

in which the dentition is in perfect harmony with the face of this ever-joking French comedian. Nature has done a wonderful job here in combining form and position harmoniously with the peculiarities of his face and his overall personality.

Characteristics such as health, well-being, a sense of order, and discipline will find important expression in the human dentition as in all other parts of the body.¹ Very often this is defined as perfect harmony or esthetic appearance. What is esthetics? A dictionary defines it as follows: "Esthetics is everything that can provoke a perception of beauty." Thus, esthetics is very often a personal or a common appreciation. Appreciation and perception of beauty varies in different ethnic populations and also throughout historical periods. Today, in most parts of the world, a normal and healthy dentition is an absolute prerequisite for a pleasing and esthetic appearance.³ Clinicians cannot afford to ignore this simple fact of life. But there is still a question: How far do we have to go to obtain an esthetic dentition?

The Evolution of Dental Care

Historically, and even today in certain parts of the world, dental care is restricted to the alleviation of pain and discomfort. With the introduction of restorative materials in dentistry, carious lesions were treated, and the teeth were retained in spite of the limitations of these restorative materials. Large cavities had to be drilled and sound tissue sacrificed to create the retentive conditions for a long-lasting result. Because of these in-

terventions, millions of teeth could be saved, and normal oral function could continue for many years. However, that treatment, which aimed to stop the infection and the pain, also had its disadvantages. The initial lesion frequently recurred because no adequate remedy was available to combat leakage and cariogenic flora. Furthermore, the gradual breakdown of the restored teeth, which resulted from the loss of tissue, was one of the consequences of such restorative care.

Adhesive dentistry eliminates some of the drawbacks of conventional restorative dentistry. New materials were proposed and new methods tested.⁴ It took more than 40 years to reach an acceptable level of confidence. It all started with the restoration of fractured incisal edges.⁵ Enamel etching, initially scorned by colleagues in the profession, proved to be a reasonable method to enable restorative material to bond to fractured anterior teeth, especially in younger patients for whom a prosthetic solution had to be postponed for biologic reasons.⁶ That therapy quickly became a success story all over the world and opened the door for more change^{7,8} (Figs 1-2a and 1-2b).

Shortly thereafter orthodontists realized the advantages of bonding brackets directly to enamel, thus eliminating the need for multiple bands. Orthodontic therapy became easier and more affordable.

Some time later clinicians started to use enamel bonding to restore small carious lesions in anterior teeth.⁹ Pushing this new technique to its limits, they achieved invisible restorations (Figs 1-3a and 1-3b), which could be perceived only by a well-trained eye.



Figs 1-4a and 1-4b Diastemata due to a tooth-arch discrepancy before treatment (a), and after treatment (b). Tooth form, alignment, the golden proportion, and the midline have been respected.

Greater difficulties were encountered when bonding to dentin, and only recently have techniques and materials been developed to offer comparable results to enamel bonding.¹⁶ Nowadays, this problem seems to have been largely resolved.^{17,18} As patients keep their teeth longer, cervical lesions are becoming more frequent, with dentin as the only substrate to be bonded to.^{19,20} The circular root lesions often present in older teeth are difficult to manage without adhesive dentistry.

Clinical investigations have demonstrated the feasibility of adhesive restorative dentistry,^{8,21} and efficient preventive measures have proved to counteract the impact of caries on the human dentition. Smaller and fewer lesions are encountered today.^{22,23} Studies have shown that microorganisms cannot survive in a sealed restoration, so caries progression underneath these restorations is stopped.²⁴ With reduced caries occurrence and more restorative possibilities, treatment requirements have shifted.²⁵ Pain is no longer the principal motive for a dental appointment. Other needs are emerg-

ing, while the older ones are diminishing and newer possibilities are becoming available.

Changing Life Patterns

In the Western world, the media is often the predominant source of information, and its influence extends around the world. From dawn to dusk, information pours out in different forms and formulas, and it is always accompanied by advertising. The most striking theme in advertising is that "beautiful is always better." This is especially characteristic among salespeople, people in the public sector, and actors, who in their daily work have to please as many people as possible. Their appearance is therefore very important.²⁶

Not every human being is born with a pleasing appearance, so plastic surgery, dermatologic intervention, and dental treatment are often needed to satisfy the minimum requirements of social contact.²⁷ These treatments or interventions are focused not only on improving ap-

pearance but also on enhancing interaction with others. In a highly competitive world, a pleasing appearance is often the difference between success and failure.²⁸

The role of dentistry in providing an acceptable appearance cannot be ignored, and although most practitioners are trained to relieve pain and maintain the masticatory function of the dentition, they should not forget that other functions are also important. While it is right to focus on the lifetime function of the dentition, as this is its principal purpose, other treatments that improve esthetics and clearly benefit the individual without harming the dentition or other oral structures must not be excluded. When the principal requirements are met, esthetic demands must be heard, analyzed, and addressed in a justified manner. Although an unpleasing color is not a disease per se, the patient may consider it a disease, meaning that the oral condition disturbs his or her well-being.

