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Grado en Odontología

PREPARATION TYPES FOR CERAMIC VENEERS

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ABSTRACTO

Antecedentes: Esta revisión bibliográfica identifica los diferentes tipos de diseños de preparación dental para las carillas de cerámica y compara su correspondiente pronóstico.
Objetivos: El objetivo de este trabajo es describir los diferentes tipos de preparación para carillas de cerámica.
Paralelamente, este estudio tendrá como objetivo:

1. Comparar los tipos de preparación en el límite cervical según su pronóstico a largo plazo
2. Comparar los tipos de preparación en el límite incisal según su pronóstico a largo plazo
3. Comparar las ventajas y desventajas de las preparaciones convencionales con las carillas "sin preparación".

Metodología: Se realizó una estrategia de búsqueda electrónica en MEDLINE, GOOGLE SCHOLAR, BIBLIOTECA CRAI y otras bases de datos. Las palabras clave utilizadas fueron carillas, tipos de preparación, tasas de supervivencia, solapamiento incisal, líneas de acabado.
Resultados: Los artículos fueron seleccionados de acuerdo con múltiples criterios de inclusión y exclusión. Un total de 76 artículos fueron incluidos en esta revisión. Se incluyeron en la revisión tanto estudios in vivo como in vitro, así como informes de casos, revisiones bibliográficas y extractos de libros. Se cuantificaron y analizaron aspectos de los diseños de preparación a partir de un análisis de estos artículos.
Conclusiones: Podemos distinguir tres tipos de preparaciones dentales para carillas anteriores: tipo I, tipo II y tipo III. 1) La preparación cervical en chamfer ligero es la opción más conservadora y adecuada y 2) Se deben favorecer las preparaciones incisales tipo I y tipo II (el tipo II presenta el menor riesgo de fracaso postoperatorio). La preparación incisal tipo III está contraindicada

ABSTRACT

Background: This literature review identifies the different types of dental preparation designs for ceramic veneers and compares their corresponding prognosis.

Obectives: The purpose of this work is to describe the different types of preparation for ceramic veneers.

In parallel, this study will aim to:

1. Compare preparation types at the cervical limit according to their long-term prognosis
2. Compare preparation types at the incisal limit according to their long-term prognosis
3. Compare the advantages and disadvantages or conventional preparations with the "no prep" veneers

Methodology: An electronic search strategy was conducted involving MEDLINE, BIBLIOTECA CRAI and GOOGLE SCHOLAR. Keywords used were veneers, preparation types, survival rates, incisal overlap, finish lines.

Results: The articles were selected according to multiple inclusion and exclusion criteria. A total of 76 articles were included in this review. Both in vivo and in vitro studies were included in the review, as well as case reports, bibliographical reviews and extracts from books. Aspects of the preparation designs were quantified and analyzed from a analyze of these articles.

Conclusion: We can distinguish three types of dental preparations for anterior veneers: type I, type II and type III. 1) The light chamfer cervical preparation is the most conservative and suitable option and 2) Type I and type II incisal preparations should be favored (Type II presenting the lowest risk of post-operative failure). Type III incisal preparation is contraindicated.

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I. INTRODUCTION

"Smile because your teeth aren't just for eating or bitting," said Man Ray, a 20th-century filmmaker and photographer. A large part of the population nowadays expresses a strong desire to present as aesthetically perfect teeth as possible. In parallel with this trend, well-informed patients prefer minimally invasive treatment modalities and in many cases do not want full-coverage crowns. These patients demand treatment methods preserving the hard tissues of the tooth without compromising on esthetic potential. Ceramic veneers which are cemented with adhesive technology, make it possible to carry out esthetic medical-dental therapy in many patients while at the same time preserving the natural tooth substance.

1. Definition of a dental veneer

A dental veneer is a prosthetic device defined as "a thin sheet of material usually used as a finish" (1) that makes it possible to modify the shade, structure, position and shape of the original tooth. This usually requires minimal preparation of the tooth concerned. Its thin thickness distinguishes it from other prosthetic devices such as crowns, and allows the practitioner to meet an aesthetic demand while remaining extremely conservative. However, this concept of thickness remains relative, particularly in indications associated with malpositioning where the preparation and thickness of the ceramic will be greater and therefore will no longer be representative of the minimal preparation on which its concept is based.

It should be noted that this definition only takes into account the main characteristic of the veneer i.e. its thickness; it does not mention its bonding to the dental tissues while this anterior partial restoration will be cemented, a key step for the durability of the treatment. O. Etienne therefore proposes to define dental veneers as a thin prosthetic device, bonded to the enamel and intended to correct the shade, position and shape of a tooth (2).

Figure 1. Details of texture of ceramic veneers

2. History of dental veneers

Dental veneers have a relatively recent history compared to the antiquity of the art in dentistry. Indeed, the first remnants of dental prostheses date back to the Etruscan civilization, in the 8th century BC (3) while dental veneers only appeared in the 20th century. We owe the initial creation of veneers to the concern of Dr. Pincus to improve the aesthetics of the smile of Hollywood actors (4). By founding the American Academy of Aesthetic Dentistry, Dr. Pincus came to be regarded as the father of cosmetic dentistry, while earning the nickname of "Dentist to the Stars". Since there were no adhesion systems yet, these veneers were temporary treatments and were never replaced by permanent prosthetic rehabilitation.

The concept of ceramic veneers was developed through three major discoveries: the etching of enamel, the development of Bis Gma resins applied to dentistry, and the surface treatment of ceramics.

The first tests of an adhesive system that could bond acrylic resins to dental tissue were conducted by the Swiss chemist Oskar Hagger in 1950. Hagger developed a product: glycerol phosphoric acid dimethacrylate (GPDM) monomer phosphate patented under the name Sevriton Cavity Seal (5).

In 1954, Buonocore conducted experiments on enamel surfaces. He applied 85% orthophosphoric acid for 30 seconds to demineralize the exposed surfaces. The experiment showed that etching increased tenfold the developed surface available for bonding by exposing the organic framework of the enamel (6).

In 1955, Buonocore, Wileman and Brudevold selected Sevriton as the material giving the best quality adhesion. They concluded that it was suitable for chemical bonding with dentin components (7).

With the discovery of BisGMA resins by Bowen in the 1960s (8), the concept of a bonding composite was born. It is only in 1975 that the use of bonded ceramic restorations on incisors without operative intereferences by Rochette is proposed (9).

From Rochette's technique summoned up many improvements in Europe and in the United States. In 1983, researchers Simonsen and Calamia discovered the possibility of etching porcelain with hydrofluoric acid (10). The application of silane on the surface of the ceramic was also studied by Calamia in order to increase the adhesion force between the ceramic and the surface of dental tissues (11).

3. Concepts regarding dental ceramics

3.1. Definition

The term “ceramic” refers to “compounds of one or more metals with a nonmetallic element, usually oxygen; they are formed of chemical and biochemically stable substances that are strong, hard, brittle, and inert nonconductors of thermal and electrical energy” (1). The word Ceramic is derived from the Greek word « *keramos* », which literally translates to « burnt stuff », but which has come to mean more specifically a material produced by burning or firing. Although these definitions are still valid today, a new concept formulated in 2013 on the ADA Code on Dental Procedures and Nomenclature completes the definition of ceramics by categorizing them as « pressed, fired, polished, or milled materials containing predominantly inorganic refractory compounds including porcelains, glasses, ceramics, and glass-ceramics ». (12)

In dentistry, ceramics represents one of the four major classes of materials used for the reconstruction of decayed, damaged or missing teeth. Other three classes are metals, polymers, and composites.

Dental ceramics are widely appreciated in the world of restorative dentistry for characteristics such as their biocompatibility, absence of corrosion, aesthetic performances, adequate marginal fit and resistance to compression.

Ceramics are two-phase materials and include:

- A vitreous phase: the matrix (disordered), which gives the aesthetic optical properties (light reflection and color)
- A crystalline (ordered) phase

The incorporation of the crystalline phase in the vitreous matrix allowed a significant improvement in the hardness and toughness of the ceramics. The nature of the crystalline phase present in the ceramic mainly conditions the physical and mechanical properties of the final restoration. The classification of ceramics is therefore based on their composition; three families can be distinguished (13).

3.2. Classification regarding chemical compostion

There are a multitude of variants for dental ceramics. Ceramics have different physical and optical properties, which are closely related to their chemical composition. Understanding the chemical elements that make up ceramics is therefore useful.

S. Gracis and al. proposed in 2015 a new classification incorporating ceramic and ceramic-like restorative materials in an attempt to systematize and include a new class of materials (14). This actual classification divides the ceramic restorative materials into three families: glass-matrix ceramics, polycrystalline ceramics, and resin-matrix ceramics.

The family of glass-matrix are nonmetallic inorganic ceramic materials that contain a glass phase whereas the polycrystalline ceramics are nonmetallic inorganic ceramic materials that do not contain any glass phase. The Resin-matrix ceramics consist of polymer-matrix containing a high percentage of inorganic refractory compounds that may include porcelains, glasses, ceramics, and glass-ceramics.

3.2.1. Glass-matrix ceramics

We are mainly interested in the first category of the glass-matrix ceramics: the feldspathic porcelain. The main components are feldspar, silica, kaolin, glass modifiers, color pigments, and opacifiers.

- Feldspar is responsible for forming the glass matrix. This component initiates the passage of ceramics from the powder state to a solid mass since it has the lowest melting point. Currently, feldspar is found in the form of potash feldspar (or albite) because it gives ceramics a certain translucency.
- Silica (also called quartz) has a very high melting point and acts as a filler for porcelain restorations.
- Kaolin, obtained from rocks containing alumina, is a member of the clay family. This component brings mouldability to the ceramic but also gives it a certain opacity, thus limiting its proportion in the material studied
- Glass modifiers (e.g. K, Na, or Ca oxides or basic oxides) are added to alter to integrity of the ceramic and therefore increase its fluidity.
- Finally, in smaller proportions are the dyes used to obtain the desired shade.

(14,15)

3.2.2. Polycrystalline matrix

The main characteristic of the ceramics classified as polycrystallines is a fine-grain crystalline structure improving strength and fracture toughness. However, polycrystalline ceramics tends to have a limited translucency. In addition, the lack of glass in their composition makes them difficult to etch with hydrofluoric acid (drawback possibly corrected by longer etching times or higher temperatures).

Alumina (eg, Procera AllCeram, Nobel Biocare; In-Ceram AL) is composed of high-purity Al_2O_3 (up to 99.5%). It presents a very high hardness (17 to 20 GPa) and relatively high strength but the elastic modulus (E = 300 GPa), highest of all dental ceramics, has led to vulnerability to bulk fractures explaining it decreased use (14)

About 15 years ago, zirconia was considered state of the art since it was the first white metal (lithium disilicate was a later development). Moreover, zirconia had this "transformation phase" leading to a spontaneous repair after a fracture. However, zirconia did not exhibit chemical bonding and there was flaking of the material. The addition of oxides such as yttrium, magnesium, calcium, and cerium stabilize the zirconia in one of its phases, thus limiting the risk of flaking. Stabilized zirconia is nowadays widely used thanks to the appearance of more transparent zirconia which allows us to manufacture crowns in monolithic (note that there is no chipping in monolithic) and improved aesthetics via the existence of multiblocks.

Zirconia-toughened and alumina-toughened are developing due to zirconia generally remaining partially stabilized in its tetragonal phase and alumina presenting a moderate toughness.

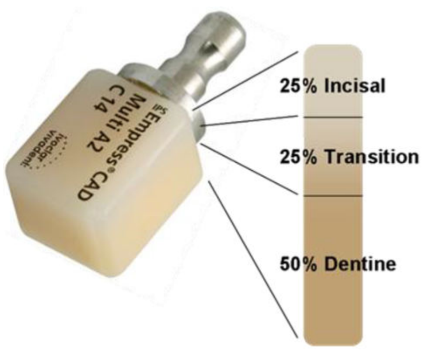

Figure 2. Multicolor block of IPS Empress

3.2.3. Resin-matrix ceramics

The materials included in this cathegory do belongs to ceramics since the definition updated in 2013 in the glossary of the American Dental association. They are composed predominantly (> 50% by weight) of refractory inorganic compound. These resin-matrix ceramics were develop to:

- obtain a material with a modulus of elasticity closer to natural dental tissues (dentin) compared to conventional ceramics
- ease milling and ajustements hence improving manufacturing compared to glass-matrix ceramics and to polycristalline ceramics
- improve and ficilitate repair protocols and/or modification with composite resins

Although it exists variable compositions of resin-matrix ceramics, they all are specifically indicated for the use of CAD/CAM technique. According to their inorganic compostion, they can be sorted into three subcathegories : the resin nanoceramic, the glass ceramic in a resin interpenetrating matrix, and the zirconia-silica ceramic in a resin interpenetrating matrix (14).

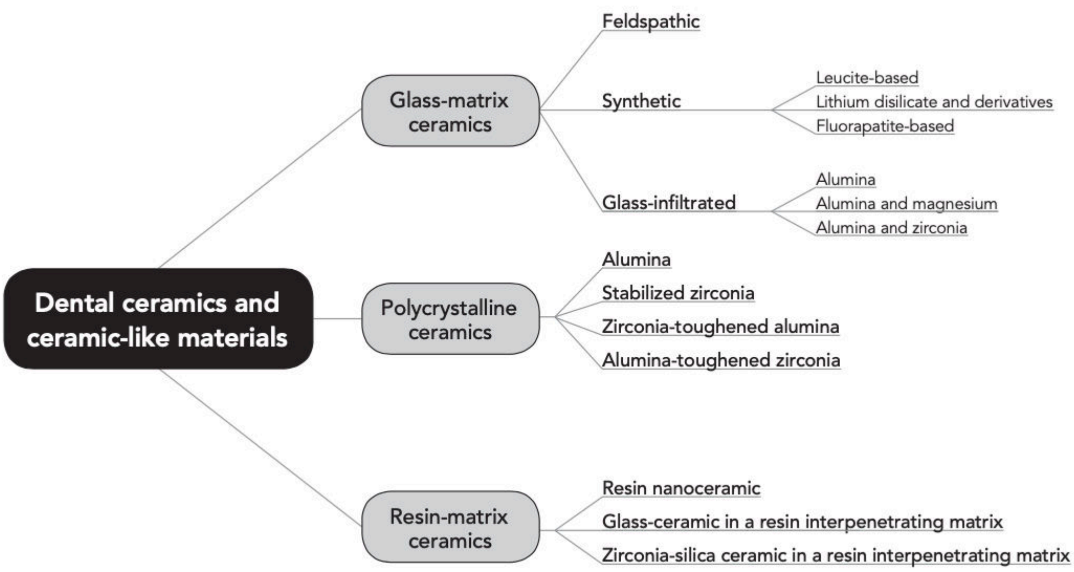

Figure 3. Schematic of the classification of all ceramic and ceramic-like materials

3.3. Physical and optical properties of ceramics

3.3.1. Physical properties

To describe and quantify the physical properties of ceramics, two variables should be noted: flexural strength and fracture toughness.

- Flexural strength, measured in MPa, corresponds to the maximum vertical force that the material can receive without fracturing.
- The fracture toughness, measured in MPa.m^1/2, represents the resistance of a material to the propagation of an initial crack. This physical property is a major contributor to the long-term failure of all-ceramic restorations. A restoration with a high toughness fracture will exhibit more favourable long-term prognosis than a restoration with a low or weak toughness fracture.

Von Mises stress is a value used to determine whether a given material will fail or fracture. It is mainly used for ductile materials, such as metals. The von Mises yield criterion states that if the von Mises stress of a material under load is equal to or greater than the yield of the same material under simple tension, the material will fail (16).

Dental ceramics possesses very good resistance to the compressive stresses, however, they are very poor under tensile and shear stresses (17). In contrast to metals, the metal atoms of the ceramic bond with the non-metallic atoms via ionic bridges. These ionic interactions are responsible for the cohesion established between particles of opposite charges. Once the ceramic receives stress that deforms the material, particles of the same charges may be shifted towards each other, leading to electric repulsive forces. The cohesion is thereof interrupted. These electrical interactions explain one of the major characteristics of ceramics: brittleness. Dental ceramics are therefore neither ductile nor elastic.

The strength of the ceramics is oriented by several factors: the microstructure of the material (density, proportion of crystals) and the initial presence of microcracks (pores, impurities, processing errors).

In view of these factors, the clinical success of an all-ceramic restoration must meet the following criteria:

- High flexural strength
- High fracture toughness
- Homogeneity of the microstructure
- Flawless processing of the material

(18)

3.3.2. Optical properties

Ceramics have the property to mimic the tooth aesthetics almost up to perfection (19). As a matter of fact, they possess optical properties very alike to those of the dental hard tissue (18).

The optical properties of ceramics are essentially centered on translucency. Ceramics with high flexural strength and high fracture toughness tend to be opaquer due to their crystalline structure. It is then possible to classify ceramic materials according to their opacity at a given thickness: veneering ceramics > Empress I > In Ceram spinell > Empress II > In Ceram alumina > In Ceram zirconia (20).

The thickness of the ceramic also plays an important role in the translucency of the material. A veneer with a thickness of 0.3mm will be more translucent than a veneer of 0.5mm, for the same given material.

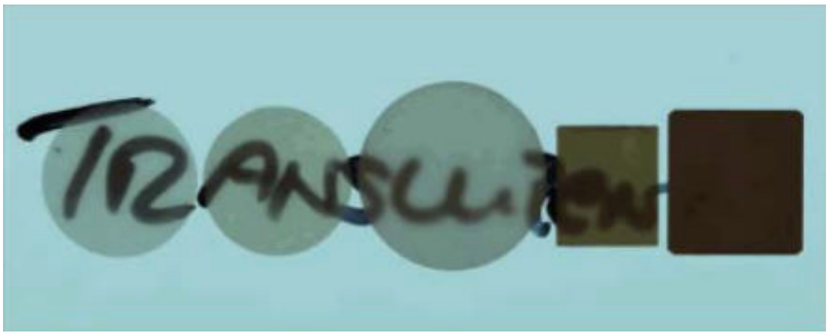

Figure 4. Optical comparison of different ceramic materials with equal slice thickness

From left to right: veneering ceramic, Empress I Zirconia, In-Ceram Alumina, In-Ceram Zirconia

3.4. Classification regarding processing methods

The manufacturing of any dental ceramics begins with a ceramic powder that can later be shaped into the required form thanks to a variety of different processing methods. The processing method is chosen according to type of ceramic material eligible for each specific dental restoration.

3.4.1. Manual processing methods

Manual processing methods include manual layering over an investment cast, pressing, and slip casting with glass infiltration (18).

3.4.1.1. Layering

Layering is commonly used to manufacture porcelain-veneered crowns and dental veneers. The dental technician use ceramic powders of different shades and translucency to replicate hard tissues aesthetics. The powders are meant to be mixed with modeling fluid (or distilled water) to create a paste. This paste, called slurry, is applied, layer by layer, onto the substructure. Once the restauration is build-up, it is sintered at aproximatively 900°, temperature at which the powdered glass particles melt and flow together at the particle interfaces. This is the sintering phenomenon. (18)

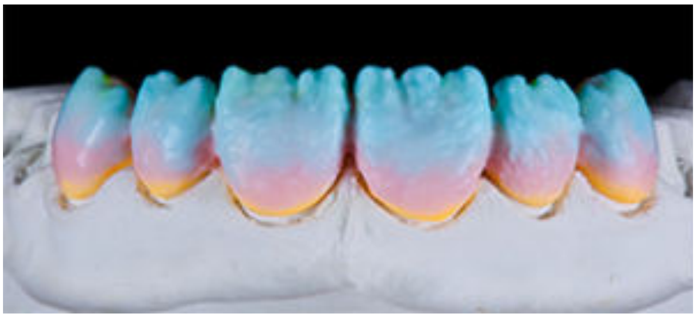

Figure 5. Ceramic layering before sintering

3.4.1.2. Pressing

Pressing relies on the mechanisms of the lost-wax technique and is the technique of choice for materials such as reinforced glass-ceramics (eg. Lithium disilicate). The starting material comes in pre-sintered blocks. For this processing methods, the dental technicien first creates a wax model that is later melted. The space left is then filled by injectingunder pressure the soften ceramic block (1180°C at 5 bar). This manual processing method can be processed alone to manufacture a full contour restauration, or processed as a core in conjunction with layering technique. (18)

3.4.1.3. Slip casting

The slip casting method is performed in two steps : sintering of alumina powder onto a special die (2 hours at 1120°C), and a second firing infiltrate glass (4 hours at 1100°C). It should be noted that this technique was developed before the arrival of machining methods, making it less popular now.

3.4.2. Machining processing methods

Machining processing methods comprise the copy-milling technique, the computer aided machining, and the computer aided design / computer aided manufacturing (CAD/CAM).

3.4.2.1. Copy-milling

The copy-milling technique consists of a model of the dental restauration previously fabricated in resin composite. A scanning tool is used to trace the replica allowing the milling onto the ceramic block. This technique brings relatively precise outcomes but presents the drawback of manufacturing a previous replica.

3.4.2.2. Computer aided machining

Computer aided machining is similar to copy-milling in the sense that both require the prefabrication of a replica beforehand. Unlike copy-milling, the replica is scanned by an optical scanning technology (e.g. Laser, white-light scanner) and digitized. This digitized data is then used to guide the machine during the milling process.

3.4.2.3. CAD/CAM technique

The CAD/CAM technique is relatively recent. Its technology is based on the use of a STL file ("Standard Triangle Language" or "Standard Tessellation Language") which implies a previous scanning of the hard and soft tissues of the patient mouth. This previous scanning can either be performed extraorally over a study cast obtained with conventional impression or performed intraorally with the use of an intraoral scanner. The computer aided design uses the STL file to design the structure of the restauration and the computer aided manufacturing leads the milling into replicating the established design.

The cad/cam technique being manufactured by milling technique could lead us to believe that aesthetics are limited but there are different techniques to push biomimetics to its maximum. Thus, it is possible with the cad/cam process to perform a cut-back technique or a core onto which ceramic can be layered. The cut-back technique consists of milling a block of ceramic into the shape of the cervical 2/3 of the crown and layering the rest of the incisal border. (18,21,22)

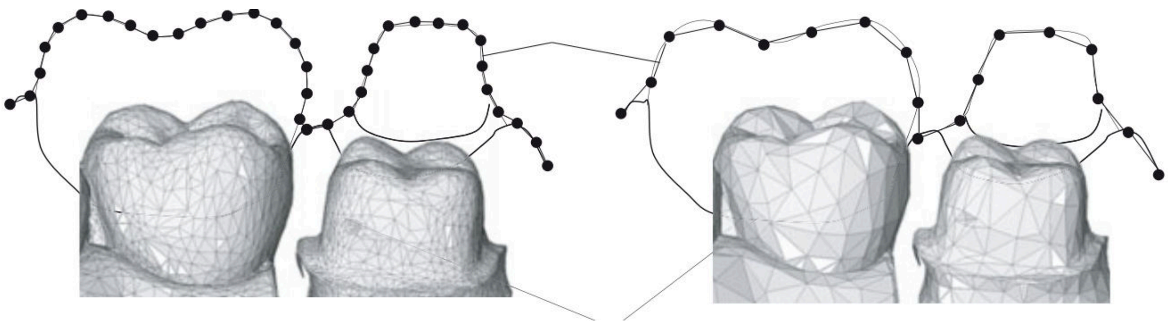

Figure 6. Meshing of the point cloud to replicate the scanned design

4. Therapeutic indications

4.1. Initial classification of therapeutic indications

Several classifications to distinguish clinical indications from dental veneers have been proposed. The most widely used is the classification of the Geneva school, initially described in 1997 by Belser and the Magne brothers (23).

