceptance.

Though these procedures have now been incorporated by a majority of dentists, their relatively recent advent must not be forgotten. Even those practitioners who have made wide use of the techniques must constantly remember that the techniques are still in a stage of rapid evolution. The need for continually updating our knowledge of materials and methods is particularly acute during this period.

Several groups and publications have sprung up to help answer the need for continuing education in the area of Cosmetic Dentistry. Organizations such as the American Academy of Cosmetic Dentistry can help both the neophyte and experienced practitioner by serving as a network that shares developments in the field. The reader is encouraged to avail himself of these opportunities.

The future holds promise for better methods of attachment and improved formulations of ceramics. In addition, new applications of the technology are already being developed. Bonded inlays, onlays, full crowns, all porcelain bridges, orthodontic applications, and other even more innovative applications are already being developed.

Doubtless, by the time this book reaches your hands some of its content will already have been superseded by newer, better methods.

This is how it should be.

It is an exciting time in dentistry.

APPENDIX*

Smile Analysis

Face shape modifier

Main shape
_____ Square
_____ Square tapering
_____ Tapering
_____ Ovoid

Modifier
_____ Ovoid

Size

Mesio-distal (at temples) _____

Vertical (taken at chin) _____

Distal of cuspid to distal of cuspid _____

Mold _____

Teeth shown 7 6 5 4 3 2 1|1 2 3 4 5 6 7

Midline disharmonies

Face to maxillary teeth _____

Maxillary to mandibular teeth_____

Lipline High _____ Normal _____ Low _____

Gingival contours _____

Malpositioned teeth _____

Tooth length discrepancies _____

Occlusal disharmonies _____

Shade

Basic shade _____

Gingival modifier _____

Incisal modifier _____

Degree of masking needed _____

Characterizations _____

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