Conditions and Rules for Esthetic Treatments

Clinical investigations are still needed to set the limits of current restorative materials and techniques.²⁹ In the last three or four decades, tooth-colored materials have been subject to scrutiny all over the world. For the restoration of anterior teeth, resin composites maintain their lead, but other materials available on the market also have their advantages. Microfilled resin composites can offer improved esthetics but are vulnerable in stress-bearing locations.³⁰⁻³² Small-particle hybrids or medium-filled, densified composites also offer more strength and

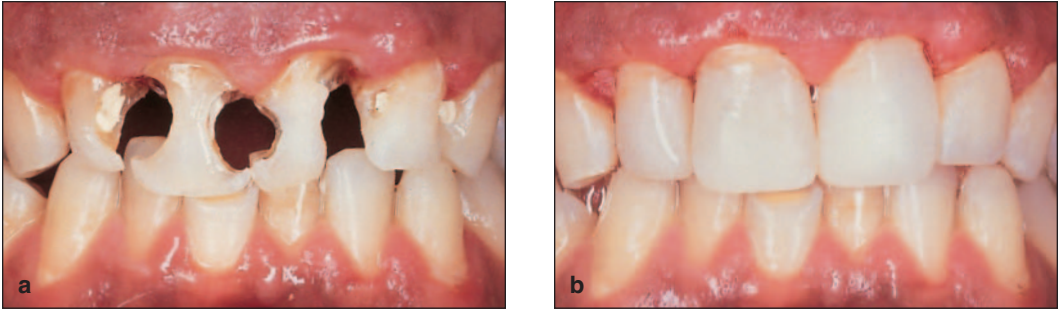
acceptable esthetics,³³ and they are the materials of choice in larger restorations. Ultrafine, compact-filled, densified composites are the materials of choice in the posterior region because they combine strength, wear resistance, and surface smoothness.³⁴

Enamel and dentin bonding have gained widespread acceptance, and long-term clinical results indicate that the best results can be obtained using smear-layer removal systems in a total-etch form applied in three steps.¹⁷ New materials with a reduced application time and less risk of error are still under investigation.³⁵ A sealed restoration has definite advantages over a conventional restoration with no bonding. This is particularly true for small restorations or restorations where sufficient tooth structure is present to counteract the shrinkage stresses induced during the curing of the resin composites.

Bonded resin composite restorations are less durable than metallic and porcelain structures, but the invasive and irreversible character of an indirect approach offsets much of their advantage. Last but not least, their cost makes them unaffordable for much of the population.³⁶

Bonded restorations can last for more than 5 years if patients maintain an acceptable level of oral hygiene, and minor adjustments can extend this time.¹³ The periodontal response is acceptable as long as fundamental rules are respected.^{13,37-39}

Today many lesions can be treated with a direct method. Sometimes, this approach can be used as a temporary solution in anticipation of more complicated work (Figs 1-5a and 1-5b). A re-



Figs 1-5a and 1-5b Severe and minor defects on the central and lateral incisors (*a*). A direct adhesive restorative treatment (*b*) has resulted in an acceptable temporary solution in anticipation of more complicated work.

versible treatment mode will provide the clinician with time to prepare a more complex intervention. Nevertheless, all direct restorations need a minimum amount of dental substrate for bonding. If the amount available is insufficient, an indirect approach must be considered.

How far should practitioners go to enhance esthetics? The answer is, as far as the dental treatment remains a treatment. Nowadays, the proper use of resin composites with adhesive techniques is entirely justified in the anterior dentition and partially justified in the posterior region.⁴⁰ Nevertheless, all treatment must be based on sound professional judgment and not on experimentation or on emotional or financial motives.

All treatment must be based on the basic rules of dental care. First, normal function of the dentition must be guaranteed over the long term.⁴¹ Second, all harm must be excluded.

Therefore, all carious lesions must be eliminated first, the pulp tissue must be allowed to recover, and then the defects have to be repaired. That process will take some time, so the clinician will have

an opportunity to develop a plan for addressing other requirements. All caries activity must be reduced to a normal level by means of normal or additional caries-preventive measures. The outcome of this approach can also be measured. Oral hygiene must be sufficient so that periodontal health can be assured. Monitoring the patient over long periods is necessary. Finally, all treatments must result in acceptable masticatory function. Once these basic requirements are met, the esthetic treatment can be considered, as it can enhance the benefit of the overall treatment and increase the satisfaction of both the patient and the practitioner.