- **Type I: Teeth resistant to bleaching**
    - Type IA: Tetracycline discoloration (grade III and grade IV)
    - Type IB: No response to external or internal bleaching
- **Type II: Major morphologic modification**
    - Type IIA: Conoid teeth
    - Type IIB: Diastemata and interdental triangles to be closed
    - Type IIC: Augmentation of incisal length and prominence
- **Type III: Extensive restoration (on adults)**
    - Type IIIA: Extensive coronal fracture
    - Type IIIB: Extensive loss of enamel (by erosion and wear)
    - Type IIIC: Generalized congenital and acquired malformation

4.1.1. Type I: Teeth resistant to bleaching

4.1.1.1. Type IA: Tetracycline discolorations (grade III and grade IV)

The action of tetracyclines on teeth is very variable. It ranges from a simple uniform yellow discoloration to a more or less pronounced grey-brown stripes or stains. The staining depends on the type of antibiotic involved. The stains appear as diffuse horizontal bands of varying width on the dental crowns. The stained areas of enamel correspond to the areas that were being mineralized during the administration of tetracycline. This allows the age of antibiotic initiation to be accurately dated, according to Bevelander, 1964 (24).

In 1958, Schwachman et al. hypothesized that at least one of the components of tetracyclines is able to cross the placental barrier and thus bind to the mineralizing teeth of the fetus.

Therefore, the administration of tetracycline to pregnant women from the fourth month of pregnancy onwards (mineralization of the milky incisors), to breastfeeding women and to children under 8 years of age (age of mineralization of the permanent second molar) is absolutely contraindicated.

In 1984, Jordan and Boksman listed and classified tetracycline stains into four classes of increasing importance. These four stages and their therapeutic solutions are summarized in the following table. (25)

Degree	1st degree	2nd degree	3rd degree	4th degree
Type of coloration	Light Uniform Without bands	Medium Uniform Without bands	Strong Irregular With bands	Very strong With bands and irregular areas
Color	Yellow / brownish Low saturation	Yellow / brownish / grey Saturated	Grey brown Blue purple Very saturated	Dark grey, deep purple Extremely saturated
Chemical treatment	Possible With very good results	Possible Good results	Complicated Acceptable results	Impossible Poor outcomes
Prosthetic treatment	Useless	Useless	Possible	Mandatory

Figure 7. Tetracycline stains of complete upper and lower arch, third degree

For first and second degrees staining, external bleaching with hydrogen peroxide or carbamide peroxide is sufficient. But from the third degree onwards, even after bleaching, the teeth will always appear opaque and not very translucent and restoration by dental veneers is justified. (23,26,27)

4.1.1.2. Type IB: No response to external or internal bleaching

➢ **Fluorosis**

Fluoride has a direct effect on enamel, depending on its dosage. In effective doses, it provides real resistance to caries. But in overdose, it leads to the appearance of dyschromia, hypomineralization and even porosities.

Depending on its severity, fluorosis is described and classified into different classes. Fejerskov and al. propose an international classification: the TFI classification (Thylstrup Fejerskov Index). This classification was adopted by Feinman and al. in 1987.

Appellation	**Simple fluorosis**	**Opaque fluorosis**	**Fluorosis with porosity**
Classes	0 to 2	3 to 5	6 to 9
Manifestations	Smooth and defect-free enamel, with the presence of brownish spots/plains	Grey teeth with whitish stains more or less opaque. The stains are mostly superficial	Dark teeth with characteristic staining. The enamel presents areas of porosity of variable size, which may even disappear completely

Figure 9. Dental fluorosis score 2

Figure 8. Dental fluorosis score 3 and 5

Chemical external lightening techniques are effective on simple and opaque fluorosis. With effective removal of surface stains in opaque fluorosis by micro-abrasion. However, external lightening is ineffective on fluorosis with porosity, due to the irregularity of the enamel surface

condition. Therefore, when the amount of residual enamel is greater than 50% (fluorosis classes 6 and 7), dental veneers should be applied. For fluorosis classes 8 and 9, we will be forced to proceed with the elaboration of conventional cemented prosthesis.
(28–30)

➢ **Other clinical situations of teeth resistant to bleaching**

This subcategory encompass endodontically treated teeth, teeth with exposed dentin and necrotic teeth. (23)

4.1.2. Type II: Major morphological modification

4.1.2.1. Type IIA: Conoid teeth

Also known as riziform teeth, these shape anomalies are caused by a gene alteration. This condition mainly affects the upper lateral incisors, but also the mandibular premolars and third molars. The maxillary lateral incisor is sometimes accompanied by agenesis of the contralateral incisor (31).

4.1.2.2. Type IIB: Diastemata and interdental triangles to be closed

Interdental "triangles" or black "holes" are due to localized loss of interdental soft tissue following bone loss due to periodontal disease or trauma.
It should be noted that some authors advocate aesthetic restoration by direct composite layering as a first-line treatment when mechanical stresses are low.

The difficulty of aesthetic treatment in the context of diastema closure is proportional to the number of diastemas to be closed. The width of the diastema will determine the type of restoration. The proportion of the teeth must be respected by keeping their length/width ratio, because teeth of the same width but of different lengths seem to have different widths. Thus, the best solution is to place veneers not only on the two central incisors, but on the four incisors, or even the six anterior teeth.

(32–34)

4.1.2.3. Type IIC: Augmentation of incisal length and prominence

Due to the anterior guidance, strong mechanical forces are exerted on the incisors, especially on their free edge. Therefore, hard tissue replacement

The use of ceramics for restorations is not a viable option. The use of ceramics to restore lost tooth volume therefore offers the best compromise, both for its aesthetic properties and its resistance to mechanical stress.

Occlusal analysis must be done in conjunction with, if not prior to, the aesthetic analysis in order to identify the etiology of the loss of dental tissue. The presence of mandibular parafunctions can represent an absolute contraindication to the placement of veneers, or singularly increase the post-treatment hazards (23).

Figure 10. Conoid lateral upper incisors and diastema between 11 and 22

Figure 11. Aesthetical rehabilitation with ceramic veneers

4.1.3. Type III: Extensive restorations (on adults)

4.1.3.1. Type IIIA: Extensive coronal fracture

In the case of an extensive coronal fracture, the first parameter to be assessed is the pulp diagnosis. In the event the tooth is necrotic, the therapy of choice will be an endodontic treatment followed by an aesthetic and functional rehabilitation. The loss of hard tissue caused by the preparation of the endodontic access cavity will force the recourse to a conventional fixed prosthesis such as inlay-core and crown.

The persistence of pulp vitality will allow us to place a dental veneer in order to preserve a maximum of residual dental tissue. It should be noted that the risk of premature fracture of the veneer and therefore of prosthetic failure is directly proportional to the volume of missing dental tissue.

In the case of a traumatic fracture in a young patient who has not yet completed facial growth, the notion of tissue economy is even more important. The practitioner will focus his attention on preserving pulp vitality. A reconstruction by stratification with composite resin will be carried out to temporize the care until the end of the patient's growth. Then, if the composite restoration no longer meets the aesthetic and functional specifications, rehabilitation by veneer can be considered.

(35–38)

Figure 12. Crown fractured incisors with silicon index. Final bonded porcelain restorations

4.1.3.2. Type IIIB: Extensive loss of enamel

Erosion is the loss of tooth substance by chemical mechanisms without bacterial involvement: such as acid dissolution. Wear, or attrition, is the loss of tooth substance by physical mechanisms, such as repeated friction from foreign objects or bruxism.

As in the case of traumatic amelo-dentinal loss, the success rate of veneer restorations is proportional to the amount of hard tissue and, above all, residual enamel. Because of the opening of the dentinal canaliculi, the presence of dentinal liquids hinders the bonding of the ceramic.

For Castelnuevo, the proposal for a veneer restoration can only be considered if the total bonding surface consists of more than half enamel. Furthermore, the boundaries of the tooth preparation must be in enamel and not dentin. Otherwise, the dento-prosthetic joint may degrade more rapidly through the mechanism of micro-infiltration: « microleakage »

If this is not the case, we will resort to a fixed prosthesis such as a crown.

Remember that these lesions are always accompanied by bad habits that must be corrected before treatment can be carried out.

(39,40)

4.1.3.3. Type IIIC: Generalized congenital and acquired malformations

A number of localized crown surface defects can be treated with very conservative means such as direct composite restorations. However, generalized enamel dysplasia may require a more invasive treatment option. As previously mentioned for Type IIIA, direct composite restorations can be placed before ceramic veneers as provisional restorations in young patients.

Amelogenesis imperfecta must be distinguished from generalized enamel dysplasia. Amelogenesis imperfecta requires caution and in most cases a full coverage crown will remain the treatment of choice.

Figure 14. Enamel hypomineralization

Figure 13. Post-operative view with ceramic veneers on 15 and 25

4.2. Completed classification of therapeutic indications

Although this classification is rigorous, it is not exhaustive. S. Kina proposed to complete it by adding two categories: small correction of dental position and special cases (41).

Indications			**Clinical situation**
I	Color alterations resistant to bleaching and/or microabrasion		• Amelogenesis imperfecta • Fluorosis • Tetracycline stains • Darkening due to trauma • Intrinsic pigmentations
II	Cosmetic modifications	Form	• Diastemata closure • Incisal length increment • Atypical shape • Retained primary teeth • Dental transformation
		Texture	• Amelogenesis imperfecta • Dysplasia • Dystrophia • Attrition, erosion, abrasion
III	Extensive restorations		• Fractured teeth • Acquired anomalies and congenital deformations
IV	Minor correction of position		• Broken teeth • Angle alteration
V	Special cases		• Lingual laminated veneers • Aesthetic correction of fractured crowns

➢ **Small correction of dental positions**

This is a controversial indication. The proposal of rehabilitation by dental veneers will only be proposed after dentofacial orthopedics and will only concern the most minimal anomalies. Moreover, any parafunction must first be corrected to ensure the durability of the prosthesis, such as: a hypertonic lip brake, a dental occlusion anomaly (e.g. Angle Class III).

(41,42)

4.3. Contraindications

The development of veneer treatments has only been significant in the last few decades due to the improvement of techniques and materials. The best progress has been made in bonding, thanks to Buonocore in 1961. Thus, the counter-indications developed below are at the present time, but may not be any more in a few years time thanks to research and improvement of our techniques. These contraindications may be absolute or relative.

- Untreated periodontal diseases, poor oral hygiene
- Erupting dentition
- Inadequate occlusion and/or position
    - Severe crowding
    - Deep overbite
    - Parafunctional habits (e.g. bruxism)

Absolute contraindication

- Inadequate anatomy
- Multiple restorations
- Occlusion of Angle class III

Relative contraindication

5. Diagnostic approach and initial treatment planning

5.1. Elaboration of a mock-up

The mock-up follows the validation of the aesthetic project by the practitioner and the patient at the wax-up stage.

Reminder: addition wax-up consists in applying wax on plaster models taking into account the biomechanical requirements of the future prosthetic restoration and the aesthetic demand of the patient (23).

Figure 15. Initial wax-up over working cast

The mock-up is an essential step in the treatment plan for facet restorations, and more generally, for all aesthetic restorations. It exists different techniques and different relation to the wax-up but it remains clear that the mock-up is essential. Its main roles are: a preview of the final result, a communication tool for the patient/practitioner/prosthetist and a clinical aid.

The mock-up can be made in two different ways: direct or indirect fabrication. The practitioner has the choice of making a direct mock-up himself, freehanded and using composite resin; or having the mock-up made by a laboratory technician. A direct mock-up has the advantage of being able to collect the patient's impressions directly, but an indirect mock-up is generally more aesthetically pleasing.

(43,44)

Figure 16. Preoperative view

Figure 17. Acrylic resin mock-up

5.2. Guided preparation with aid of silicone index

It is the simplest technique to implement but requires a greater time investment because of the multitude of silicone index apposition during the tooth preparation. Technique used by Magne and Belser, it is carried out with simple cylindrical-conical burs (45). This silicone key must be created beforehand. For this purpose, it is recommended to use of an addition silicone with high rigidity to register the wax-up. The key needs to be prepared. Two vertical sections will be made at the margins of the teeth to be restored. A horizontal section will be performed at the level of the occlusal third of the teeth to be prepared. This results in a key that is easy to position due to its posterior stops and allows the cutting depth to be checked by height level. Vision is improved by the absence of silicone in palatal. The part of the separate key including the palatal-incisal portion will be kept to control the incisal reduction of the preparation. This can be done by making a vertical section along the entire length passing through the middle of the incisal edges. In order to check the cutting depth at different tooth heights, the key is horizontally cut at multiple heights from one of the positioning stops to the contralateral stop. These silicone lamellae are movable and therefore remain attached to the key by one of their edges. This is the technique of the "notepad" key.

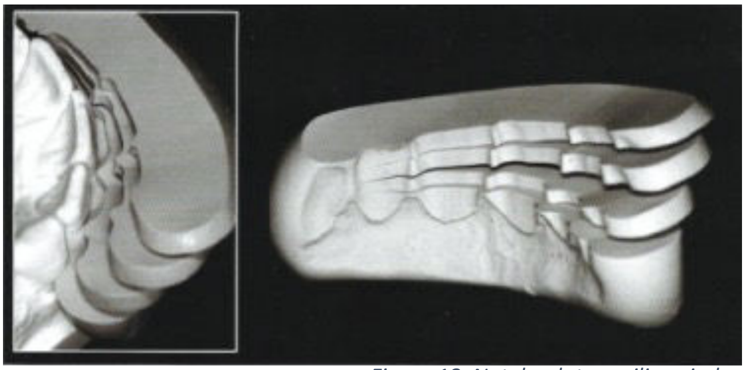

Figure 18. Notebook-type silicon index

Before starting the dental preparation, a gingival retraction cord is placed in order to improve the visibility of the cervical margin line. Some authors also recommend the placement of thin metal matrix strips between the preparation border teeth and the adjacent teeth to protect the latter from unintentional milling (2). An initial check with the key is performed before carrying out any preparation in order to objectivize the areas most prone to preparation and to have an overall view of the size to be achieved. This size will be determined using the reduction key, without consideration for the dental tissue itself. The preparation begins with the proximal surfaces. A small-diameter burr will be used. Oscillating instruments are suitable for removing the enamel beak resulting from the preparation, especially on preparations opposite unprepared teeth.

For the preparation of the buccal surfaces, vertical grooves should be made with a medium-diameter bur to indicate the preparation depth. Magne and Belser recommend making two grooves for the lateral maxillary incisors and three for the central incisors and maxillary canines. The entire buccal surface should then be prepared with a larger-diameter burr to avoid deepening the grooves and achieving a wavy surface (23).

Then the preparation of the incisal edge will be done under control of the palatal part of the reduction key. The preparation is completed by removing all sharp edges and ensure the least possible roughness to optimize the quality of the impressions.

(45,46)

5.3. Guided preparation through mock-up

This technique was proposed by Galip Gürel. It optimizes the action of thrust burrs, and facet preparation kits. The acrylic composite resin mock-up is placed in the mouth together with gingival retraction cords. The choice of preparation depth and thus the diameter of the burs depends on the type of veneer and dental dyschromia. The vestibular surface is first prepared with burrs with a thrust stop. The resulting horizontal grooves thus follow the vestibular convexity of the tooth.

Figure 19. Calibrated three-disc bur used over the mock-up

The cervical margin is then prepared using a long-neck ball burr. Finally, two to three grooves are made at the incisal edge.

Once these preparations have been completed, Gürel recommends that the grooves be objectified with a pencil to facilitate cutting. The mock-up is then removed.

The rest of the enamel is prepared with a large-diameter cylindrical-conical bur to homogenize the preparation depth in relation to the guide slots. The same finish as in the previous preparation technique is applied.

(47,48)

6. Definitions and concepts of tooth preparation

6.1. Definition of tooth preparation

The preparations allow the tooth surfaces to be conditioned with various rotatably mounted instruments for cementation or sealing of prosthetic restorations. The dental preparation stage takes place within an aesthetic project that is clearly established and validated by the practitioner and the patient, and therefore with defined objectives.

Preparations for adhesive ceramic restorations must allow an optimal marginal adaptation of the restoration while preserving the dental hard tissue as much as possible. It follows a minimal approach. However, the mere pursuit of tissue preservation, ignoring the objectives of the dental preparation, will lead irremediably to overcontouring and failure in the short/medium term. The ideal integration of veneers (functional, biological and esthetic) is only achieved if the dental preparation satisfies the four basic principles of adhesive ceramic restorations: retention, stabilization, support and adhesion.

Dental preparation must therefore meet several requirements:

- Only hard surfaces should be used
- Reconstitute an ideal emergence profile
- Do not expose any dento-prosthetic seals at an occlusal contact point
- Allow the placement of a ceramic thickness of 0.3 to 0.9 millimeters
- Restore the function and aesthetics of prepared teeth
- Spare the dental hard tissues as much as possible

6.2. Instrumentation

The dental preparation for veneers is very meticulous and requires a great deal of clinical experience to be carried out properly. Thus, industrialists have developed and marketed certain types of instruments specially dedicated to veneer preparation.

6.2.1. Rotatories

Because dental veneers usually involve teeth with positive vitality the choice of speed must be decided carefully. The rotation speed has a direct impact on the iatrogenic heating and the surface condition of the prepared area. In order not to cause pulpal changes or ameliorative fissures, the rotational speed should be below 3000 rpm or above 200000 rpm, and should be accompanied by abundant irrigation to ensure lubrication of the burs and proper cooling of the enamel. A rotational speed greater than or equal to 400,000 rpm results in less surface debris. Clinicians agree that the choice of the rotating part should be made on the turbine or on a high-speed contra-angle handpiece in order to reach 400.000 rpm. For O. Etienne, the constant torque of the contra-angle provides a gain in terms of efficiency compared to the turbine for amalgam milling (2).

6.2.2. Dental burs

The minimal dental preparation for veneers combined with the ease of use of diamond burs compared to tungsten carbide burs make the former a very suitable choice. It is advisable to use several burs with different grit sizes. Large diamond burrs are used for preparing the tooth, while smaller burrs are used for finishing to smooth the surface and optimize the precision of the impression material.

In order to simplify the dental preparation process, manufacturers have introduced burr sets for veneer preparations. These sets contain a limited number of burs of different shapes and sizes, each designed for a specific localized preparation.

For Pascal Magne and Urs Belser, the use of burs with depth markers is strongly contraindicated. These cause excessive enamel reduction and increased risk of dentine exposure. This is due to the fact that these burs work in relation to the pre-existing tooth surface and volume and not in relation to the intended prosthetic project. However, it should be noted that this limitation can be overcome by the technique of guided preparation through mock-up.

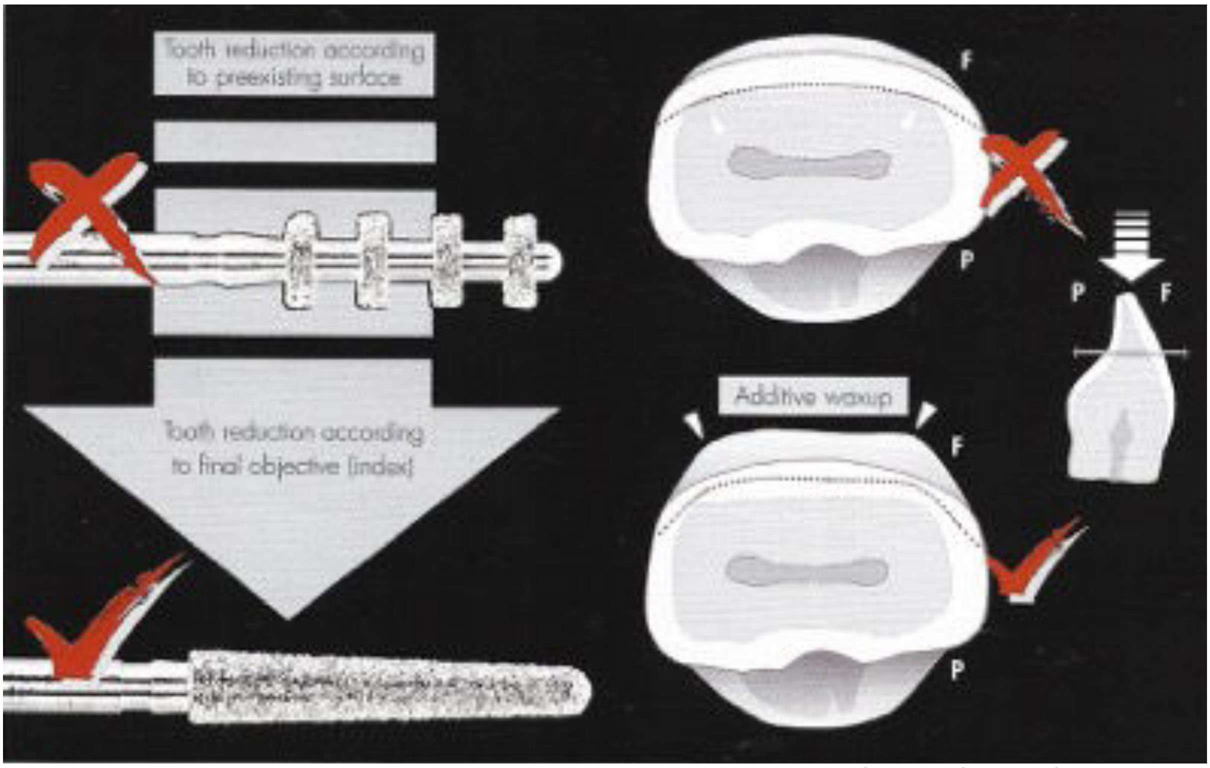

Figure 20. Schematic drawing of the burs for initial facial reduction

6.2.3. Ultrasonic instruments

For Christensen, rotary instrumentation can cause vibrations that are detrimental to the accuracy required in dental preparation. For this reason, many dentists use oscillating instruments to complete the milling process when finishing the milling. These instruments allow a clean cut of the hard tissue without the risk of damaging the underlying soft tissue.

6.3. Limits of preparation

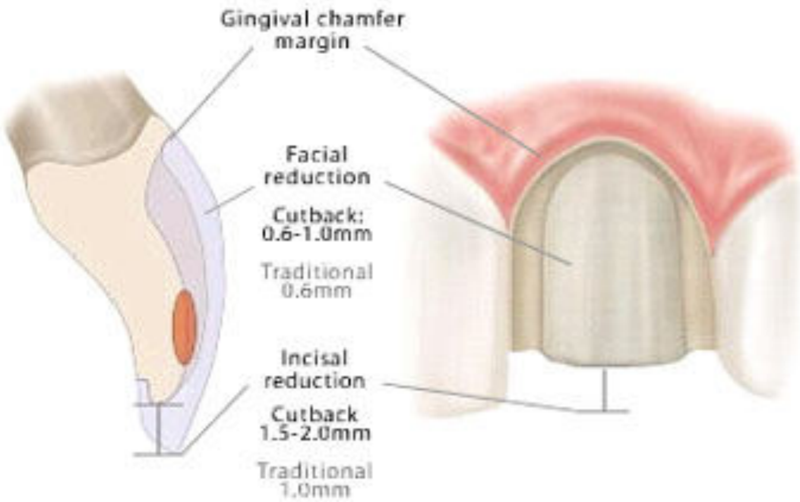

Figure 21. Schema of the different limits of preparation

6.3.1. Buccal limits

The purpose of the vestibular amelioration preparation is to prepare the enamel to allow the veneers to be bonded to the enamel with a minimum of preparation time and with a maximum of hard tissue thickness. The deeper the milling, the greater the risk of dentine exposure. The wider the range of exposed dentine, the poorer the bonding will be due to the water content of the dentine. It is almost impossible to achieve a perfect buccal preparation because of the variation in enamel thickness depending on the location, type of tooth and wear. The average milling depth varies between 0.3 mm and 1 mm. The thickness of the enamel, and thus the depth of preparation, increases from the neck to the incisal edge (0.3 mm in the cervical third, up to 2 mm at the incisal edge). The depth of preparation is also influenced by the discoloration of the tooth and the type of veneer selected: highly colored teeth require a less conservative preparation.

6.3.2. Cervical limits

The ideal cervical limit is para or slightly supragingival and follows the gingival festoon. Due to the optical properties of cemented ceramic restorations, the dental seal is invisible and, its hygiene is much easier to maintain due to its accessibility. The subgingival limit should only be used in exceptional cases: it allows the dental technician to increase the convergence profile to close diastemas or fill black triangles. It also allows the dentist to mask a sudden color change on teeth that are severely dyschromiated. Finally, it can also be used on conoid incisors, because in this case it is the targeted emergence profile that will guide the height of the cervical limit.

6.3.3. Proximal limits

The proximal limits are the ones that will condition the insertion axis of the veneers. This axis is anteroposterior, unlike conventional crown-type prostheses, where the insertion axis is coronal. The preparation of the proximal limit must comply with an important requirement: place the limits beyond the zone of visibility.

With regard to the preservation or not of the contact point, there are different opinions. The preservation of the contact point allows to remain in a minimally invasive approach (23).

Preservation of the contact point makes it possible to:

- Simplify the clinical trial
- Exempt the dental technician from reproducing it, which is very difficult, especially with thin layers of ceramic
- Keep the tooth wedged in the mesio-distal direction

However, contact points may sometimes need to be milled or modified. According to Dr Kina, removing the contact points will prevent the impression from tearing and will ease the individualization of the dies at the lab. The removal of the contact point also ease the cementation process ends by allowing the excess cement to flow in palatal (41). Note that contact points should be removed whenever the interproximal surface is not sound (eg. Caries, infiltrated obturation) or lacking favorable anatomy (eg. Conoid teeth, diastema, palatal contact surface).

(49,50)

6.3.4. Incisal limits

The free edge is only reduced in the case of preparations with incisal overlap or an increase in tooth height. It must be possible for the dental technician to layered at least 1.5 mm of ceramic material to ensure good esthetic integration with the dentin, enamel and translucent layers. As seen in the contraindications, its preparation must never result in an important unsupported ceramic height. For Touati (51), full coverage of the free edge offers many advantages:

- Reduced risk of angled fractures due to the increased thickness of the ceramic
- An increase in aesthetic integration
- Greater freedom for the dental technician to modify the shape and position of the tooth
- Better control of occlusal contacts
- Facilitation of clinical manipulation during fitting and gluing

This opinion is also shared by Magne and Belser. In addition, Highton et al. conducted a study demonstrating that an incisal/proximal veneer provides intrinsic strength to the superior restoration due to the better stress distribution within it. Thus, preparations with incisal veneers are the most common. However, total preparation of the free edge involves preparation of the palatal-lingual surface.

(23,46,52,53)

6.3.5. Lingual limits

Since the dentoceramic joint is a zone of weakness and a potential fracture starting point, the preparation margin should not be located at the occlusal contact points in the position of maximum intercuspidity. Furthermore, the preparation margin should not be located in the area of greatest palatal concavity, which is subject to high tensile stress, as this would increase the risk of ceramic fracture. In practice, the limit lies above the occlusal contact points in the IOM. For Magne and Belser, the shoulder limit is to be preferred to the traditional chamfer which constitutes a thin and brittle margin. Thes flat edge of the shoulder line would provide better support for the ceramic.

(51,52)

6.3.6. Finishing of the preparation

A correct tooth preparation is free of any sharp edges and angles and presents a smooth surface. The contact points can be lightly open with polishing strips. These factors will contribute to a better adhesion, easier printing both conventionally and in cad/cam.

(23,54)

II. OBJECTIVES

It exists plethora of descriptions and indications for each type of preparation; a range that can sometimes lead to confusion.

The purpose of this work is to describe the different types of preparation for ceramic veneers.

In parallel, this study will aim to:

1) Compare preparation types at the cervical limit according to their long-term prognosis.
2) Compare preparation types at the incisal limit according to their long-term prognosis.
3) Compare the advantages and disadvantages of conventional preparations with the "no prep" veneers

III. MATERIALS AND METHODS

This study evaluated the existing literature regarding the different types of tooth preparation types for the realization of dental veneers. The electronic search strategy involved MEDLINE, GOOGLE SCHOLAR, BIBLIOTECA CRAI and other databases. Keywords used were veneers, preparation types, survival rates, incisal overlap, finish lines.

The articles were selected according to multiple inclusion and exclusion criteria (see table below). Duplicates were removed; titles and abstracts were checked for relevant studies that addressed the aim of this critical review.

A total of 76 articles were included in this review. Both in vivo and in vitro studies were included in the review, as well as case reports, bibliographical reviews and extracts from books. Aspects of the preparation designs were quantified and analyzed from a analyze of these articles.

Inclusion criteria	Exclusion criteria
- Written in English, Spanish, or French - Full text articles only - Regarding at least one preparation type - Anecdotal reports on incisal preparation design - In vivo and In vitro studies	- Only available the abstract - Regarding composite veneers - No clear description of the preparation design

IV. RESULTS

1. Studies and materials regarding the types of preparation at the cervical margin

Studies	Type of study	Type of preparations analyzed	Conclusion
Seymour and al., 2001	Modelization	- Knife-edge - Chamfer - Shoulder	Less tensile stress with knife-edge termination
Magne and al., 2003	Book section	- Chamfer	Chamfer is the preparation of choice
Al-huwaizi, 2005	Finite element analysis	- Chamfer - Deep chamfer - Shoulder	Deep chamfer allows for better stress repartition **see annex 1*
Shillingburg and al., 2012	Book section	- Chamfer	Finish line in chamfer recommended
Pahlevan and al., 2014	In situ	- Knife-edge - Chamfer	Chamfer preparations presented more tendency to dentinal exposure

2. Studies that conclude in favor of Type I or Type II incisal preparations

Studies	Type of study	Type of preparations analyzed	Conclusion
Highton and al., 1987	Photo-elastic models	- Feathered edge - Butt joint	Butt joint type has favorable outcomes
Hui and al., 1991	In vitro	- Window - Feather - Incisal overlap	Superior outcomes for window type
Galiastos and al., 2002	Prospective over 5 years	- Incisal reduction of 0.5mm	98.4% of success
Magne and al., 2002	Book section	- Type I - Bevel or partial bevel - Incisal overlap	Type I and incisal overlap (type III) not recommended **see annex 2*
Zarone and al., 2006	In situ	- Incisal overlap - Window	Window presents lowest rate of fracture
Schmidt and al., 2011	In vitro	- Butt joint - Incisal overlap	Failure loads decreased in butt joint preparations
Bergoli and al., 2014	In situ	- Incisal overlap - Feathered edge	Palatal chamfer exhibits higher maximum principal stress

**Please refer to Part V. Discussion for all materials citation included in the above tables*

3. Studies that conclude in favor of Type III incisal preparations

Studies	Type of study	Type of preparations analyzed	Conclusion
Castelnuovo and al., 2000	In vitro	- Incisal overlap - Butt joint	Teeth prepared with incisal overlap presented the lowest rate of failure Butt joint preparation not recommended
Zarone and al., 2005	3D models	- Incisal overlap - Window	Palatal overlap allows uniform distribution of forces Window preparations induce repartition of stress at the incisal area **see annex 3*
Stappert and al., 2005	In vitro	- Incisal overlap	The incisal overlap allows for best support

4. Studies inconclusive regarding incisal preparations

Studies	Type of study	Type of preparations analyzed	Conclusion
Smales and al., 2005	Retrospective	- Incisal coverage - No incisal coverage	No statistical difference
Alghazzawi and al., 2012	Typodont	- Incisal overlap - Three quarter preparation	No statistical difference of prognosis

**Please refer to Part V. Discussion for all materials citation included in the above tables*

V. DISCUSSION

Currently, there is a lack of clinical consensus regarding the type of design preferred for ceramic veneers. Widely varying survival rates (48–100%) and methods for estimating it have been reported for porcelain veneers over the last century (55).

The different types of tooth preparations indicated for ceramic veneers can be divided into three categories:

- Type I: only the buccal surface of the tooth is prepared
- Type II: the tooth is prepared buccally and at its incisal border
- Type III: the tooth is prepared at its buccal, incisal, and palatal surfaces

This study will focus on comparing the different types of preparations at the cervical limit and the incisal edge.

Preparation types at the cervical limit	**Preparation types at the incisal limit**
○ Knife edge ○ Chamfer ○ Shoulder	○ Window (type I) ○ Feather edge (type I) ○ Butt joint (type II) ○ Incisal overlap (type III)

It is essential to mention another type of therapeutic approach that does not quite correspond to any of the three categories mentioned above: the "no prep" veneer.

1. Preparation types at the cervical limit

The classification of boundaries implies an important distinction between the actual form of the cervical preparation and finishing line. In fact, the cervical margin can be defined as a line or finishing area. The linear finish is represented by a separate line for all its circumference while the finishing area adapts the preparation to an entire surface. Each of the two has several possible configurations.

The knife-edge design is an example of finishing area while the chamfer design and the shoulder design fall into the category of finishing line. The finishing lines can be complex or simple (e.g. with or without angular finishes on their periphery: bevels or chamfers).

1.1. Knife-edge

The finishing area “knife-edge” consists of a simple and minimal eviction from any overhang located coronary to the prosthetic finishing line (54).

This design is the most conservative one because it has the lowest angle of convergence. Its cervical profile is flat and can therefore be indicated on vital teeth or at reduced periodontal support.

1.2. Chamfer

A chamfer is defined as an oblique, slightly concave surface, connecting the cervical region to the tooth surface. It is a finish line without an acute internal angle. It is obtained by preparing the edge of a tooth with a burr with a round to oblong tip held in the axis of the tooth (e.g. Bur 856). The chamfer can be more or less wide.

This choice of cervical limit profile is at the expense of the tooth substance but allows for the protection of the marginal periodontium. It would be the best preparation for the respect of the periodontal environment. Indeed, it is the cervical excavation which saves the space necessary to the use of the material for the restoration avoids overcontouring.

In addition, the chamfer is the form of cervical margin that ensures the best distribution of the occlusal stresses and the stress on the supporting teeth.

1.3. Round shoulder

This limit is a flat shaping a wide horizontal and vertical floor perpendicular to the axial surfaces of the peripheral preparation. This finish line can be milled with a bur 847KR (KR standing for round corners). It is a broad limit, and it has long been the cervical limit of choice for preparations for ceramic-ceramic crowns. The wide flatness of this limit favors stress resistance to occlusal forces. However, this preparation requires more tooth mutilation than all other cervical limits.

The sharp internal angle of 90° concentrates the forces towards the tooth and may conclude that it is fractured. It is why the acute right-angled shoulder was quickly replaced by the round-corner angled shoulder.

(23,54,56)

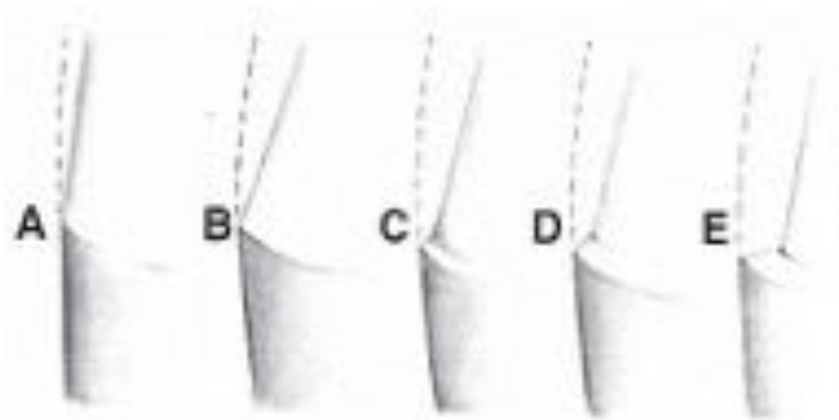

Figure 22. Margin designs (from left to right): knife-edge, chamfer, shoulder

2. Preparation types at the incisal edge

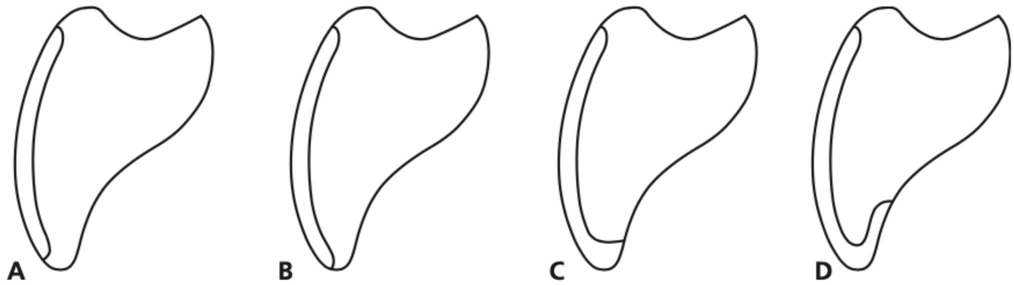

Figure 23. Incisal preparation types: Window (A), feathered-edge (B), butt-joint (C), incisal overlap (D)

2.1. Type I: Window design

The oldest technique is the one used by C. Pincus. The preparation only involves the vestibular surface without modification of the free edge. Very economical in tissue loss, the practitioner can preserve more than 80% of dental tissue. Since the enamel is only poorly prepared, the risk of micro-infiltration is very low. The presence of the mini cervical leave will facilitate its insertion.

As with no prep veneers, the free edge is left intact, so there is no possibility to modify the transverse shape and height of the tooth. This type of preparation can therefore only be performed on teeth with a thick incisal edge. Teeth with severe dyschromia may also be problematic, since the thickness of the ceramic material available with the window preparation may be insufficient.

(4,23,57)

2.2. Type I: Feathered-edge design

The feather edge preparation consists in as window taken up to the height of the incisal edge but without reducing it (58).

2.3. Type II: Butt joint design (or bevel)

It is a preparation that also interests the free edge, without having a palatal return. The incisal edge is reduced by an average of 1.5 mm. The incisal edge will be flat, forming a right angle with the transverse axis of the tooth. In this case, a maximum of 80% of the enamel tissue will be preserved with an exposed dentin volume of 10 to 20%.

Since the volume of ceramic material with this preparation is larger, the dental technician has greater freedom of action to reconstruct and modify the shape of the tooth. Severe dyschromia will also be more effectively masked. The veneer has two axes of insertion: vestibular and coronal**.**

(57,59)

2.4. Type III: Incisal overlap design

The preparation is similar to that of the butt joint, but in addition, it has a palatal return with a chamfer. The volume of hard tissue preserved will be 75%, with 20-40% of dentin exposed. As the volume of ceramic material allowed by this preparation is the largest, this preparation technique is the most indicated for large restorations and severe dyschromia.

However, the return palate is an area of fragility. Besides, Magne and Belser recommend replacing this finish line with a shoulder, which considerably reduces the risk of fracture thanks to better seating of the occlusal forces. Clinically, the veneer has only one insertion axis (coronary) and a cervical finish line, which greatly facilitates its handling.

(23,57,59)

3. Comparison of survival rate depending on the preparation

3.1. Survival rate depending on the cervical preparation

In the early 2000's, the knife-edge termination was opted to avoid dentin exposure, increasing its long-term prognosis. With labial and palatal loading, tensile stresses were lesser within porcelain associated with knife-edge veneer margins than shoulders or chamfers (60). Pahlevan and al. analyzed the maximum thickness encountered in central and lateral maxillary incisors. For both maxillary central and lateral incisors, the thickest amount of enamel in vestibular was found at the incisal third, whereas the thinnest layer of enamel was located at the cervical third (61). The point of comparing enamel thickness was to study which preparation type was the most suitable. The authors concluded that the thickness in the cervical third was insufficient to perform a chamfer preparation, possibly leading to dentin exposure.

Nonetheless, several articles validate the chamfer finish line. The light chamfer line presents a balance between hard tissue conservation and accepted prosthetic space. In addition to better repartition of the forces at the cervical level, a chamfer finishing line appears to redistribute loading forces more equally at the incisal level, increase veneer's long-term prognosis.

(18,23,54,62)

3.2. Survival rate depending on the incisal preparation

Whether it is best or not to prepare the incisal border remains an discussed theme. By studying models of teeth (at the scale of 2.5x) made from photo-elastic materials, Highton and al. concluded that the bevel type showed the most favorable outcomes (53).

Galiatsatos A. Aristidis conducted a five-year follow-up over porcelain laminate veneers cemented on tooth prepared with an incisal reduction of 0.5mm. After five years, the results are clear; 100% of the dental veneers had been retained without presenting signs of alterations (e.g. fracture, recurrent caries, marginal discoloration) (63).

Via an in vitro study , KK Hui showed that the “window” preparation type was the strongest compared to other preparation types such as the “feathered” design and the “overlap” design, and therefore designated the “window” design as the preparation of choice for dental veneers (64).

Zarone and al. concluded that via a dynamometric assessment of the mechanical resistance of porcelain veneers related to tooth preparation, the window preparation was the most recommended design as it presented the lowest fracture rate (65).

Another in vitro study executed by Schmidt and al. concluded that the use of a shoulder finish line lower rates of failure load compared to a preparation design with a palatal chamfer (34).

Bergoli and al., through a finite element analysis, align their conclusion with the previous studies mentioned. Ceramic veneers cemented on teeth prepared with an incisal overlap displayed a propensity to generate higher maximal principal stress (MPS) (66).

Nevertheless, in another study performed by Zarone and al., it was found that the stress observed in the chamfer with palatal overlap was distributed uniformly in the cement layer. In contrast, in the window preparation, the stress was mainly concentrated at the incisal area (67).

An in-vitro study evaluated the fracture load and mode of failure of ceramic veneers with four tooth preparation designs cemented on extracted human maxillary central incisors. The lowest rate of fracture was reported for the group of teeth prepared with 1 mm of incisal reduction and 1 mm height of palatal chamfer. The highest rate of fracture was presented on the butt joint preparation type (68). The authors concluded that the that deep incisal overlap provided the best retention for the restoration and that the butt joint incisal reduction was not recommended.

Stappert and al. performed a study to evaluate the survival rate of ceramic veneers after exposure to masticatory simulation (dynamic loading and thermal cycling). The in-vitro study concluded that the incisal overlap allowed for best support (69).

Lastly, although some studies may have led to a definite conclusion, other articles are inconclusive. Smales and al. conducted a retrospective study of feldspathic porcelain veneers of up to 7 years. The researcher compared 46 veneers with incisal coverage with 64 without incisal coverage. At years 5, 6, and 7, the survival rate was around 95.8% for veneers with incisal porcelain coverage against 85.5% for those without incisal coverage. Also, six of the nine failures occurred due to fracture in veneers without incisal coverage. However, the differences were not statistically significant. (55)

Another study had for objective to examine the correlation between material, design and fracture mode for veneers supported by composite resin abutments. This specific study concluded that there were no statistical difference of prognosis depending on the type of incisal preparation performed (70).

Although the results of this literature review seem clear, it is important to mention the lack of homogenization between each of the articles mentioned. Little information is given about the specific modalities of each study (e.g. randomization, teeth prepared, means of measurements).

4. « No prep » veneers

Frequently referred to as "addition veneers". In this case, the tooth is either not prepared or only very slightly prepared (0.5 mm at the incisal level). This is the concept of addition veneer. The ceramic is bonded directly to the enamel surface layer.

Reminder: “addition veneer” refers to a direct or indirect veneer restoration that does not require any (or a few) dental preparation. In contrast, “substraction veneer” necessarily involves the removal of hard tissue. A veneer is not perforce only additive or subtractive. The strategic choice is based on the individual needs of each tooth and each patient.

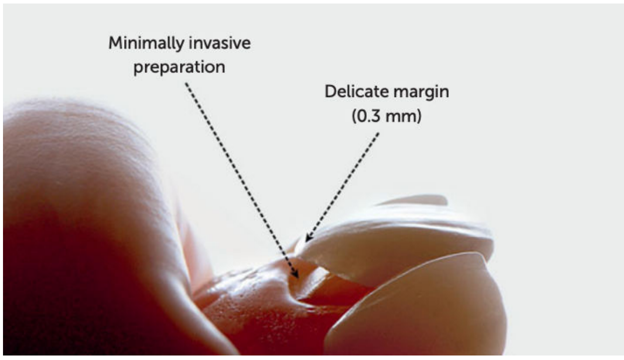

Figure 24. The preparation of the tooth is important because it clearly shows the dental technician the limits of the veneer, allowing for a more natural contour and transition between the restoration and the tooth.

4.1. Advantages of “no prep” veneer compared to traditional preparation

The advantage of this type of veneer is that it falls into the category of ultra-conservative restorations since more than 95% of the dental tissue is preserved. The preservation of the hard tissue greatly contributes to increasing the long-term prognosis since veneers derive their strength from their adhesion to the enamel. Furthermore, the absence of milling represents a significant time saving which not only facilitates the dentist's work but can also improve the patient's experience in the office.

(71–73)

4.2. Inconvenients of “no prep” technique compared to traditional preparation

The absence of a cervical finish line makes clinical manipulation and therefore insertion much more difficult, and significantly increases the risk of over-contouring. The ceramic layer is much thinner, which contraindicates no prep veneers for severely dyschromic teeth.

The superficial enamel layer is aprismatic and counteracts the bonding ability of the resins. In order to improve the qualities of these no-prep veneers, this aprismatic enamel layer must be removed, thus resulting in "prep-less" veneers.

With such finesse, certain characteristics of the lutting cement can have important repercussions on the success of the procedure. Magne and al. (74) state that a too thin veneer presenting a poor internal fit can experience higher stresses at both the surface and the interface of the restoration with the dental tissues, leading to cracks in the ceramic, posterior to the cementation. The use of fluid resin composite cement can palliate this problem and ensure a correct seating of the veneer (75,76).

(71–73)

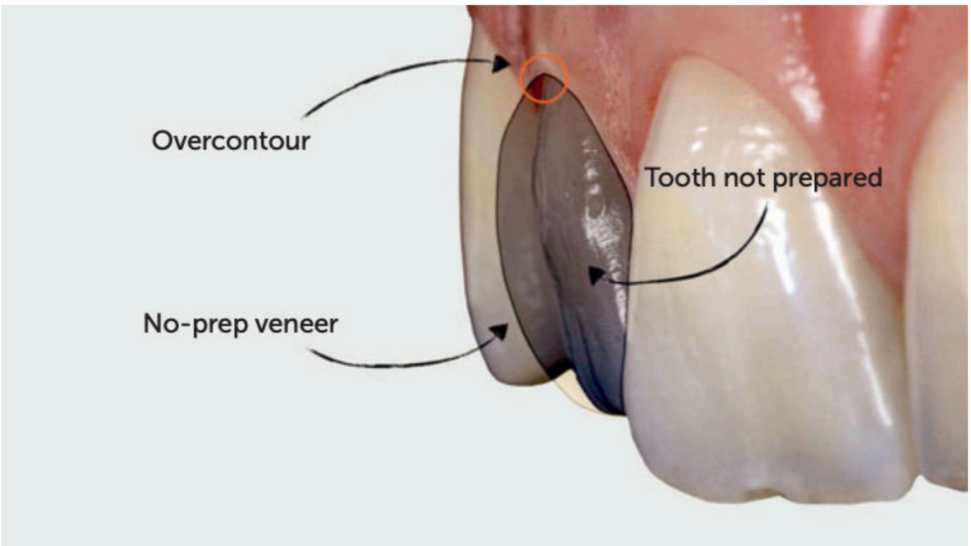

Figure 25. No-prep veneers give the false impression of greater technical ease, as this technique dispenses with the skills required to prepare the teeth. However, there is a risk of unwanted overcontouring.

VI. CONCLUSION

Of the many different tooth preparation designs for ceramic veneers, the type of preparation performed at the incisal edge has the greatest influence on treatment prognosis. We can distinguish three different types of design:

- Type 1: including the window design and the feathered-edge preparation
- Type 2: bevel preparation, also known as butt-joint
- Type 3: incisal overlap (or palatal chamfer)

From this systemic review, it is possible to state that 1) The light chamfer cervical preparation is the most conservative and suitable option and that 2) Type I and type II incisal preparations should be favored (Type II presenting the lowest risk of post operative failure). Type III incisal preparation is contraindicated.

Given the limitations of the available literature, one of the decisive factors in choosing the type or preparation remains the clinician's preference. Apart from the dentist's selection criteria, various factors in relation to the patient play a role in the decision on dental preparation (e.g. condition of the dental tissue, patient expectations). Before considering the options available to improve their smile, patients must first undergo a complete clinical examination, including both esthetic and functional evaluation.