Patients can exhibit different levels of oral fitness. Those who can meet the basic requirements concerning caries activity, periodontal health, and masticatory function over long periods of time can be considered for esthetic treatment. Others must participate in a series of preliminary sessions that provide information about not smoking or eating or drinking substances that may harm the restorations before they can become a candidate

for esthetic treatment. Clinicians have to be flexible in their daily work but should not forget that a number of patients are orally unfit for esthetic restorations. The basic rules for success in dentistry must not be neglected, because esthetic restorative dentistry can be a minefield for the clinician. Commitment from both the patient and the dentist is needed to ensure long-term success. In cases where this is lacking, it is wiser to refrain from acting.

As dental esthetic restorations are judged by the final outcome rather than by the effort invested in realizing them, careful attention should be paid to the preparation of the treatment. Clinicians must have a clear knowledge of the prospects offered by esthetic interventions. Furthermore, the practitioner has to know the results of controlled clinical investigations, which provide information about the longevity of these treatments. Each new clinical technique should undergo validation against objective criteria over a long period of time and in sufficient numbers so that the limits of application can be clearly designated. Within the established limits, a particular restoration mode can be justified.

Practitioners must not only be familiar with the different esthetic dysfunctions that can occur in the dentition,⁴² they must also be able to grade them on a scale from minor to severe. Treatment, if affordable, should be advocated when the dysfunction is clearly disturbing. In such cases, both the patient and the clinician must have a say in the decision making.

Patients with esthetic complaints often make demands beyond the clinician's ability to treat the situation, and some-

times patients are unable to define the dysfunction of their appearance. Therefore, a careful discussion, perhaps aided by study casts and photographs, should precede all treatment.⁴³ Patients who opt for a direct approach using resin composite materials must be aware of certain obligations afterward. In addition to rigorous oral hygiene, they must refrain from consuming food or drinks rich in pigments. For the same reason, smoking should be ceased. Finally, an annual visit to the practitioner is needed to assess and possibly repair shortcomings. Although esthetics are not essential for the survival of the dentition, their careful selection and application will provide great satisfaction and function to the patient.

Conclusion

As the incidence of caries has been reduced and patients keep their teeth longer, patients are requesting more treatment to enhance esthetics. The advent of adhesive dentistry and the development of resin composites have opened new possibilities for dental esthetics. With careful selection of an adhesive technique by the clinician and diligent oral hygiene by the patient, bonded composite restorations can provide a successful outcome that satisfies the requirements of both parties.

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Composite Layering

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Abstract

Composite layering allows the clinician to accomplish invisible restorations—that is, restorations that cannot be perceived by the patient. The prerequisite is the meticulous application of adhesive technology and the use of composite materials in different translucencies: “dentin,” “enamel,” and special effect material (eg, “clear”). Using these materials, dentin is replaced by an opaque composite and enamel by a more translucent one to mimic nature. Furthermore, mechanical and physical properties must be respected, especially in large and complex cavities. For these cases, a special layering technique is proposed for restoration of both anterior and posterior teeth. In the anterior segment there are two options: Many cases can be satisfactorily restored with a two-layer technique, or a three-layer tech-

nique can be used to obtain the best esthetic integration of the restoration.

Esthetic dentistry requires the clinician to mimic the natural tooth by inserting restorations that are invisible (or at least imperceptible) to the patient. To do so, the clinician must be familiar with the neighboring structures, such as the tooth to be restored, adjacent teeth, the antagonists, the lips, and the whole face. The less structure that remains, the more the reconstruction is guided by the knowledge of esthetics—rules that govern shapes, proportions, relations, and colors.^{1,2} This is the case if complete dentures or extensive fixed partial denture reconstructions are fabricated. In operative dentistry there is usually a different challenge: Only portions of a single tooth are to be reconstructed. Therefore, the different anatomic structures of the single



Fig 10-6 Debonded resin-bonded prosthesis. (Courtesy of Dr S. Northeast.)

resin-bonded prostheses, this is an application worth exploring further. The adhesive resins are popular precisely because of their adhesive qualities. Nevertheless, debonding of resin-bonded prostheses is a common mode of failure.¹⁷ The general view is, quite reasonably, that the higher the bond strength of the resin to the metal, the less likely it will be that the resin-bonded prosthesis will debond. In a tensile bond strength test carried out by Degrange and Attal,¹⁸ an MDP-based adhesive showed a bond strength nearly three times greater than that of a 4-META-based resin, 71 and 28 MPa respectively, and well above that of the resin-bond to enamel. However, does this mean that the MDP-based luting resin will perform better? With retainers having a surface area of approximately 10 mm², the tensile force required to cause a debond would have to be in the region of 300 to 700 N. Such high forces on a resin-bonded prosthesis are very unlikely. So, if they adhere so well to the metal, why do resin-bonded prostheses debond, and why does this debond typically occur at the metal-resin interface rather than at the enamel-resin interface (Fig 10-6)? An

interesting observation made by Creugers and Käyser¹⁷ was that prostheses that had debonded were considerably more likely to debond again after re-bonding, suggesting that the problem is more fundamental than what at first glance appears to be merely a lack of adhesion.