VII. FIGURE INDEX

Figure 25: Farias-Neto A, de Medeiros FCD, Vilanova L, Simonetti Chaves M, Freire Batista de Araújo JJ. Tooth preparation for ceramic veneers: when less is more. Int J Esthet Dent. 2019;14(2):156–64.

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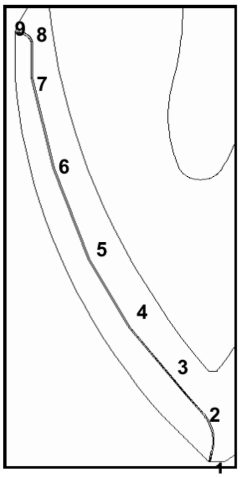
IX. ANNEXES

ANNEX 1

Al-huwaizi HF. A finite element analysis of the effect of different margin designs and loading positions on stress concentration in porcelain veneers. J Coll Dent. 2005;17(2):8–12.



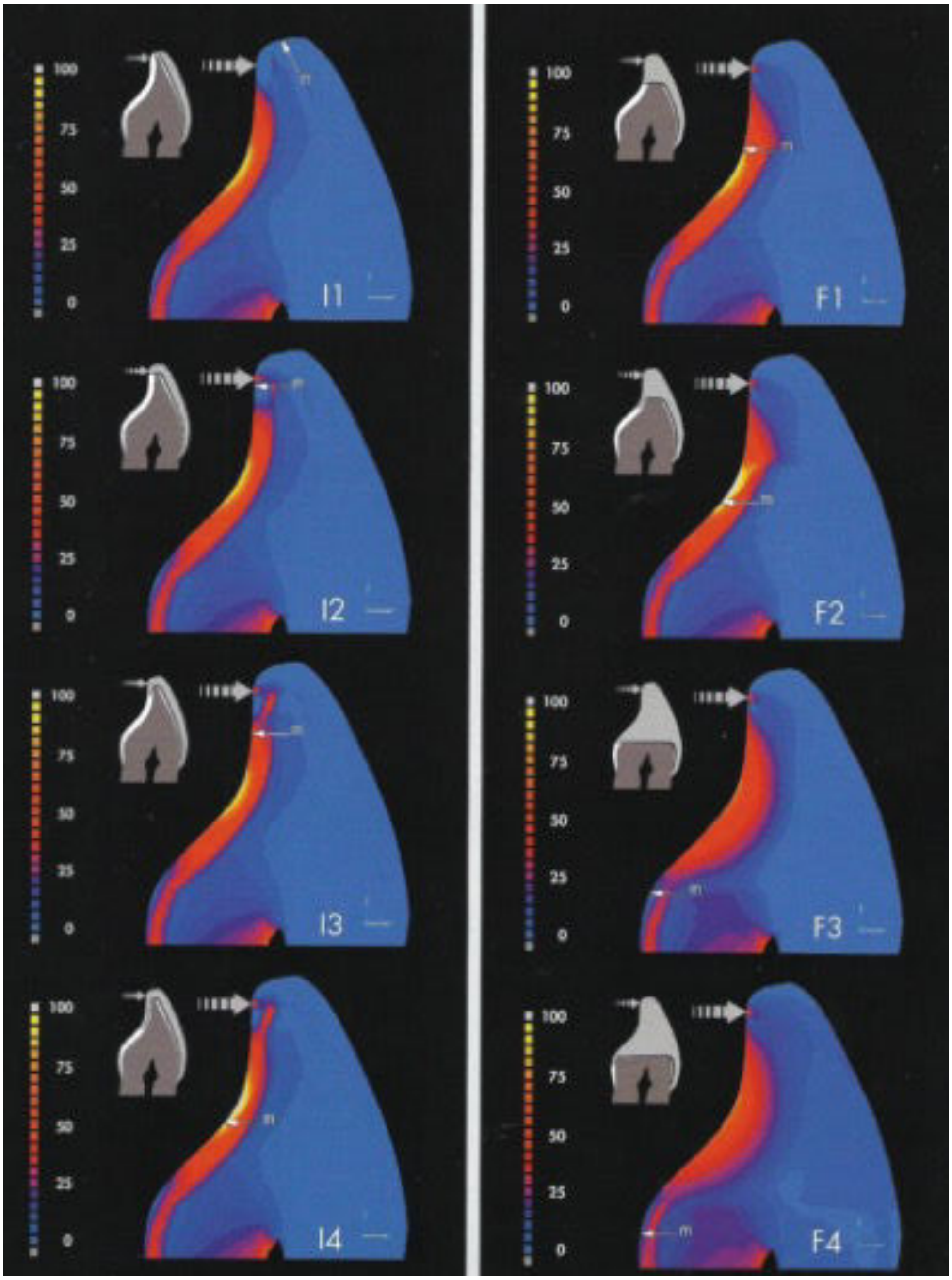
Stress concentration measured in 9 different points of an incisor.

		Incisal Third Force				Middle Third Force				Cervical Third Force		
		A	B	C		A	B	C		A	B	C
Butt Finishing Line	1	138	71.1	9.3	1	1.7	0.9	0.1	1	0.5	0.2	0.003
	2	325.5	35.5	99.6	2	8.5	1.2	3.4	2	1.5	0.19	0.49
	3	35.8	11.1	36.6	3	6.4	6.1	5.5	3	1.4	1.3	1.1
	4	23.8	9.7	44	4	3.1	1.6	4.4	4	6	4.9	4.6
	5	30.1	9.7	34.8	5	1.9	0.7	3.0	5	6.8	4.4	7.2
	6	19.2	4.2	29.7	6	9.5	9.5	8.4	6	7.9	7.2	7.5
	7	26.3	5.8	47.2	7	14.1	8.2	20.2	7	5.9	5.2	5.9
	8	116.7	18.3	77.5	8	73.7	11.1	38.9	8	27.4	4.1	12.2
	9	23.3	14.9	63	9	12.8	8.2	32.2	9	4.7	3	11
Deep chamfer Finishing Line		A	B	C		A	B	C		A	B	C
	1	149.6	71.8	9.3	1	0.5	0.3	0.2	1	0.07	0.3	0.005
	2	55.9	37.8	45.6	2	2	1.4	1.7	2	0.29	0.2	0.28
	3	34.9	9.8	36.2	3	6.4	6	5.5	3	1.4	1.2	1.1
	4	23.3	9.2	43.7	4	2.8	1.5	4.4	4	6.2	4.8	4.6
	5	29.9	9.4	35	5	1.8	0.6	3.0	5	6.6	4.3	7.1
	6	19.1	4.0	24.8	6	9.3	9.3	8.3	6	7.7	7.1	7.1
	7	21.9	5.0	45.9	7	12.1	7.7	19.7	7	5.6	4.9	5.8
	8	27.9	26.2	47.7	8	11.6	13.1	24.6	8	3.9	4.1	7.9
	9	25.6	12.9	59.5	9	13.9	7.1	30.4	9	5.1	2.6	10.3
Chamfer Finishing Line		A	B	C		A	B	C		A	B	C
	1	149.6	71.6	9.2	1	0.4	0.1	0.2	1	0.9	0.44	0.006
	2	55.9	42.9	48.6	2	1.8	1.5	1.8	2	0.27	0.2	0.29
	3	35	9.3	30.4	3	6.4	6	5.5	3	1.4	1.2	1.1
	4	23.2	9.2	44.7	4	2.8	1.5	4.5	4	6.2	4.8	4.6
	5	30.1	9.3	34.6	5	1.8	0.6	3	5	6.6	4.2	7.1
	6	21.2	3.8	25.6	6	9.4	9.3	8.1	6	8	7.1	7.1
	7	20.9	5.4	56.7	7	13.2	7.1	23.8	7	6.8	4.5	6.3
	8	34.9	36.1	48.0	8	17.5	18.2	24.3	8	5.4	5.7	7.7
	9	44.1	20.9	47.8	9	23.1	11.8	24.3	9	8	4.1	8.4

Von mises stress analysis in Mpa of porcelain veneers with different cervical finish lines and force of application site.
We can observe that the lowers values are located on the second block line, corresponding to deep chamfer finishing line.

ANNEX 2

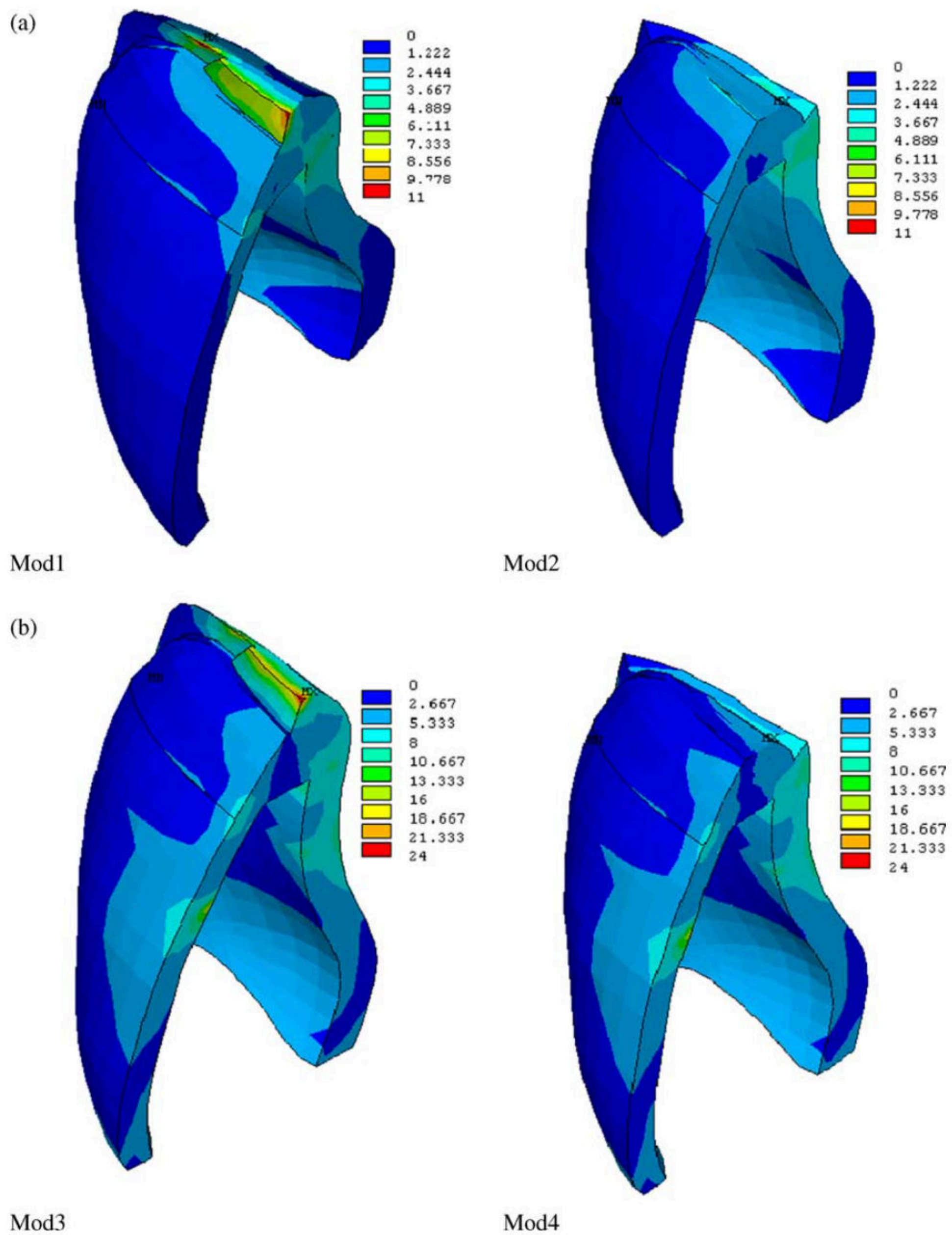
Magne P, Belser U. Bonded Porcelaine Restorations in the Anterior Dentition : A Biomimetic Approach. IL: Quintessence. 2002:129–78.



Comparison of the porcelain veneer stress distribution (Equivalent modified Von mises in Mpa)
The thin white arrow "m" locates the margin of the preparation.
Margin location is considered favorable for I1 and I2 but less favorable for I3 and even detrimental for I4 therefore concluding that the incisal overlap is contraindicated.
Regarding the left column, stress in the palatal concavity is acceptable for F1 and detrimental for F2. F3 and F4 are the most favorable cases. However, these preparations should be indicated only in particular cases of severe loss of tissue.

ANNEX 3.1

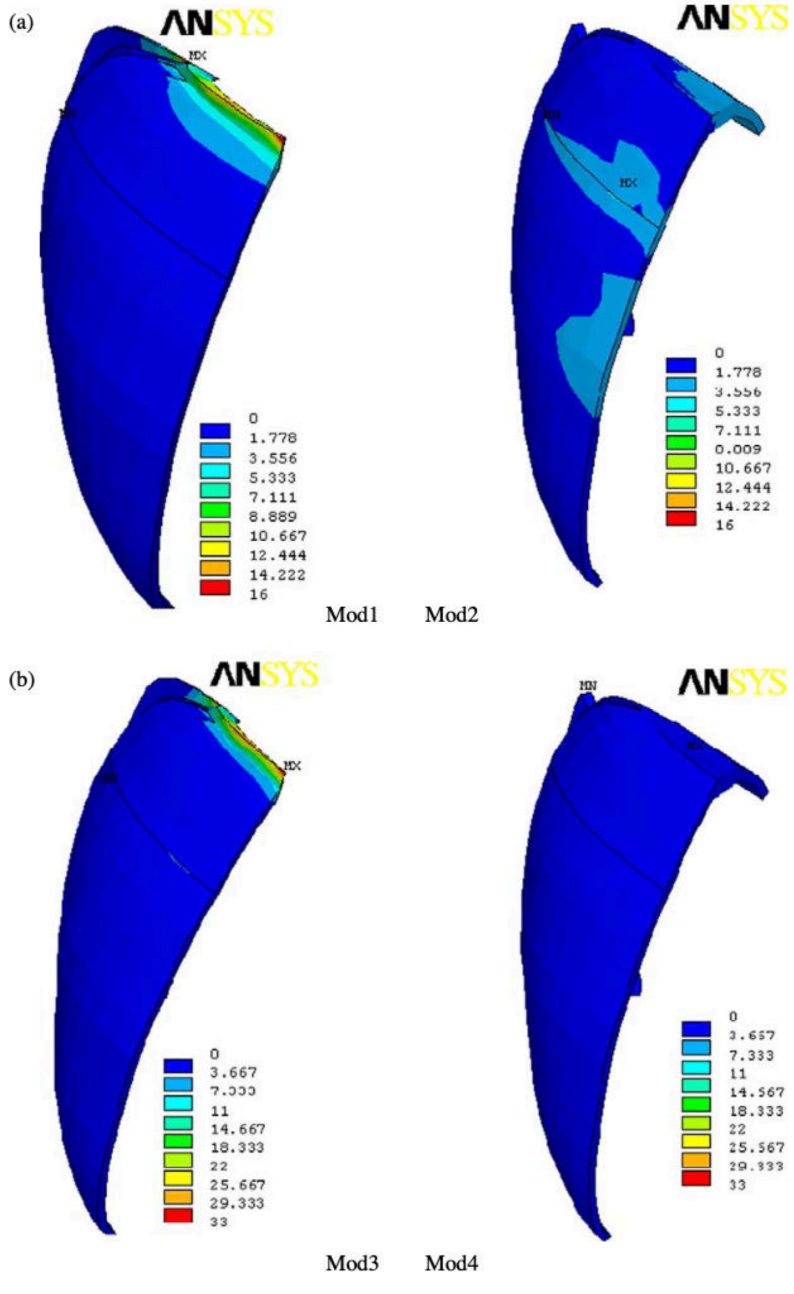
Zarone F, Apcella D, Sorrentino R, Ferro V, Aversa R, Apicella A. Influence of tooth preparation design on the stress distribution in maxillary central incisors restored by means of alumina porcelain veneers: A 3D-finite element analysis. Dent Mater. 2005 Dec 1;21(12):1178–88.



Comparison of the porcelain veneer stress distribution.
Mod1 and Mod3 represent the window incisal preparation type respectively under loads applied at 125° and 60° angles with the long axis at the palatal surface of the tooth.
Mod2 and Mod4 represent the incisal overlap prepraration type respectively under loads applied at 125° and 60° angles with the long axis at the palatal surface of the tooth.
We can observe lesser amount of stress regarding Mod2 and Mod4.

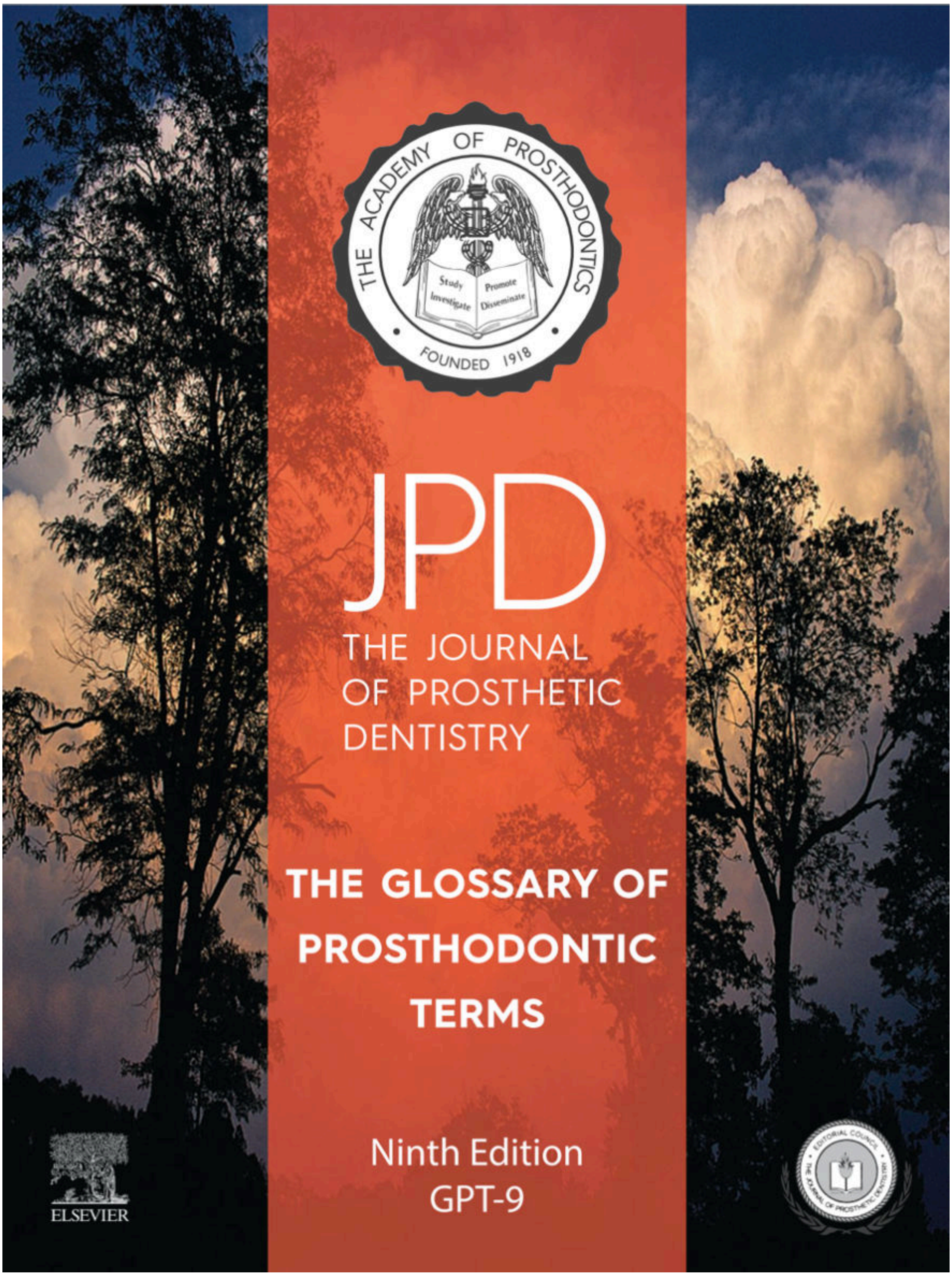
ANNEX 3.2

Zarone F, Apcella D, Sorrentino R, Ferro V, Aversa R, Apicella A. Influence of tooth preparation design on the stress distribution in maxillary central incisors restored by means of alumina porcelain veneers: A 3D-finite element analysis. Dent Mater. 2005 Dec 1;21(12):1178–88.



Comparison of the cement layer stress distribution.
Mod1 and Mod3 represent the window incisal preparation type respectively under loads applied at 125° and 60° angles with the long axis at the palatal surface of the tooth.
Mod2 and Mod4 represent the incisal overlap prepraration type respectively under loads applied at 125° and 60° angles with the long axis at the palatal surface of the tooth.
We can observe lesser amount of stress regarding Mod2 and Mod4.

Please note that the following appendices are listed in order of appearance following the bibliography.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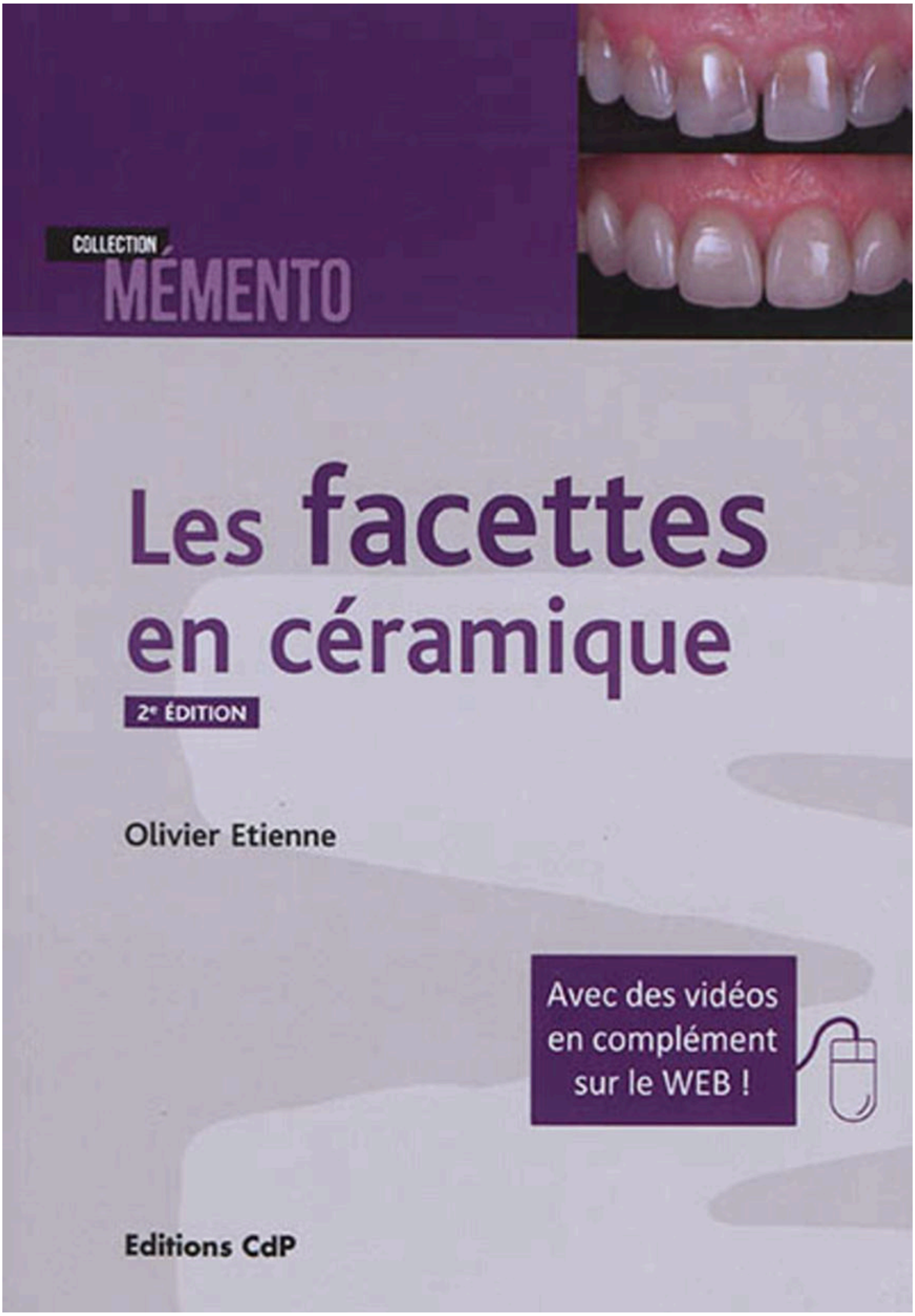
COLLECTION
MÉMENTO
Les facettes
en céramique
2e ÉDITION
Olivier Etienne
Avec des vidéos
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HISTOIRE

L'art dentaire chez les Étrusques

RÉSUMÉ

Les auteurs procèdent à une présentation de la pathologie et de la thérapeutique dentaire chez les Étrusques en effectuant une lecture critique de l'ouvrage de Gaspare Baggieri et de Marina di Giacomo, publié à Rome en 2005, *Odontoiatria dell'antichità in reperti osteo-dentari e archeologici* (L'art dentaire antique d'après des découvertes ostéo-dentaires et archéologiques). En particulier, les descriptions des pièces prothétiques trouvées lors des fouilles archéologiques sont parfaitement illustrées par l'admirable iconographie de cet ouvrage.

Stéphane MONIER
Thibault MONIER
Membre titulaire de l'Académie nationale de chirurgie dentaire,
Chargé de cours à la faculté de chirurgie dentaire Paris Descartes.

Avec la collaboration du :

Pr. Danielle GOUREVITCH
Directeur d'études à l'École Pratique des Hautes Études

Mots clés

- **étude critique**
- **histoire**
- **pathologie**
- **prothèse dentaire**
- **monde étrusco-romain**

AOS 2008;243:279-293
DOI:10.1051/AOS:2008035

Jurnal Medical Aradean (Arad Medical Journal)
Vol. XVII, issue 1, 2014, pp. 40-44

PRINCIPLES OF PINCUS IN ESTHETIC DENTISTRY

Authors: Mugur-George Popescu, Gabriela Elisei, Radu Elisei, Freiman Paul, Melinda Oneţ, Dana Vincze, Gag Otilia, Oprea Otilia

Affiliation: Faculty of Medicine, Pharmacy and Dentistry - Western University "Vasile Goldis" Arad, Romania.

ABSTRACT. Dr. Charles L. Pincus known as the "Dentist of the Stars" played an important role in the evolution of dental aesthetics, founded the American Academy of Cosmetic Dentistry, which became the inspiration and stimulus for global expansion of dental aesthetics outright fixed, including the establishment International Federation of Dental aesthetics, was credited with being the first to use aesthetic veneers. Veneers he applied to his patients - actors in Hollywood - did not last very long not beeing very resistant but had an enormous positive impact among "movie stars".
KEYWORDS: dental aesthetics, Dr. Pincus, prosthetic devices, light reflection.

INTRODUCTION:

The first steps of dental aesthetics was Dr.Pincus whose first publications appeared in 1938 in a magazine specialized in California, but his real work began much earlier, in 1928 when he was asked by two major film companies (Twentieth Century Fox, Warner Bros) for some fireworks dental importance at the time, the film has made the big switch from mute to the spoken, was absolutely necessary to improve the image of the actor concerning the teeth or changeing the visual image in the roles like Frankenstein or Dracula but this had to be done without causing discomfort to the actor or to affect its oratorical skills.

One of the major contributions of Dr. Charles Pinks importance was the discovery of light reflectance, surface texture and contour of teeth, tjis beeing consindered the base of the dental aesthetics, being responsible for the success or failure of an aesthetic dentistry's work.

Oral cavity personality creation- a few years ago and maybe even today, some dentists and dental technicians insist in making dental treatment only on certain factors: physiological, biological and mechanics sometimes neglecting the fourth factor, namely the aesthetic, which is extremely important for the confidence of the patient.

Both the dentist and dental technician should be able to combine the patient's whishes to the existing techniques and principles of dental aesthetics to have the claim that their work is really effective.

The importance of light in esthetic dentistry- the basic rule in the success of cosmetic dentistry work is knowing and understanding the properties of light. Unfortunately this factor: LIGHT is given less attention.

There are three characteristics of light that must be followed to obtain superlative results with ceramics, namely: light direction, light's color and the movement.

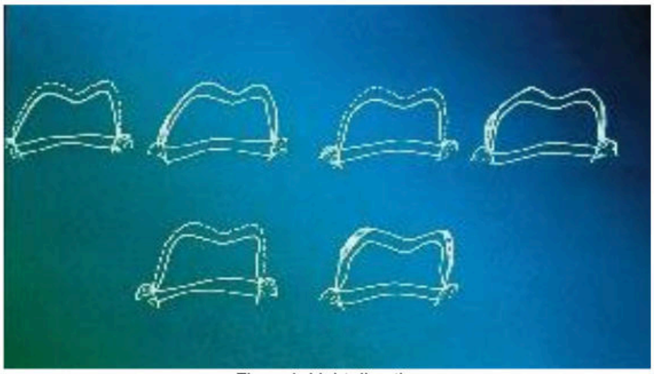

Figure1. Light direction

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REVIEW ARTICLE

WILEY

Adhesive dentistry: Current concepts and clinical considerations

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Abstract

Objectives: To address contemporary concepts in adhesive dental materials with emphasis on the evidence behind their clinical use.

Overview: Adhesive dentistry has undergone major transformations within the last 20 years. New dental adhesives and composite resins have been launched with special focus on their user-friendliness by reducing the number of components and/or clinical steps. The latest examples are universal adhesives and universal composite resins. While clinicians prefer multipurpose materials with shorter application times, the simplification of clinical procedures does not always result in the best clinical outcomes. This review summarizes the current evidence on adhesive restorative materials with focus on universal adhesives and universal composite resins.

Conclusions: (a) Although the clinical behavior of universal adhesives has exceeded expectations, dentists still need to etch enamel to achieve durable restorations; (b) there is no clinical evidence to back some of the popular adjunct techniques used with dental adhesives, including glutaraldehyde-based desensitizers and matrix metalloproteinase inhibitors; and (c) the color adaptation potential of new universal composite resins has simplified their clinical application by combining multiple shades without using different translucencies of the same shade.

Clinical Significance: New adhesive restorative materials are easier to use than their predecessors, while providing excellent clinical outcomes without compromising the esthetic quality of the restorations.

KEYWORDS
dental adhesion, dental bonding, dental materials, universal adhesives, universal composite resins

1 | INTRODUCTION

Establishing durable adhesion to dentin with resin monomer solutions has been an arduous task since the pioneering work of several research teams in the 1950s using the phosphate monomer glycerol phosphoric acid dimethacrylate (GPDM). This monomer, patented by Oskar Hagger in 1951, was included in the composition of Sevitron Cavity Seal (Amalgamated Dental Trade Distribution, Ltd., London, UK).[1-4]

©Operative Dentistry, 2003, **28-3**, 215-235

Buonocore Memorial Lecture

Adhesion to Enamel and Dentin: Current Status and Future Challenges

Michael Buonocore

B Van Meerbeek • J De Munck • Y Yoshida
S Inoue • M Vargas • P Vijay
K Van Landuyt • P Lambrechts • G Vanherle

Bart Van Meerbeek

SUMMARY

Bonding to tooth tissue can be achieved through an "etch&rinse," "self-etch" or "glass-ionomer" approach. In this paper, the basic bonding mechanism to enamel and dentin of these three approaches is demonstrated by means of ultra-morphological and chemical characterization of tooth-biomaterial interfacial interactions. Furthermore, bond-strength testing and measurement of marginal-sealing effectiveness (the two most commonly employed methodologies to determine "bonding effectiveness" in the laboratory) are evaluated upon their value and relevance in predicting clinical performance. A new dynamic methodology to test biomaterial-tooth bonds in a fatigue mode is introduced with a recently developed micro-rotary fatigue-testing device. Eventually, today's adhesives will be critically weighted upon their performance in diverse laboratory studies and clinical trials. Special attention has been given to the benefits/drawbacks of an etch&rinse versus a self-etch approach and the long-term performance of these adhesives. Correlating data gathered in the laboratory with clinical results clearly showed that laboratory research CAN predict clinical effectiveness. Although there is a tendency to simplify bonding procedures, the data presented confirm that conventional three-step etch&rinse adhesives still perform most

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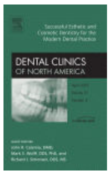
Guido Vanherle, MD, DDS, emeritus full professor, Leuven BIOMAT Research Cluster, Department of Conservative Dentistry, School of Dentistry, Oral Pathology and Maxillo-facial Surgery, Catholic University of Leuven, Belgium

*Reprint request: Catholic University of Leuven, Kapucijnenvoer 7, B-3000, Leuven, Belgium; e-mail: bart.vanmeerbeek@med.kuleuven.ac.be



N Y J Dent 1983;53(6):255–9.

Etched porcelain facial veneers: a new treatment modality based on scientific and clinical evidence

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Since its introduction more than two decades ago [1,2], etched porcelain veneer restoration has proved to be a durable and aesthetic modality of treatment [3–6]. These past 25 years of success can be attributed to great attention to detail in the following areas: (1) planning the case, (2) conservative (enamel saving) preparation of teeth, (3) proper selection of ceramics to use, (4) proper selection of the materials and methods of cementation of these restorations, (5) proper finishing and polishing of the restorations, and (6) proper planning for the continuing maintenance of these restorations. This article discusses failures that could occur if meticulous attention is not given to such details. Failures that did occur structurally and aesthetically warned individuals who were learning the procedure what to watch for. Some concerns as to newer products and methods and their effect on the continued success of this modality of treatment are also addressed.

Shade matching

Aesthetic shade matching and masking with thin porcelain veneer restorations are arguably the most demanding facets of this procedure. The key to success is understanding that the final color obtained is a combined metamerism of the tooth, the resin cement selected, and the porcelain used for the restoration.

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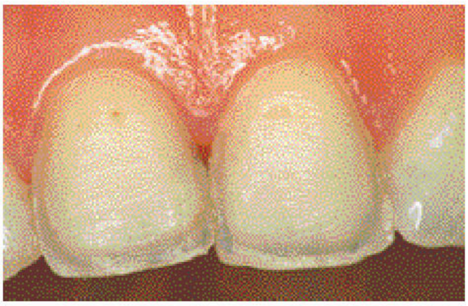
Les facettes collées en composite de laboratoire à matrice epoxine.

Mots clés :
Facette prothétique
Composite
Adhésivité
Technique restauratrice
Traitement nouveau



Bonded laminate veeners made from laboratory matrix epoxine.

Keywords :
Laminate veener
Composite
Adhesiveness
Restorative technique
New technique

Paul MIARA, Alexandre MIARA
Pratique privée, Paris

résumé

Le but de cet article est double :
• Faire découvrir au praticien et au technicien de laboratoire une nouvelle famille de composites utilisant une matrice résine originale : la résine époxine, plus communément appelée PEX (Phenolic Epoxine Monomer). Ce composite semi-cristallin peut être utilisé au laboratoire de prothèse pour tous les types de restaurations en composite mais aussi en clinique pour les restaurations antérieures et postérieures en technique directe.
• Développer à partir d'un cas clinique simple les procédures cliniques et de laboratoire pour la réalisation de facettes en composite collées par une technique originale : la " One Day Technique ". Elle consiste à préparer les dents, à prendre l'empreinte, à monter les composites au laboratoire et à coller les facettes dans une même séance.

abstract

This article has a double aim :
• To help the clinician and the laboratory technician discover a new family of composites using an original resin matrix : the epoxine resin, more commonly called PEX (Phenolic Epoxine Monomer). This semi-crystalline composite can be used in prosthetic laboratories for all types of composite restorations but also in the dental office for direct anterior and posterior restorations.
• To develop clinical procedures using, as an example, a simple clinical and laboratory case for the construction of bonded composite laminate veeners employing an original technique: " the one day " technique. Teeth are prepared, impressions are taken, composites are builded in the laboratory and the laminate veeners are bonded all in the same session.

accepté pour publication le 15/05/02

Fixed partial dentures and operative dentistry

A ceramic restoration bonded by etched enamel and resin for fractured incisors

Alain L. Rochette, Dr.Sc.Odont., M.D.
Saint Raphael, France

The successful long-term attachment of polymethylmethacrylate to etched enamel has enabled us to restore angles of fractured maxillary incisors[1] by means of a ceramic block produced by firing in the laboratory and bonded to the fractured enamel without operative interference.

PRINCIPLES

The ceramic block is bonded to the fractured etched enamel with Sevriton.*

1. The enamel-to-Sevriton bond is obtained by etching.
2. The porcelain-to-Sevriton bond is obtained by a retentive cavity in the ceramic block which produces a mechanical bond. A silane coupling agent† applied to the porcelain provides a chemical bond between the porcelain and the resin.

The ceramic block with its retentive cavity is fired on a 24 karat gold casting.[2]

TECHNIQUE

A technique will be described for the restoration of the fractured mesial angle (Ellis Class II) of a right maxillary central incisor (Fig. 1).

First patient appointment. 1. Carefully select the color and shade for the ceramic block and the Sevriton.

2. Isolate the four incisors with a rubber dam.

3. Make an elastomer impression of the anterior teeth, without modification of the surface of the fracture. Make an occlusal registration by the usual methods.

Laboratory procedure. 1. Pour a hard stone‡ cast in the elastomer impression.

2. On the hard stone cast, in the fractured area corresponding to the dentin, apply inlay wax conforming approximately to the contour of the dentin (dentin wax in Fig. 2). It is important that the wax not cover the zone corresponding to the fractured enamel (Fig. 3).

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*Sevriton Simplified, Claudius Ash, Inc., Niagara Falls, N. Y.

†Fusion, George Taub Products, Jersey City, N. J.

‡Vel-Mix, Kerr Manufacturing Company, Romulus, Mich.

Porcelain Veneers: Dentin Bonding Optimization and Biomimetic Recovery of the Crown

Pascal Magne, Dr Med Dent[a]
William H. Douglas, BDS, MS, PhD[b]

Purpose: The purpose of this study was to investigate the biomimetic principle in porcelain veneer reconstruction, or in other words, to assess the extent to which the restoration can mimic the biomechanics and structural integrity of the original tooth. Using an optimized luting procedure, porcelain veneers are expected to present such features even when bonded to an extensive dentin surface. **Methods and Materials:** Dentin-bonded porcelain veneers were assessed using functional and cyclic thermal loads with respect to two parameters: coronal stiffness (investigated using experimental strain gauges and finite element analysis) and morphology of the tooth-restoration interface (scanning electron microscope evaluation). Two different application modes of the same dentin-bonding agent, Optibond FL, were evaluated: a traditional method (dentin adhesive applied when proceeding to luting the veneer) and an alternative method (dentin adhesive applied to dentin and cured before taking the impression for the veneer). **Results:** In the finite element model, the crown compliance increased by a factor of 2.16 after facial enamel removal and returned to 96% of its original value after the placement of the veneer. The finite element values showed a good correlation with strain gauge experimental results (one-sample *t* test, $P > 0.35$ after facial enamel removal and $P > 0.19$ after veneer placement). The dentin adhesive application mode was not critical to the recovery of tooth stiffness (analysis of variance, $P = 0.10$). However, qualitative scanning electron microscope observations demonstrated that the traditional dentin adhesive application was associated with bonding failures between the hybrid layer and the overlying resin, whereas unbroken and continuous interfaces were obtained with the new method using the same dentin adhesive. **Conclusion:** The results of this study definitely favor the biomimetic behavior of porcelain veneers bonded to teeth using an optimized application mode of dentin adhesives, because this treatment modality proved to restore both the mechanical behavior and microstructure of the intact tooth. *Int J Prosthodont 1999;12:111–121.*

Modern concepts in medical research involve the investigation of both structures and physical functions of biologic "composites" and the designing of new and improved substitutes.[1] This newly emerging interdisciplinary material science is called "biomimetics." The primary meaning refers to material processing in a manner similar to the oral cavity, such as the calcification of a soft tissue precursor. The secondary meaning of biomimetics refers to the mimicking or recovery of the biomechanics of the original tooth by the restorative material. This of course is the goal of restorative dentistry.

It is assumed that the hardness of enamel protects the soft underlying dentin. On the other hand, the crack-arresting effect of dentin and of the thick collagen fibers at the dentinoenamel junction[2] compensate for the inherently brittle nature of enamel. This structural and physical interrelationship

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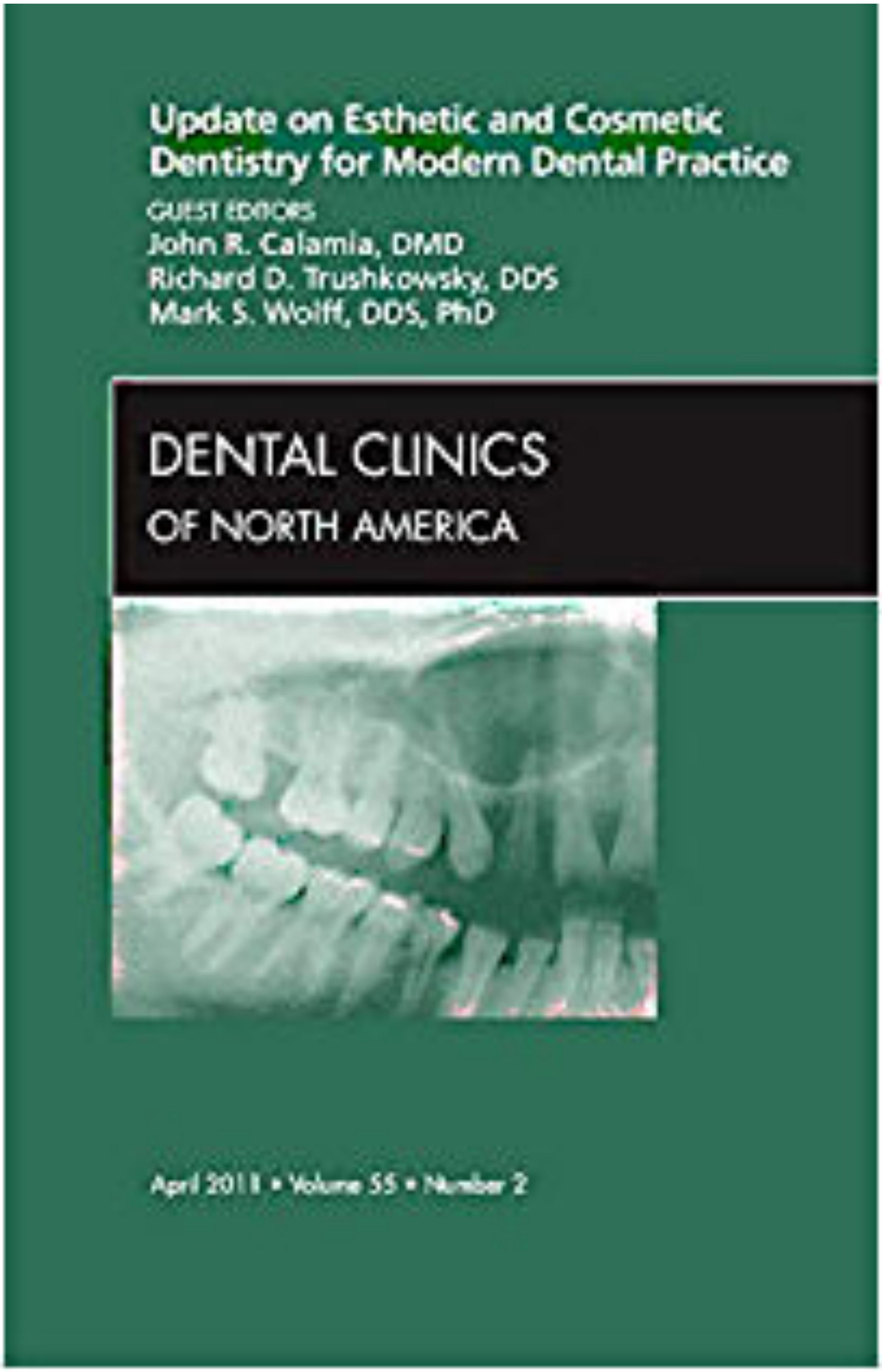
Update on Esthetic and Cosmetic Dentistry for Modern Dental Practice
GUEST EDITORS
John R. Calamia, DMD
Richard D. Trushkowsky, DDS
Mark S. Wolff, DDS, PhD
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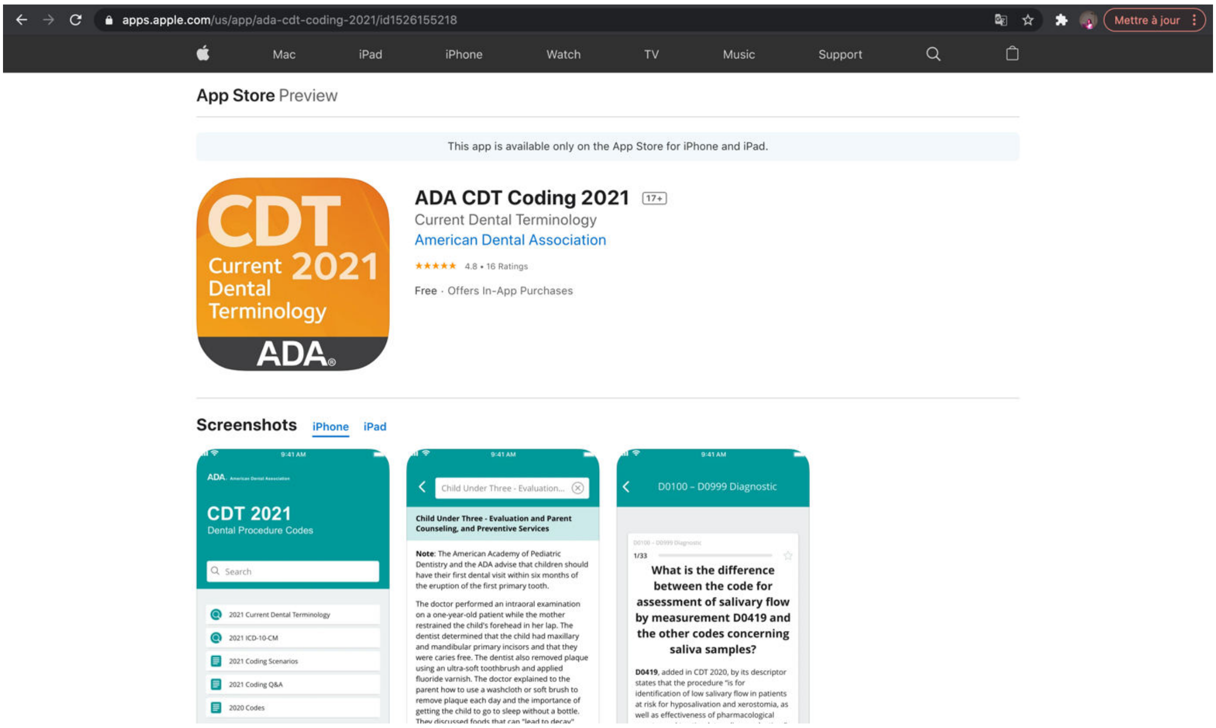
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Mettre à jour
Mac
iPad
iPhone
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TV
Music
Support
App Store Preview
This app is available only on the App Store for iPhone and iPad.
CDT
Current 2021
Dental
Terminology
ADA
ADA CDT Coding 2021
17+
Current Dental Terminology
American Dental Association
4.8 • 16 Ratings
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2021 ICD-10-CM
2021 Coding Scenarios
2021 Coding Q&A
2020 Codes
Child Under Three - Evaluation and Parent Counseling, and Preventive Services
D0100 – D0999 Diagnostic
What is the difference between the code for assessment of salivary flow by measurement D0419 and the other codes concerning saliva samples?