In the case of resin-bonded prostheses, the adhesive plays a dual role. That is, it has to bond the metal to the tooth, and it also has to transfer the load applied to the prosthesis across the adhesive into the tooth. Since the prosthesis acts essentially as a beam bonded to the tooth surface, the adhesive layer will need to be able to resist a considerable amount of stress,^{19,20} and this suggests that a structural adhesive is required. That is, the adhesive not only has to bond well to the metal and the tooth, but it also has to be sufficiently strong to withstand the stresses within the adhesive layer. For example, glass-ionomer cements produce an excellent bond to enamel and dentin but make poor adhesives because of their lack of strength. In addition, inherent in the design of a resin-bonded prosthesis are highly local-

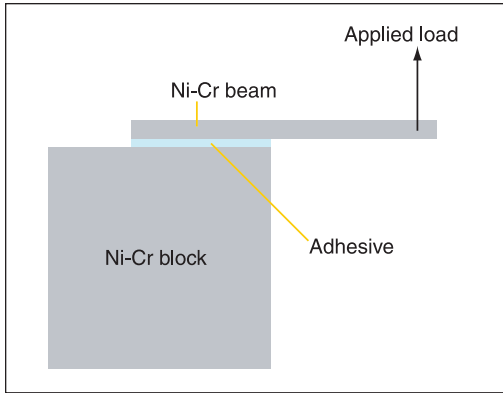


Fig 10-7 Schematic of the tensile peel strength test arrangement.

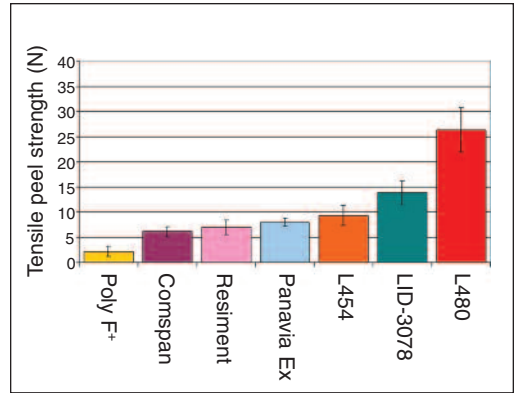


Fig 10-8 Tensile peel strength data for a range of adhesives with increasing fracture toughness, including a dental cement (Poly F+ [Dentsply, Weybridge, UK]), three luting resins (Comspan [Kerr UK, Peterborough, UK], Resiment [Septodont, New Castle, DE], and Panavia Ex [Kuraray]), and three experimental adhesives (L454, LID-3078, L480) provided by Loctite International (Dublin, Ireland).

ized stresses in the region of the connector, such that the adhesive has to be able to not only withstand very high stresses but also resist the propagation of cracks from any internal or surface defects. This means that the adhesive needs to be tough. However, most dental adhesives are brittle due to the nature of the resins used and the incorporation of particulate fillers. This aspect of the behavior of adhesives is frequently overlooked.

The concept of a tensile peel strength as a means of comparing the adhesive capabilities of luting resins was explored in a study by Northeast et al²⁰ in which a beam was bonded to a simple support structure (Fig 10-7). This study showed that the tensile peel strength was a function of the thickness of the beam, such that the thicker the beam, the less the tensile peel force. With a thicker beam the level of

stress within the adhesive layer was reduced. This demonstrates that the stress the adhesive has to withstand is an important contributory factor to the clinical outcome and is governed by the choice of alloy and its design. Northeast et al²⁰ also showed that the tensile peel force depended on the choice of luting resin. When a series of materials with increasing toughness were tested using the tensile peel strength test, it was found that, irrespective of their ability to bond to the metal, the tensile peel force increases as the fracture toughness of the adhesive is increased (Fig 10-8). Interestingly, De-grange and Attal¹⁸ showed that the 4-META-based luting resin is tougher than many other luting resins. It has also been reported that the 4-META-based resin caused fewer debonds of resin-bonded prostheses than when a more brittle bis-