Céramiques dentaires : de leurs évolutions aux implications cliniques

Durand J-C, Pourreyron L, Bennasar B, Jacquot B, Fages M

RÉSUMÉ

L'amélioration concomitante des matériaux céramiques et des colles durant ces dix dernières années a ouvert de nouveaux champs d'applications cliniques. Parmi celles-ci, la réalisation de facettes en céramiques constitue l'expression la plus conservatrice et la plus respectueuse des tissus dentaires. Cette préservation maximale des tissus sains assure à la fois le bénéfice du collage sur l'émail et la possibilité de réintervention dans le temps. Afin de contrôler au mieux la nécessaire mise en forme initiale, plusieurs protocoles de préparation ont été proposés. Ils font appel à la notion de pénétration tissulaire contrôlée, grâce à l'utilisation de fraises diamantées dédiées. La technique de préparation à travers le masque esthétique constitue certainement la réflexion la plus aboutie en terme de protocole de préparation. En effet, contrairement à d'autres propositions, cette technique est fiable, reproductible et facile à mettre en oeuvre cliniquement.

IMPLICATION CLINIQUE

La préparation des dents destinées à recevoir des facettes céramiques requiert une préservation maximale du support amélaire, plus favorable au collage et garant de la pérennité.

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DCD, MCU-PH

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La dentisterie adhésive constitue sans aucun doute une des révolutions majeures des vingt dernières années en Odontologie (1). Les progrès constants en termes d'adhésion aux tissus dentaires, associés aux améliorations mécaniques des matériaux céramiques, ont permis le développement d'une dentisterie esthétique sans métal réservée jusque-là aux plus audacieux tant les risques de fractures étaient grands (2, 3).
Cette révolution adhésive a rapidement rejoint le concept d'économie tissulaire en offrant de nouvelles formes de préparation, mélange de notions mécaniques classiques et de propriétés spécifiques du collage. Parmi ces dernières, il en est une qui revêt une importance clinique cruciale : la différence de qualité de l'adhésion entre la dentine et l'émail. En effet, de par la nature très différente de ces deux substrats, le collage amélaire est toujours supérieur au collage dentinaire (4, 5, 6). Dès lors, le praticien doit systématiquement rechercher le meilleur compromis entre une épaisseur de matériau prothétique suffisante pour assurer sa résistance et son esthétique (tableau I), et une préservation maximale de l'émail sur le support dentaire préparé. Compte tenu de la translucidité variable des céramiques collées (7) et de la couleur initiale du support, une attitude plus « agressive » peut être nécessaire afin de masquer plus efficacement une dyschromie (8). Dans le même ordre d'idées, les facettes à armature vitrocéramique demandent plus d'épaisseur totale que les céramiques feldspathiques montées directement sur le die réfractaire.

A New Classification System for All-Ceramic and Ceramic-like Restorative Materials

Stefano Gracis, DMD, MSD[a]/Van P. Thompson, DDS, PhD[b]/Jonathan L. Ferencz, DDS[c]/
Nelson R.F.A. Silva, DDS, MSc, PhD[d]/Estevam A. Bonfante, DDS, MSc, PhD[e]

Classification systems for all-ceramic materials are useful for communication and educational purposes and warrant continuous revisions and updates to incorporate new materials. This article proposes a classification system for ceramic and ceramic-like restorative materials in an attempt to systematize and include a new class of materials. This new classification system categorizes ceramic restorative materials into three families: *(1)* glass-matrix ceramics, *(2)* polycrystalline ceramics, and *(3)* resin-matrix ceramics. Subfamilies are described in each group along with their composition, allowing for newly developed materials to be placed into the already existing main families. The criteria used to differentiate ceramic materials are based on the phase or phases present in their chemical composition. Thus, an all-ceramic material is classified according to whether a glass-matrix phase is present (glass-matrix ceramics) or absent (polycrystalline ceramics) or whether the material contains an organic matrix highly filled with ceramic particles (resin-matrix ceramics). Also presented are the manufacturers' clinical indications for the different materials and an overview of the different fabrication methods and whether they are used as framework materials or monolithic solutions. Current developments in ceramic materials not yet available to the dental market are discussed. *Int J Prosthodont 2015;28:227–235. doi: 10.11607/ijp.4244*

Ceramics have been the mainstay of esthetic dentistry for more than 100 years. Originally in the naturally occurring feldspathic form, ceramics were used primarily for anterior teeth as high fusing porcelain jacket crowns, denture teeth, and partial coverage. Beginning with John McLean's introduction of aluminous porcelain in the mid-1960s,[1] there have been continuous improvements in strength, esthetics, and methods of fabrication, resulting in dozens of products for clinicians to choose from.

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[d]Associate Professor, Department of Restorative Dentistry, Federal University of Minas Gerais, Belo Horizonte, Minas Gerais, Brazil.
[e]Assistant Professor, Department of Prosthodontics, University of São Paulo—Bauru College of Dentistry, Bauru, São Paulo, Brazil.

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Due to the high number of products available and the speed at which new products are being introduced, today's clinician faces a complex decision process when choosing a ceramic restorative material for a particular indication. The selection is seldom made on the basis of a thorough understanding of the materials' characteristics. More often, it is based on criteria such as strength measured in vitro, degree of translucency, manufacturing techniques, the preference of the dental laboratory technician, and even advertising claims.

A classification system of the ceramic materials used in dentistry is useful for a variety of purposes, including communication and education. Ideally, a classification system should be helpful in providing clinically relevant information about where to use the material (anterior versus posterior), for what type of restoration (partial versus full, short versus long-span), and how to lute it (adhesively versus traditionally). Different classification systems have been proposed that focus on clinical indications, composition, ability to be etched, processing methods, firing temperatures, microstructure, translucency, fracture resistance, and antagonist wear.[2–6] These classifications, however, tend to be either vague or imprecise, and they do not easily allow for the inclusion of new restorative materials.

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Dental Ceramics: Part I – An Overview of Composition, Structure and Properties

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Abstract Over the last decade, it has been observed that there is an increasing interest in the ceramic materials in dentistry. Esthetically these materials are preferred alternatives to the traditional materials in order to meet the patients' demands for improved esthetics. Dental ceramics are usually composed of nonmetallic, inorganic structures primarily containing compounds of oxygen with one or more metallic or semi-metallic elements. Ceramics are used for making crowns, bridges, artificial denture teeth, and implants. The use of conservative ceramic inlay preparations, veneering porcelains is increasing, along with all-ceramic complete crown preparations. This article is a review of dental ceramics; divided into two parts such as part I and II. Part I reviews the composition, structure and properties of dental ceramics from the literature available in PUBMED and other sources from the past 50 years. Part II reviews the developments in evolution of all ceramic systems over the last decade and considers the state of the art in several extended materials and material properties.

Keywords: *ceramics, porcelains, feldspar, silica, glass, firing*

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1. Introduction

In dentistry, ceramics represents one of the four major classes of materials used for the reconstruction of decayed, damaged or missing teeth. Other three classes are metals, polymers, and composites. The word Ceramic is derived from the Greek word "keramos", which literally means 'burnt stuff', but which has come to mean more specifically a material produced by burning or firing [1]. A ceramic is an earthly material usually of silicate nature and may be defined as a combination of one or more metals with a non-metallic element usually oxygen. The American Ceramic Society had defined ceramics as inorganic, non-metallic materials, which are typically crystalline in nature, and are compounds formed between metallic and nonmetallic elements such as aluminum & oxygen (alumina - Al_2O_3), calcium & oxygen (calcia - CaO), silicon & nitrogen (nitride- Si_3N_4) [2]. Ceramics are characterized by their refractory nature, hardness, chemical inertness, biocompatibility [3,4,5] and susceptibility to brittle fracture [6,7]. Ceramics are used for pottery, porcelain glasses, refractory material, abrasives, heat shields in space shuttle, brake discs of sports cars, and spherical heads of artificial hip joints [1,8]. In dentistry, ceramics are widely used for making artificial denture teeth, crowns, bridges, ceramic posts, abutments, and implants and veneers over metal substructures [1,9]. This article in part I; reviews the composition, structure and properties of dental ceramics from the literature available in PUBMED and other sources from the past 50 years. Part II reviews the developments in evolution of all ceramic systems over the last decade and considers the state of the art in several extended materials and material properties.

Dental ceramics are usually referred to as nonmetallic, inorganic structures primarily containing compounds of oxygen with one or more metallic or semi-metallic elements like aluminum, calcium, lithium, magnesium, phosphorus, potassium, silicon, sodium, zirconium & titanium [1,10]. The term porcelain is referred to a specific compositional range of ceramic materials made by mixing kaolin, quartz and feldspar in proper proportioning and fired at high temperature [1,10,11]. Porcelain is essentially a white, translucent ceramic that is fired to a glazed state. [5] Dental porcelains may be classified based on their fusion temperature, microstructure, and processing technique [1,12,13]. According to their fusion temperature, porcelains are classified as high fusing, medium fusing, low fusing and ultra-low fusing porcelains. The fusion temperature ranges of dental porcelains and their clinical recommendations are detailed in Table 1.

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Finite element analysis of stress distribution in intact and porcelain veneer restored teeth

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The aim of this study was to investigate the stress distribution generated in a veneer restoration of an upper central incisor compared to intact teeth using the finite element analysis after applying a lingual buccal loading at the incisal edge. *Methods*: Two models were developed: one model contained enamel, dentine, cementum, periodontal ligament, cortical and trabecullar bones, and the other model was a veneer restoration; both models were developed using MSC/Nastran software (MacNeal-Schwendler Corporation, Los Angeles, CA, USA) as the pre- and post-processor. A 10-N load was applied at the incisal edge from the lingual to the buccal side to simulate oral conditions in this area (protrusion). *Results*: Von Mises stresses were then analysed for three different regions: A-B (enamel elements under the veneer or second enamel layer), A′-B′ (buccal enamel and/or veneer element layer) and C-D (lingual enamel elements layer). A higher stress mode was observed for both models at the lingual cervical region. *Conclusions*: The presence of a veneer restoration on the incisors is a good alternative to mimic the behaviour of enamel under protrusion loading conditions. The use of veneers to replace enamel during rehabilitations is recommended.

Keywords: dental veneers; dental porcelain; finite element analysis; mechanical stress

1. Introduction

Adhesive dentistry has improved restoration procedures. These procedures, based on cavity preparation principles and their implications, have focused on the maintenance of tooth structure, changed the cavity preparation philosophy and determined characteristics and properties of all dental restorative materials (Perdigão and Gomes 2008). The preparation of a partial indirect restoration using an aesthetic material such as veneers as possible restorative rehabilitations for anterior teeth has shown advantages in bonding conditions that are provided by the adhesive systems and resin cements.

Veneers preparations are made by removing buccal enamel with or without part of the lingual enamel and adhering it to a thin layer or directly to the dentine (Magne and Tan 2008). These preparations are mechanically not very strong because they are made up of a brittle material (ceramic), but they have good retention due to the resin–dentine bonding (Addison et al. 2007; Ohlmann et al. 2008). Many ceramic systems have been developed with well-defined benefits regarding the mechanical resistance of the material to tension loading. The way the chewing force is applied is much more important than the dentine and the enamel properties or even the restorative material when one considers parafunction or even only concentrated loading points. The consequences of the same chewing force for different teeth also need to be highlighted because structural changes can occur depending upon the magnitude of the force, which can affect the tooth morphology in extreme (premature contacts) or repetitive cases (fatigue; Uddanwadiker et al. 2007; Miura and Maeda 2008).

In healthy patients, an intact tooth is usually subjected to chewing forces (Reinardt et al. 1993; Guldberg et al. 1998; Dietschi et al. 2007, 2008), which generate stresses that are distributed to the dentine and also to the tooth support structures such as the periodontal ligament (PDL) and the bone. Therefore, the appearance and behaviour of an intact tooth can guide the professional to choose the best restorative materials or to identify other teeth of the same type that need to be improved (Ferrari et al. 2008; Soares et al. 2008) in an attempt to mimic the healthy condition.

The finite element (FE) method has recently been used to validate the behaviour of materials under different circumstances without the need for physical models. This method is based on mathematical equations that determine the stress peaks, thus allowing critical analysis of the behaviour of those materials under possible stress distributions. There has been a range of FE models in the literature and there are still discussions about the use of two dimensional (2D) and three dimensional (3D) models. Some authors have considered the possibility of performing their studies using 2D as well as simplified 3D models,

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*New Book Received **

Non-Metallic Biomaterials for Tooth Repair and Replacement. By Pekka Vallittu, Woodhead Publishing, 2013; 406 pages. Price £145.00/US$245.00/€175.00 ISBN 978-0-85709-244-1

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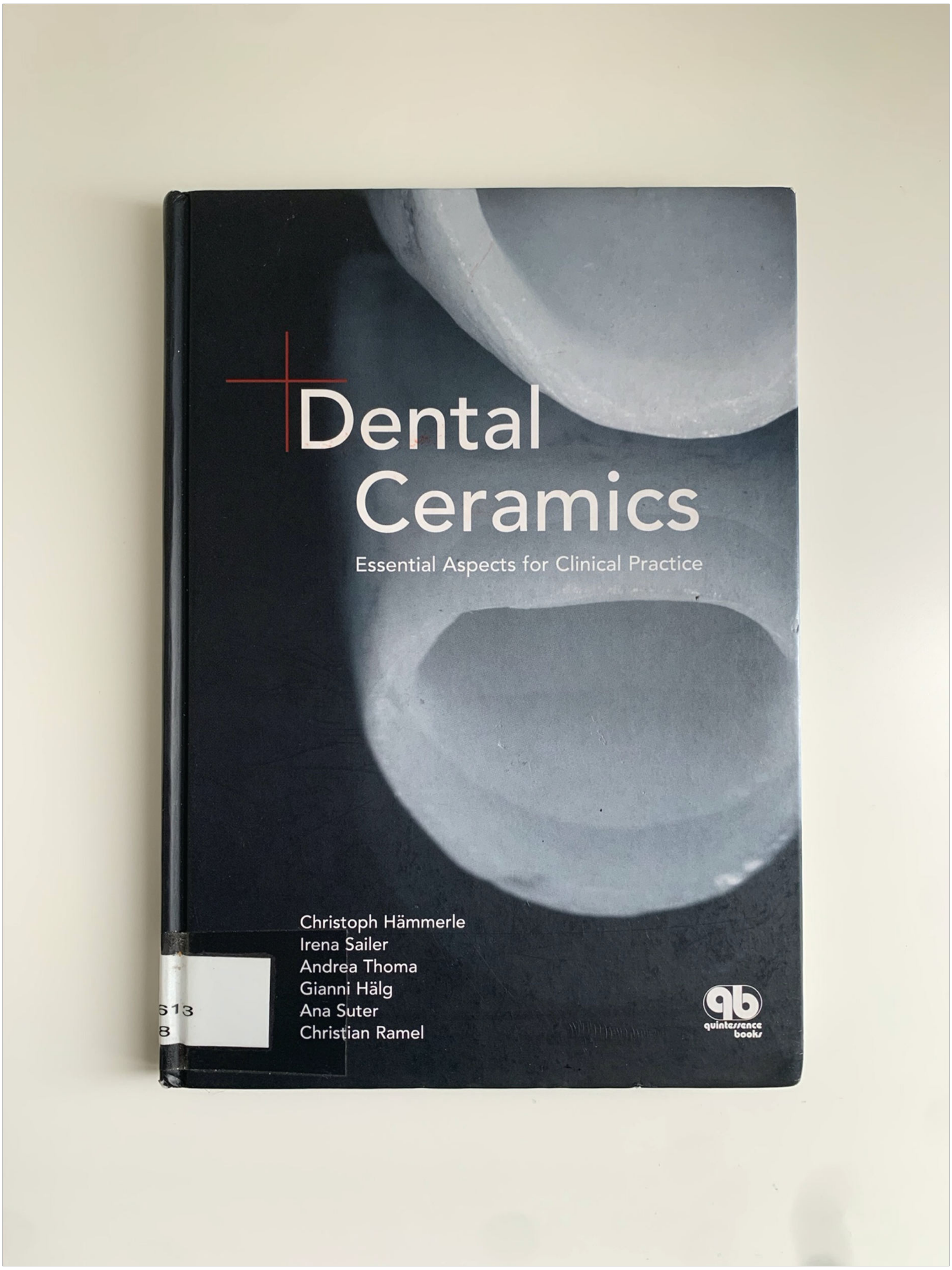
The following paragraphs are reproduced from the website of the publisher [1]:

1. Discusses the properties of enamel and dentin and their role in adhesive dental restoration;
2. Chapters also examine the wear properties of dental ceramics, glasses and bioactive glass ceramics for tooth repair and replacement;
3. Dental composites and antibacterial restorative materials are also considered;
4. Provides a concise overview of non-metallic biomaterials for dental clinicians, materials scientists and academic researchers alike.

As the demand for healthy, attractive teeth increases, the methods and materials employed in restorative dentistry have become progressively more advanced. Non-metallic biomaterials for tooth repair and replacement focuses on the use of biomaterials for a range of applications in tooth repair and, in particular, dental restoration.

Part one reviews the structure, modification and repair of dental tissues. The properties of enamel and dentin and their role in adhesive dental restoration are discussed, along with biomineralization and biomimicry of tooth enamel, and enamel matrix proteins (EMPs) for periodontal regeneration. Part two goes on to discuss the processing, bonding and wear properties of dental ceramics, glasses and sol-gel derived bioactive glass ceramics for tooth repair and replacement. Dental composites for tooth repair and replacement are then the focus of part three, including composite adhesive and antibacterial restorative materials for dental applications. The effects of particulate filler systems on the properties and performance of dental polymer composites are considered, along with composite based oral implants, fibre reinforced composites (FRCs) as dental materials and luting cements for dental applications.

With its distinguished editor and international team of expert contributors, Non-Metallic Biomaterials for Tooth Repair and Replacement provides a clear overview for all those involved in the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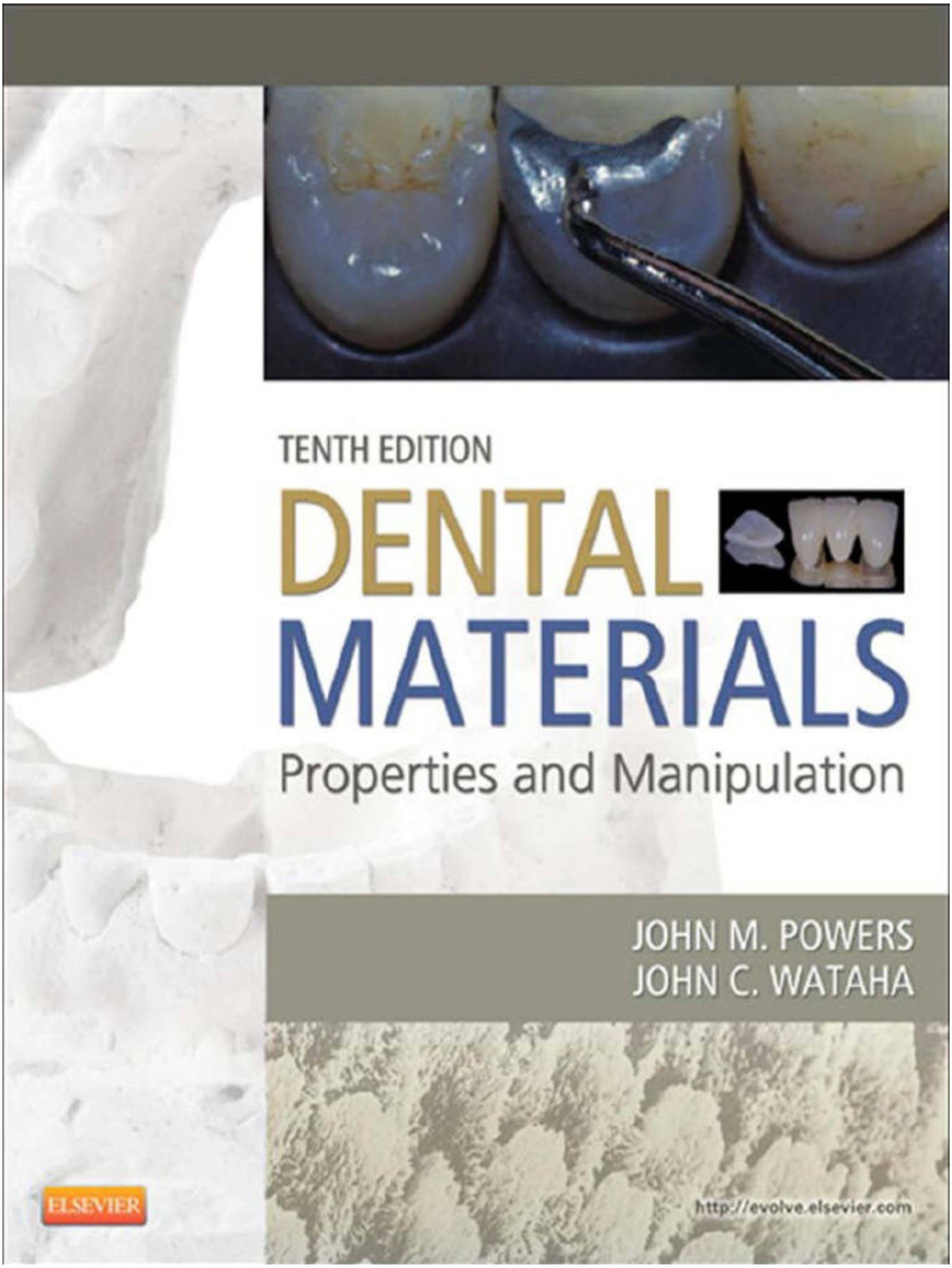
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Relative translucency of six all-ceramic systems. Part I: Core materials

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Statement of problem. All-ceramic restorations have been advocated for superior esthetics. Various materials have been used to improve ceramic core strength, but it is unclear whether they affect the opacity of all-ceramic systems.

Purpose. This study compared the translucency of 6 all-ceramic system core materials at clinically appropriate thicknesses.

Material and methods. Disc specimens 13 mm in diameter and 0.49 ± 0.01 mm in thickness were fabricated from the following materials (n = 5 per group): IPS Empress dentin, IPS Empress 2 dentin, In-Ceram Alumina core, In-Ceram Spinell core, In-Ceram Zirconia core, and Procera AllCeram core. Empress and Empress 2 dentin specimens also were fabricated and tested at a thickness of 0.77 ± 0.02 mm (the manufacturer's recommended core thickness is 0.8 mm). A high-noble metal-ceramic alloy (Porc. 52 SF) served as the control, and Vitadur Alpha opaque dentin was used as a standard. Sample reflectance (ratio of the intensity of reflected light to that of the incident light) was measured with an integrating sphere attached to a spectrophotometer across the visible spectrum (380 to 700 nm); 0-degree illumination and diffuse viewing geometry were used. Contrast ratios were calculated from the luminous reflectance (Y) of the specimens with a black (Yb) and a white (Yw) backing to give Yb/Yw with CIE illuminant D65 and a 2-degree observer function (0.0 = transparent, 1.0 = opaque). One-way analysis of variance and Tukey's multiple-comparison test were used to analyze the data ($P<.05$).

Results. Contrast ratios in order of most translucent to most opaque were as follows: Vitadur Alpha 0.60 ± 0.03, Empress (0.5 mm) 0.64 ± 0.01, In-Ceram Spinell 0.67 ± 0.02, Empress 2 (0.5 mm) 0.68 ± 0.02, Empress (0.8 mm) 0.72 ± 0.01, Procera 0.72 ± 0.01, Empress 2 (0.8 mm) 0.74 ± 0.01, In-Ceram Alumina 0.87 ± 0.01, In-Ceram Zirconia 1.00 ± 0.01, and 52 SF alloy 1.00 ± 0.00.

Conclusion. Within the limitations of this study, there was a range of cera[illegible]ically relevant core thicknesses. In order of decreasing translucency, the ranges were [illegible]d) > In-Ceram Spinell > Empress, Procera, Empress 2 > In-Ceram Alumina > [illegible] alloy. (J Prosthet Dent 2002;88:4-9.)

CLINICAL IMPLICATIONS

In this in vitro study on 6 different all-ceramic core materials, a range of translucency was found. An understanding of the degree of restorative material opacity should help the clinician match ceramic core translucency to natural teeth.

Ceramics have been advocated as the material of choice for matching the natural dentition.[1] The ability to blend a porcelain crown with its natural counterpart involves consideration of size, shape, surface texture, translucency, and color.[2] The problem of color matching to natural teeth has been investigated and described.[3-5] The popularity of metal-ceramic restorations is due largely to predictable strength achieved with reasonable esthetics. The drawback of such restorations is increased light reflectivity because of the opaque porcelain needed to mask the metal substrate.[6] All-ceramic materials offer an esthetic advantage.[7] Kelly et al[1] identified core translucency as one of the primary factors in controlling esthetics and a critical consideration in the selection of materials. Some all-ceramic core materials have high in vitro strength values.[8,9] However, an increase in crystalline content to achieve greater strength generally results in greater opacity.[1,10-12]

The translucency of dental porcelain is largely dependent on light scattering.[13] If the majority of light passing through a ceramic is intensely scattered and diffusely

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Clinical

Ceramics overview: classification by microstructure and processing methods

Edward A. McLaren[1] and Russell Giordano[2]

Abstract

The plethora of ceramic systems available today for all types of indirect restorations can be confusing and overwhelming for the clinician. Having a better understanding of them is important. In this article, the authors use classification systems based on microstructural components of ceramics and the processing techniques to help illustrate the various properties.

Introduction

Many different types of ceramic systems have been introduced in recent years for all types of indirect restorations, from very conservative nonpreparation veneers, to multi-unit posterior fixed partial dentures and everything in between. Understanding all the different nuances of materials and material processing systems is overwhelming and can be confusing. This article will cover what types of ceramics are available based on a classification of the microstructural components of the ceramic. A second, simpler classification system based on how the ceramics are processed will give the main guidelines for their use.

The term "ceramic" derives from the Greek "keramos", which means "a potter or a pottery". This word is related to a Sanskrit term meaning "burned earth", since the basic components were clays from the earth heated to form pottery. Ceramics are non-metallic, inorganic materials. Ceramics refer to numerous materials, including metal oxides, borides, carbides, nitrides and complex mixtures of these materials.[1] The structure of these materials is crystalline, displaying a regular periodic arrangement of the component atoms, and may exhibit ionic or covalent bonding. Although ceramics can be very strong, they are also extremely brittle and will catastrophically fail after minor flexure. Thus, these materials are strong in compression but weak in tension.

Contrast that with metals: metals are non-brittle (display elastic behaviour) and ductile (display plastic behaviour). This is because of the nature of the interatomic bonding, which is called metallic bonds; a cloud of shared electrons that can easily move when energy is applied defines these bonds. This is what makes most metals excellent conductors. Ceramics can be very translucent to very opaque. In general, the more glassy the microstructure (i.e. non-crystalline), the more translucent; and the more crystalline, the more opaque. Many other factors contribute to translucency, for example, particle size, particle density, refractive index and porosity to name a few.

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Different types of ceramics used in dentistry

The term "ceramic" technically refers to a crystalline material. Porcelain is a mixture of glass and crystal components. A non-crystalline containing material is simply a glass. However, dentistry typically refers to all three basic materials as dental ceramics. How ceramics are classified can be very confusing. Ceramics can be classified by their microstructure, (i.e. amount and type of crystalline phase and glass composition). They can also be classified by processing technique (powder/liquid, pressed or machined)

Critical Review
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Dental ceramics: a review of new materials and processing methods

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Erick de LIMA[b]
Ranulfo Benedito de Paula MIRANDA[b]
Stéphanie Soares FAVERO[b]
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Abstract: The evolution of computerized systems for the production of dental restorations associated to the development of novel microstructures for ceramic materials has caused an important change in the clinical workflow for dentists and technicians, as well as in the treatment options offered to patients. New microstructures have also been developed by the industry in order to offer ceramic and composite materials with optimized properties, *i.e.*, good mechanical properties, appropriate wear behavior and acceptable aesthetic characteristics. The objective of this literature review is to discuss the main advantages and disadvantages of the new ceramic systems and processing methods. The manuscript is divided in five parts: I) monolithic zirconia restorations; II) multilayered dental prostheses; III) new glass-ceramics; IV) polymer infiltrated ceramics; and V) novel processing technologies. Dental ceramics and processing technologies have evolved significantly in the past ten years, with most of the evolution being related to new microstructures and CAD-CAM methods. In addition, a trend towards the use of monolithic restorations has changed the way clinicians produce all-ceramic dental prostheses, since the more aesthetic multilayered restorations unfortunately are more prone to chipping or delamination. Composite materials processed via CAD-CAM have become an interesting option, as they have intermediate properties between ceramics and polymers and are more easily milled and polished.

Keywords: Ceramics; Dental Materials; Dental Porcelain; Computer-Aided Design; Composite Resins.

Declaration of Interest: The authors certify that they have no commercial or associative interest that represents a conflict of interest in connection with the manuscript.

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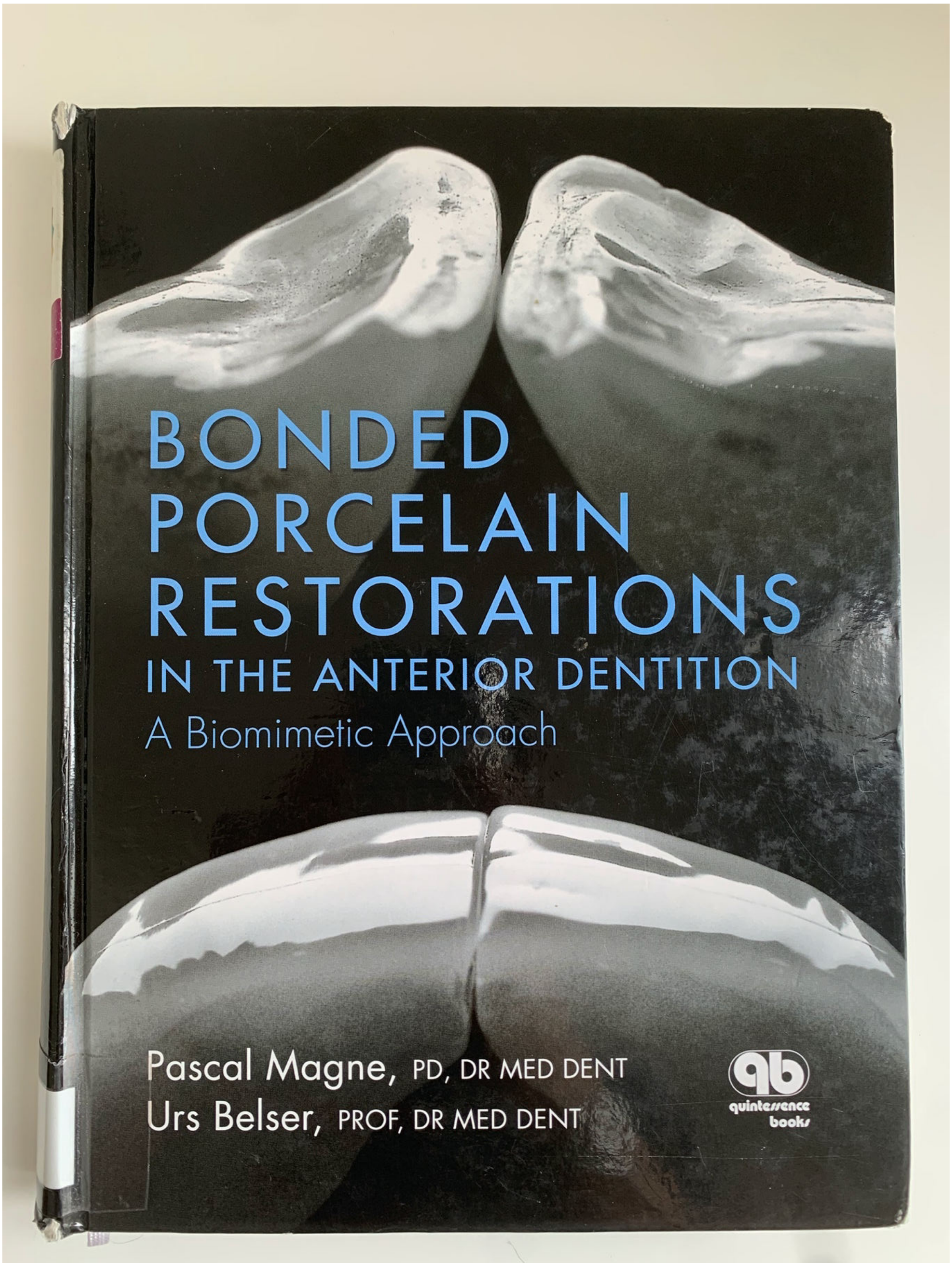
Introduction

The evolution of computerized systems for the production of dental restorations associated to the development of novel microstructures for ceramic materials has caused an important change in the clinical workflow for dentists and technicians, as well as in the treatment options offered to patients. One of the most important changes in this scenario was the introduction of monolithic restorations produced from high-strength ceramics, like zirconia. This concept *per se* is not new, since ceramic materials have been used for a relatively long time for the production of monolithic restorations, but it was only when zirconia started to be used to produce full-contour crowns that dentists and technicians became more confident to indicate a ceramic material for crowns and bridges in the posterior region.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The Effect of the Administration of Tetracycline on the Development of Teeth

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Department of Histology, New York University College of Dentistry, and the Department of Pediatrics, New York University Medical Center

Several investigators[1-3] have shown that the tetracyclines complex with several metallic ions. It has also been shown that tetracycline or a fluorophore of this drug is incorporated into growing bones.[4-5] In our own studies[6-7] it was shown that not only is the drug incorporated in developing skeletons, but that at appropriate levels a marked inhibition of skeletal development also occurs.

The present study was designed to amplify our previous findings, to ascertain the effect of the administration of tetracycline on developing teeth. We selected young rats 2 weeks old for this purpose, since at this age both incisors and molars undergo rapid growth and mineralization—a situation somewhat comparable to that which obtains in the human when the deciduous and mixed dentition are being formed.

MATERIALS AND METHODS

Two litters, each consisting of seven rats 2 weeks of age, were injected daily with 5 mg. of tetracycline hydrochloride* (achromycin) dissolved in 1 ml. of distilled water on 5 successive days. In addition, one rat of each litter was injected with distilled water only. The teeth of these rats served as controls.

One of the litters was sacrificed 1 day following the last injection; the other, 1 week after the last injection of the drug. The heads were removed and fixed in a mixture of 95 per cent ethyl alcohol and 5 per cent neutral formalin. Thirty-six upper incisors were removed, sectioned by grinding, and subsequently examined. Corresponding blocks of molars were similarly sectioned and examined. A total of 16 jaws, containing 32 incisors and 96 molars in all, was used in this study. The sectioned teeth were subsequently examined with the aid of a compound microscope in both visible and ultraviolet light. In visible light, one can usually identify tetracycline by its characteristic yellow-brown color. In the presence of ultraviolet light, tetracycline exhibits a characteristic yellow-gold fluorescence. A fluorescence lamp† with high-pressure mercury source was used with appropriate filters to assess the tetracycline-induced fluorescence in the teeth.

This investigation was supported in part by U.S.P.H.S. research grants D-473 and D-422 from the National Institute of Dental Research, National Institutes of Health.

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† Leitz Fluorescence Lamp CS-150.

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Conservative treatment of the stained dentition: vital bleaching

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and

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ABSTRACT—The multiple potential causes for staining of the dentition are discussed. A conservative technique of vital tooth bleaching is outlined which may successfully be employed in cases of fluorosis, hypocalcified brown stains, and selected cases of tetracycline staining.

(Received for publication February, 1983.)

There are few commonly encountered aesthetic problems more potentially devastating to the young patient psychologically than discoloured or malformed teeth (Fig. 1) for until comparatively recently there were few, if any, known means of conservative treatment. The recent introduction of early treatment procedures in the form of vital bleaching and resin labial veneer restorations have proven to be reliable and conservative methods of cosmetic improvement (Fig. 2, 3).

There are three major indications for vital bleaching (1) the conservative treatment of dark brown fluorosis stain; (2) certain cases of tetracycline discolouration; and, (3) enamel hypoplasia.

Fig. 1.—Severe hypocalcification with staining.

* Australian Dental Association Overseas Guest Lecturer, 1982.

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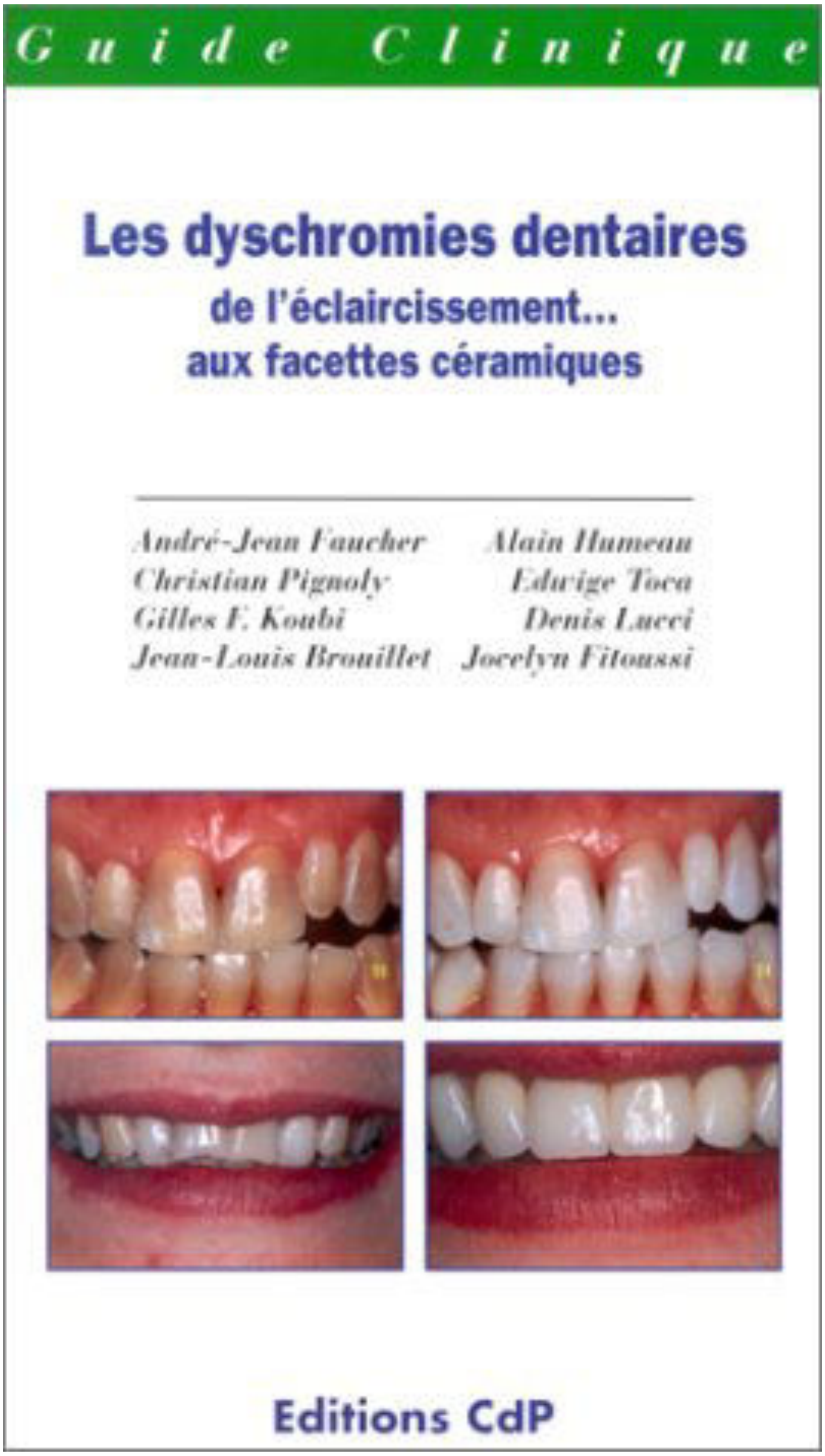
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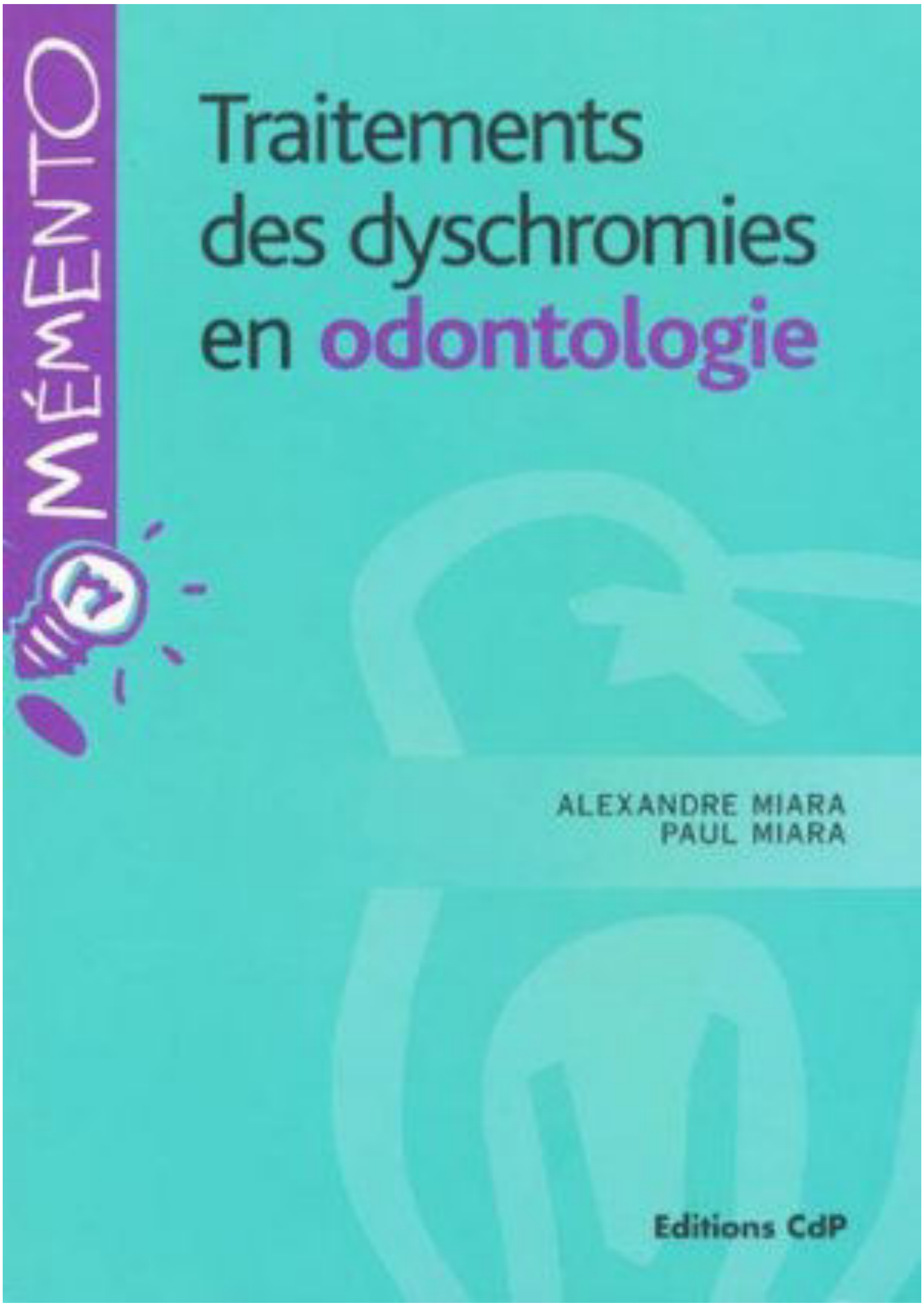
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Bonding to ground versus unground enamel in fluorosed teeth

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ABSTRACT

Objectives. To determine the effect of grinding on the bonding effectiveness of a self-etch and an etch-and-rinse adhesive to fluorosed enamel.

Methods. The teeth were classified using the Thylstrup and Fejerskov index (TFI). Fluorosed teeth (TFI = 5) obtained from Isparta (Turkey) and control teeth (TFI = 0) obtained from Leuven (Belgium) were used. Using a depth-marking diamond bur, 0.3 mm of enamel was removed from mid-buccal and mid-palatal/lingual surfaces of the teeth, whereas the area adjacent to the ground area was left unprepared. A two-step self-etch (Clearfil Protect Bond, Kuraray) and a three-step etch-and-rinse adhesive (Optibond FL, Kerr) were used to bond the resin composite to the ground and unground enamel. Rectangular micro-specimens were prepared using the slow-speed diamond saw and tested in tensile to determine the micro-tensile bond strength (μTBS).

Results. The μTBS to unground fluorosed enamel was significantly lower than to ground fluorosed enamel for Clearfil Protect Bond (15.8 ± 15.2 and 45.0 ± 12.4 MPa, $p < 0.0001$) and for Optibond FL (35.5 ± 21.4 and 50.5 ± 12.3 MPa, $p < 0.05$), respectively. In control teeth, Clearfil Protect Bond bonded better to ground enamel ($p < 0.01$), whereas OptiBond FL exhibited a similar bonding effectiveness to ground and unground enamel ($p = 0.0634$).

Significance. Preparation of enamel improved the resin–enamel bond strength in fluorosed teeth. The bonding effectiveness to unground enamel was lower in fluorosed teeth than in control teeth for the self-etch adhesive tested.

1. Introduction

Fluorosed teeth have an altered structure, composition and appearance. The severity of fluorosis defects is correlated with the amount and duration of fluoride ingestion during tooth development [1,2]. With increasing fluorosis severity, the sub-surface enamel becomes increasingly more porous and the sub-surface lesion extends towards the inner enamel. Because of the fluorapatite, hypermineralization in the surface layer of enamel has also been described in fluorosed teeth [3,4]. Little research on the bonding effectiveness of resin monomers, especially of the newer mild self-etch adhesives, to such altered enamel surfaces has been conducted.

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CASE REPORT

Esthetic Rehabilitation of Anterior Conoid Teeth: Comprehensive Approach for Improved and Predictable Results

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Revisión de tema

Clinical aspects of dental fluorosis according to histological features: a Thylstrup Fejerskov Index review

Aspectos clínicos da fluorose dentária de acordo com as características histológicas: revisão do Índice Thylstrup Fejerskov

Aspectos clínicos de la fluorosis dental de acuerdo con las características histológicas: una revisión del Índice de Thylstrup Fejerskov

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Abstract

Dental fluorosis is a developmental defect of enamel caused by chronic and excessive fluoride intake resulting in a hypomineralized enamel with increased porosity. It is clinically identified as spots ranging from mild white lines to opaque spots covering all or part of the enamel surface and breakdown after teeth eruption. However, the clinical definition of the fluorosis degree in teeth is not an easy task, having been presented many indices that generally qualify the severity degree with variations in the details. As the choice of treatment is closely linked to the defect severity, the purpose of this article is to present the clinical aspects of dental fluorosis represented through the Thylstrup-Fejerskov Index. The severity scores are presented according to histological features and the differences between them will be discussed in order to enable the dentist to correctly diagnose and choose the most appropriate treatment for the patient with DF.

Keywords: dental fluorosis; diagnosis; classification.

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Resumo

A fluorose dental (FD) é um defeito de desenvolvimento do esmalte causado pela ingestão crônica e excessiva de flúor, resultando em um esmalte hipomineralizado com maior porosidade. Clinicamente é identificada como manchas que vão desde delicadas linhas brancas até manchas opacas que cobrem parte ou toda a superfície do esmalte podendo sofrer pigmentações ou fraturas após a irrupção. No entanto, a definição clínica do grau de comprometimento dos dentes não é uma tarefa fácil e tem sido apresentada na forma de índices que geralmente qualificam o grau de severidade com

Le traitement endodontique : l'essentiel

> Coordination et rédaction : Stéphane SIMON (Rouen)

Dans cette rubrique intitulée « Endo... autrement », il n'est pas forcément inutile de revenir aux fondamentaux... C'est l'objectif de cet article qui rappelle étape par étape les procédures cliniques qui permettent de mener un traitement endodontique à son terme dans les meilleures conditions. Sans forcément rentrer dans le détail, il insiste sur le fait que c'est la validation des étapes successives, les unes après les autres, qui conduit au succès et qu'une seule approximation peut nuire aux procédures suivantes et être responsable d'un échec global.

Mots-clés
- > Endodontie
- > Anesthésie
- > Mise en forme
- > Obturation

> Le mois prochain :

texte

L'objectif de tout traitement, et notamment en endodontie, est de maintenir une dent dans un contexte biologique proche de la physiologie, et de prévenir ainsi tout développement d'une pathologie osseuse inflammatoire.
Depuis les travaux de Miller (1885) et de Kakehashi (1963), l'infection bactérienne a été clairement établie comme étant à l'origine des pathologies endodontiques.
Quel que soit le traitement à appréhender, de la conservation de la vitalité de la pulpe à la pulpectomie, le maintien de l'asepsie reste l'objectif principal.
À l'exception de la nécrose, les pathologies de la pulpe sont inflammatoires et donc, par définition, indemnes de toute contamination bactérienne. Cette stérilité du canal doit donc être maintenue, quelles que soient les procédures mises en œuvre.
L'endodontie est souvent considérée comme une discipline complexe et compliquée à mettre en œuvre. Les évolutions techniques des 10 dernières années ont permis de proposer des instruments et autres périphériques facilitant les protocoles et, surtout, de rendre l'endodontie de qualité accessible à tout praticien.
Contrairement au retraitement endodontique pour lequel chaque cas est particulier, les séquences du traitement endodontique initial ont largement été rationalisées, conduisant même parfois jusqu'à une standardisation des protocoles.
Malgré ces évolutions, l'anatomie endodontique demeure le seul facteur aléatoire **(fig. 1 et 2)**. Les

Fracture Resistance of Ceramic Veneers with Different Preparation Designs

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Keywords
Laminate veneer; fracture; dentin; preparation design.

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Abstract

Purpose: The purpose of this study was to examine the fracture load of ceramic veneers with different preparation designs.
Materials and Methods: Seventy-five extracted, intact, human maxillary central incisors were prepared according to five preparation designs (P) (n: 15) as follows: (1) P2e: 2-mm incisal reduction, preparation entirely in enamel; (2) P4e: 4-mm incisal reduction, preparation entirely in enamel; (3) P2d: 2-mm incisal reduction, preparation entirely in dentin; (4) P4d: 4-mm incisal reduction, preparation entirely in dentin; and (6) Pc: Unrestored, intact teeth as control. All preparations had a butt joint incisal finish line, rounded internal line angles, and cervical finish lines 1 mm above the cementoenamel junction. Ceramic veneers were fabricated with IPS Empress (Ivoclar Vivadent AG, Schaan, Liechtenstein) and cemented with Syntac Classic Adhesive system and Variolink II (Ivoclar) resin cement. Veneers were loaded until fracture at a 90° angle to the lingual surface of the test tooth following the thermocycling process (5° to 55°, 3500 times). Statistical analyses were performed using analysis of variance (ANOVA) and Tukey's Multiple Range Test.
Results: The mean fracture loads (SD) were (in N) as follows: (1) P2e: 262 (63); (2) P4e: 189 (40); (3) P2d: 239 (53); (4) P4d: 162 (36); and (5) Pc: 277 (66). The amount of incisal reduction exhibited a significant influence on fracture resistance regardless of the preparation depth ($p < 0.05$).
Conclusions: Ceramic veneers with preparation designs entirely on dentin with 4-mm incisal reduction yielded lower fracture loads than those prepared with 2-mm incisal reduction. Veneers with 2-mm incisal reduction exhibited fracture resistance similar to that of intact teeth for preparation designs supplied on both enamel and dentin.

Ceramic veneers, which are chosen to provide excellent esthetics, are a well-established treatment method for conservative esthetic restoration of malformed, discolored, misaligned, traumatized, fractured, and worn anterior teeth. The recommended superficial preparation within the enamel and adhesive luting facilitates restoration with minimal loss of healthy tooth structure.[1,2] Edelhoff and Sorensen[3] reported that tooth preparations for porcelain laminate veneers required 3% to 30% of tooth structure by weight and one-quarter to one-half the amount of tooth reduction of conventional complete-coverage crowns.

The success rate of porcelain veneers has been clinically evaluated and has shown a range from 18 months up to 15 years; the rate of success reported in these studies varies between 75% and 100%. Fracture, microleakage, and debonding are types of failures seen in ceramic veneers.[1,4-6]

Different designs of tooth preparations have been described as the feathered incisal edge, incisal 0.5- to 1-mm bevel, the intraenamel (or window), and the overlapped incisal edge preparations.[6-8] Castelnuovo et al[9] reported that elimination of the palatal chamfer for ceramic veneers with incisal butt joints resulted in stronger restorations and simplified tooth preparation. They also suggested that the faciopalatal path of insertion allowed easier seating of multiple veneers and eliminated the risk of fracture of thin, unsupported palatal ceramic ledges.

Ceramic veneers are mainly recommended for margins located in enamel to provide reliable marginal integrity; however, Nattress et al found a high risk for dentin exposure at the cervical margins, even with preparation margins located coronally to the cementoenamel junction (CEJ).[10] Also, advanced periodontal disease therapy often results in exposed root surfaces and wide interproximal spaces. Instead of full-crown preparations,

A conservative approach toward restoration of fractured anterior tooth

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Abstract

Reattachment of the fractured anterior tooth is a highly conservative and aesthetic treatment that has gained popularity in the recent past. Presented here is one such case in which a combination of external enamel bevel and internal dentinal groove has been used to enhance the bonding between the fractured fragment and the remaining tooth. The treatment was found to be successful both functionally and aesthetically at the 18-month follow-up.

Keywords: Anterior tooth trauma, bonding, reattachment

Introduction

Uncomplicated and complicated crown fracture is the most common traumatic dental injury to permanent teeth.[1] Most dental injuries involve just one tooth, and the majority of the affected teeth are maxillary central incisors.[2-4] This may be attributable to their anterior position and protrusion caused by the eruptive pattern.[5]

During the last century, clinicians used a variety of procedures (e.g., pin-retained resin, orthodontic bands, modified three-quarter crowns, full-coverage gold with bonded porcelain, porcelain jacket crowns, porcelain-bonded crowns, porcelain inlays) for the restoration of the fractured crown.[6] Several factors influence the management of coronal tooth fractures, including extent of fracture (biological width violation, endodontic involvement, alveolar bone fracture), pattern of fracture and restorability of fractured tooth (associated root fracture), secondary trauma injuries (soft tissue status), presence/absence of fractured tooth fragment and its condition for use (fit between fragment and the remaining tooth structure), occlusion, aesthetics, finances and prognosis.[7-9]

If the fracture is uncomplicated (i.e., not involving the pulp) and the pulpal health is uncompromised, it may be restored with composite resin or a jacket crown. If the pulp is involved, the tooth is treated endodontically and then restored with the help of a jacket crown with or without post and core. If the fracture is sub-gingival, the tooth may require surgical crown lengthening or forced eruption (orthodontic extrusion) followed by prosthetic rehabilitation.[10] In situations where a ferrule effect cannot be established, the only treatment left is the extraction of the tooth followed by prosthetic rehabilitation.

One of the options for managing coronal tooth fractures, especially when there is no or minimal violation of the biological width, is the reattachment of the dental fragment when it is available. Tooth fragment bonding offers the advantage of being a highly conservative technique that promotes preservation of natural tooth structure, good aesthetics and acceptance by patients, who receive a psychological benefit from amelioration of the mutilation.[11]

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Case Report

A 13-year-old boy reported to the Department of Pedodontics and Preventive Dentistry with a history of fall from cycle 2 days back. The child complained of sensitivity in the upper anterior teeth. The medical history of the child was found to be insignificant. Proper immunization schedule was followed for the child. Clinical and radiographic examination revealed Ellis class III fracture (involvement of enamel and dentin compromising the pulp) of the maxillary left central incisor [Figure 1]. No significant hard or soft tissue injury other than tooth fracture was observed. An intraoral periapical radiograph was taken, which showed the coronal fracture with no root fracture or any other periapical changes [Figure 2]. The child was carrying the broken tooth fragment that was confirming adequately to the fractured left central incisor [Figure 3]. The tooth fragment was stored in water and did not show any significant change in color.

Influence of preparation design and existing condition of tooth structure on load to failure of ceramic laminate veneers

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Statement of problem. Although investigators have evaluated the effect of ceramic veneer preparation design, limited information is available regarding preparation design in association with the condition of existing tooth structure.

Purpose. The purpose of this in vitro study was to evaluate the effect of preparation design and the amount of existing tooth structure on the fracture resistance of pressable ceramic laminate veneers.

Material and methods. Thirty-two extracted human maxillary central incisors were allocated into 4 groups (n=8) to test for 2 variables: (1) the preparation design (a 2 mm incisal reduction shoulder finish line with or without palatal chamfer) and (2) the existing amount of tooth structure (non-worn tooth or worn tooth). Measurement of the remaining enamel thickness on the inciso-occlusal surface was made after the tooth was prepared. All prepared teeth were restored with pressable ceramic (IPS Empress) veneers, and the veneers were luted with resin cement (Rely-X Veneer). These luted specimens were loaded to failure in a universal testing machine, in the compression mode, with a crosshead speed of 0.05 mm/min. The data were analyzed using a 2-way ANOVA and Tukey's HSD multiple comparison test (α=.05)

Results. Preparation design and the amount of existing tooth structure had a significant effect on the load to failure value ($P<.001$); however, the interaction between preparation design and existing amount of tooth structure was not significant ($P=.702$). Mean (SD) load to failure values were as follows: a preparation design with a palatal chamfer margin with a non-worn tooth (166.67 N (28.89)) revealed a significantly higher failure load than the group with a shoulder finish line alone (131.84 N (18.88)) ($P<.01$). The preparation design with a palatal chamfer margin for worn teeth (119.56 N (23.88)) revealed a significantly higher failure load than a shoulder finish line design alone (90.56 N (9.32)) ($P<.05$). The preparation design with a shoulder finish line for worn teeth had a significantly lower failure load than those on non-worn teeth ($P<.003$).

Conclusions. Preparation design and the amount of existing tooth structure had a significant effect on load to failure for ceramic veneers. This study revealed that using a palatal chamfer margin design significantly increased the load to failure compared to a shoulder finish line. (J Prosthet Dent 2011;105:374-382)

Clinical Implications

The addition of a palatal chamfer to the incisal butt joint of a ceramic veneer resulted in an increased load to failure compared to a shoulder finish line. The use of a palatal chamfer margin is particularly important when the existing tooth structure is worn.

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A Difference in Perspective— The North American and European Interpretations of Tooth Wear

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Purpose: There is considerable interest in the European dental research literature about the problem of tooth wear and specifically about dental erosion, but this interest does not appear to be matched in North America based on the volume of the literature there. The purpose of this article is to consider the possible explanations for this difference. **Materials and Methods:** This article examines the reasons for this disparity and attempts to explain the difference by reviewing the North American and European literature on the etiology, pathogenesis, and prevalence of tooth wear. **Results:** It would appear from the literature that the reason for the difference in interest between the 2 continents is a reflection of how the appearance, etiology, and terminology are interpreted and used to define tooth wear, attrition, and erosion. **Conclusion:** Attrition is the wear of teeth against teeth; therefore, by definition any worn surface that does not contact the opposing tooth must have another etiology. An appropriate descriptive term is "tooth wear" when the etiology is multifactorial or cannot be determined. A search of the literature shows more studies in the European literature of the etiology and prevalence of tooth wear than in the North American literature. The thrust of the European studies supports the view that erosion is more important than attrition in the etiology of tooth wear. *Int J Prosthodont 1999;12:401–408.*

Much of the emphasis on the nature of tooth wear in the European literature has recently been directed to erosion caused by dietary or gastric acids. On the other hand, research from North America has appeared to concentrate on attrition as the predominant factor, with little acknowledgment of the role of acid erosion. This difference will be explored by reviewing the etiology, prevalence, and appearance of erosion, attrition, and abrasion.

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Definition

"Tooth wear" is an all-embracing term used to describe the combined processes of erosion, attrition, and abrasion, or when the specific diagnosis cannot be determined.[1] Erosion is defined as the chemical dissolution of teeth by acids other than those produced by bacteria, attrition is the wear of tooth against tooth, and abrasion is the wear of teeth by physical means other than opposing teeth.[2] The term tooth wear can be used as a generic description until a more specific diagnosis can be made; this is comparable to making the observation that a patient is pyretic and then moving on to a diagnosis of pneumonia and then investigating the cause of pneumonia. Some tooth wear continues as a slow process throughout life and is normal, but in some individuals the rate increases to such an extent that the longevity of the teeth is compromised. The term "pathologic tooth wear" has been used to describe the state when the destruction

Distinguishing and diagnosing contemporary and conventional features of dental erosion

Mohamed A. Bassiouny, PhD, DMD, MSc

The vast number and variety of erosion lesions encountered today require reconsideration of the traditional definition. Dental erosion associated with modern dietary habits can exhibit unique features that symbolize a departure from the decades-old conventional image known as *tooth surface loss*. The extent and diversity of contemporary erosion lesions often cause conflicting diagnoses. Specific examples of these features are presented in this article. The etiologies, genesis, course of development, and characteristics of these erosion lesions are discussed. Contemporary and conventional erosion lesions are distinguished from similar defects, such as mechanically induced wear, carious lesions, and dental fluorosis, which affect the human dentition.

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Key words: erosion, definition, contemporary features, conventional signs, brown lesions

The increased incidence of dental erosion associated with dietary sources has become a growing universal concern for dental health care providers.[1-7] The severity of this widespread issue has gained the attention of clinicians, researchers, the media, and the public in both the United States and worldwide.[1-7] Published literature has indicated that acidic constituents of dietary ingredients—especially acidulated carbonated beverages, considered to be the single most prominent etiology—have considerable impact on the development of dental erosion.[7-14] The excessive consumption of these beverages among younger generations renders these consumers extremely vulnerable to this dental hard tissue disease.[5-15] Likewise, excessive consumption of highly acidic citrus fruit and juices increases the potential for dental erosion in a large segment of the senior population.[16-19]

An overwhelming variety of dental erosion lesions are encountered by clinicians.[16,17,20-22] The clinical features of these contemporary lesions transcend the definition of conventional tooth surface loss (TSL) that has been known for more than half a century.[8,14,16,23] The range of these lesions is associated with numerous sources of acidic dental erosion, the most predominant of which are nutritional sources.[8,14,16,17,23] Each type of erosion lesion possesses specific clinical signs and a unique appearance. These signs differ widely from each other, but their spectrum defines the general characteristics of contemporary dental erosion. Recognizing the unique characteristics of each, and identifying their respective etiologies, could facilitate their differentiation from similar lesions of nonerosion origins. Examples of these are noncarious defects, carious lesions at various stages of development, and acquired anomalies such as dental fluorosis and tetracycline-stained hard tissues.[24-27]

Distinguishing and decoding contemporary erosion lesions is fundamental for achieving an accurate diagnosis and planning a proper course of management. The most clinically satisfactory, economical, and practical approach is prevention. However, proper identification of these lesions may present a clinical challenge. This is primarily due to an inadequate awareness of the specific characteristics of each type of lesion. It can also be due to the shortage of relevant information from patients' health and dietary histories, as well as their oral hygiene care. These factors collectively could negatively impact the diagnostic process and result in an impulsive and potentially incorrect conclusion. Arming dental professionals with the ability to recognize the wide spectrum of these newly emerged erosion lesions, and familiarizing them with the specific features of each, could expedite identification and alleviate confusion. The objectives of this article are to identify and precisely describe the assortment of contemporary erosion lesions observed today, and clearly differentiate between their clinical features and those of lesions with closely similar characteristics.

The commonly known definition and the classical description of conventional erosion lesions allude to TSL of enamel with or without dentin involvement. This enamel/dentin defect is presented clinically as a smooth surface with either partial or complete loss of topographic and anatomic configurations. The TSL could appear in the form of a flat or saucer-shaped defect that is usually limited to enamel, but may also involve dentin in the affected region.[23,28,29] Progression of the enamel defect leads to removal of the entire enamel thickness, exposure of dentin, and further invasion into the dentin core.[14,23,28-30] These defects are often seen on the cervical to middle segments of the tooth crown, although their vertical expansion may lead to either crown and/or root surface involvement. These erosions are commonly seen on the facial aspects of the dentition and should be differentiated from defects due to toothbrush abrasion and abfraction (Fig. 1). Their presence on the lingual aspect of a tooth is etiology-specific. In severe cases, they may also affect the biting surfaces of teeth.

Examples of erosion lesions that present features of TSL on the lingual aspects of dentition are those that develop as a result of either extrinsic or intrinsic sources. The former could be caused by excessive sipping of lemonade; sucking slices of lemon, orange, or grapefruit; or soaking the dentition in pooled soda for a while before swallowing.[8,14,16] Erosion lesions from intrinsic sources that appear on the lingual aspects of the anterior maxillary incisors and canines may be an indicator

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Survival rate and fracture strength of maxillary incisors, restored with different kinds of full veneers

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SUMMARY This *in vitro* study evaluated the survival rate and fracture strength of different kinds of ceramic full veneers, fabricated with a new experimental press ceramic (EPC VP2117/TC2, Ivoclar-Vivadent AG, Schaan, Liechtenstein). Eighty, caries-free human maxillary central incisors were used as abutments and were randomly divided into one control group and four test-groups of 16 samples each. In group A, unprepared teeth served as control. In the test groups, four different types of full veneer preparations were performed. In test groups B/C, the preparation was maintained in enamel and the contact point was on the tooth/on the veneer, respectively. In test groups D/E, the preparation was extended into dentin and the contact point was on the tooth/on the veneer, respectively. All veneers were adhesively luted using Variolink® II (Ivoclar-Vivadent AG). Then, the samples were exposed to the artificial mouth for 1·2 million chewing cycles (49 N). After exposure in the artificial mouth, a survival rate of the abutment teeth of 81–100% was reported among the different groups, but was not significantly different between the groups. However, no failures of the ceramic materials could be recognized. The median fracture strength of group A was 713·3 N, of group B 647·1 N, of group C 594·8 N, of group D 483·8 N and of group E 502·6 N. Among the different groups no significant difference was found. All mean values obtained were within the limits of clinical acceptance, indicating further clinical investigations on full veneers made out of the EPC.

KEYWORDS: veneers, incisal edge reduction, full veneers, survival rate, fracture strength

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Introduction

The increasing demand for aesthetic anterior teeth requires sophisticated treatment strategies. In order to serve the public's demands several treatment options have been proposed to restore the aesthetic appearance of the anterior dentition. For many years the most predictable results for anterior tooth restoration have been achieved with full crowns. Undoubtedly, this approach is most invasive due to substantial removal of large amounts of sound tooth substance and possible adverse effects on the pulp and adjacent periodontal tissues.

In search for durable but also conservative aesthetics, porcelain veneers have been introduced. Several studies could prove their long-term prognosis *in-vivo* and achieve a high level of acceptance by patients (1–7). The failure rate ranged from 0% (1) to 33% (8). Additionally, *in-vitro* studies could demonstrate the long-term porcelain veneer retention (9–11). Furthermore, in cases of more severe defects, like a tooth fracture at the middle third of the crown, or when extended proximal caries and old fillings are present, a full veneer preparation can be a restorative option.

Despite the promising results there certainly are limits in regards to the possibilities which veneers can offer. The implemented material and the type of preparation are key factors in the prognosis. There are limited studies concerning the design and thickness of the preparation. Regarding the design of the

ORIGINAL ARTICLE

Prevalence and distribution of dental anomalies in orthodontic patients

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Introduction: The purpose of this study was to determine the prevalence of developmental dental anomalies in the Turkish population. **Methods:** The study was based on the dental casts, intraoral photographs, and panoramic radiographs of 3043 Turkish children (1658 girls, 1385 boys) who had orthodontic treatment at the Department of Orthodontics at the University of Ankara between 1978 and 2003. These patients were examined for 8 developmental dental anomalies: fusion, gemination, microdontia, macrodontia, oligodontia, hypodontia, hyperdontia, and amelogenesis imperfecta. The percentages of these anomalies were assessed in the whole group, and the sexes were compared. **Results:** It was found that 5.46% of the total group had at least 1 developmental dental anomaly. The distribution by sex was 70 boys (5.05%) and 96 girls (5.79%). **Conclusions:** Hypodontia is the most common developmental dental anomaly in the Turkish population, followed by microdontia. (Am J Orthod Dentofacial Orthop 2007;131:510-4)

Abnormalities in tooth size, shape, and structure result from disturbances during the morphodifferentiation stage of development.[1] It is important to treat these anomalies because they can create disturbances in maxillary and mandibular dental arch lengths and occlusions; these problems might complicate orthodontic treatment planning.

Several studies gave percentages of various dental anomalies in various populations, but their results are conflicting. The discrepancies in their results were attributed to racial differences, variable sampling techniques, and different diagnostic criteria.[2-9] The only common point of these studies was the unavoidable frequency of developmental dental anomalies in every community.

The purpose of this study was to determine the prevalence and distribution of abnormalities in shape, size, and structure of teeth in the Turkish population; these data are a new contribution to the orthodontic literature.

SUBJECTS AND METHODS

The study was undertaken with the pretreatment dental casts, intraoral photographs, and panoramic radiographs of 3043 Turkish children (1658 girls, 1385 boys), 8.50 to 14.75 years of age, from the files of the Department of Orthodontics at the University of Ankara between 1978 and 2003.

The following developmental dental anomalies were assessed.

1. Shape abnormalities: fusion, gemination, microdontia (peg-shaped maxillary and mandibular lateral incisors), and macrodontia.
2. Number abnormalities: oligodontia, hypodontia (congenitally missing maxillary lateral incisors, mandibular incisors and canines, maxillary and mandibular premolars), and hyperdontia (supernumerary incisors and premolars).
3. Structural abnormalities: amelogenesis imperfecta.

RESULTS

There were a total of 166 developmental dental anomalies (5.46%) in the group of 3043 subjects. The distribution by sex was 70 boys (5.05%) and 96 girls (5.79%) (Table I).

Shape abnormalities

Macrodontia of the maxillary central incisors was observed in only 1 female patient. The prevalence of this abnormality in all patients was calculated as 0.03%, making it the rarest anomaly in the study group (Table I).

Gemination was observed in 2 boys; its prevalence was 0.07%, the second most rare occurrence. This was followed by fusion, observed in 2 male and 5 female patients, for a total prevalence of 0.23% (Table I).

The most common tooth formation anomaly was microdontia; it was overall the second most frequent of

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AMELOGENESIS IMPERFECTA AMONG ISRAELI JEWS AND THE DESCRIPTION OF A NEW TYPE OF LOCAL HYPOPLASIC AUTOSOMAL RECESSIVE AMELOGENESIS IMPERFECTA

GENÉTICA DA AMELOGÊNESE IMPERFEITA - UMA REVISÃO DA LITERATURA

A Chosack, E Eidelman, I Wisotski, T Cohen

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ABSTRACT

Amelogenesis imperfecta (AI) is a group of inherited defects of dental enamel formation that show both clinical and genetic heterogeneity. Enamel findings in AI are highly variable, ranging from deficient enamel formation to defects in the mineral and protein content. Enamel formation requires the expression of multiple genes that transcribes matrix proteins and proteinases needed to control the complex process of crystal growth and mineralization. The AI phenotypes depend on the specific gene involved, the location and type of mutation, and the corresponding putative change at the protein level. Different inheritance patterns such as X-linked, autosomal dominant and autosomal recessive types have been reported. Mutations in the amelogenin, enamelin, and kallikrein-4 genes have been demonstrated to result in different types of AI and a number of other genes critical to enamel formation have been identified and proposed as candidates for AI. The aim of this article was to present an evaluation of the literature regarding role of proteins and proteinases important to enamel formation and mutation associated with AI.

Uniterms: Amelogenesis imperfecta; Mutation; Enamel protease; Enamel proteinase.

RESUMO

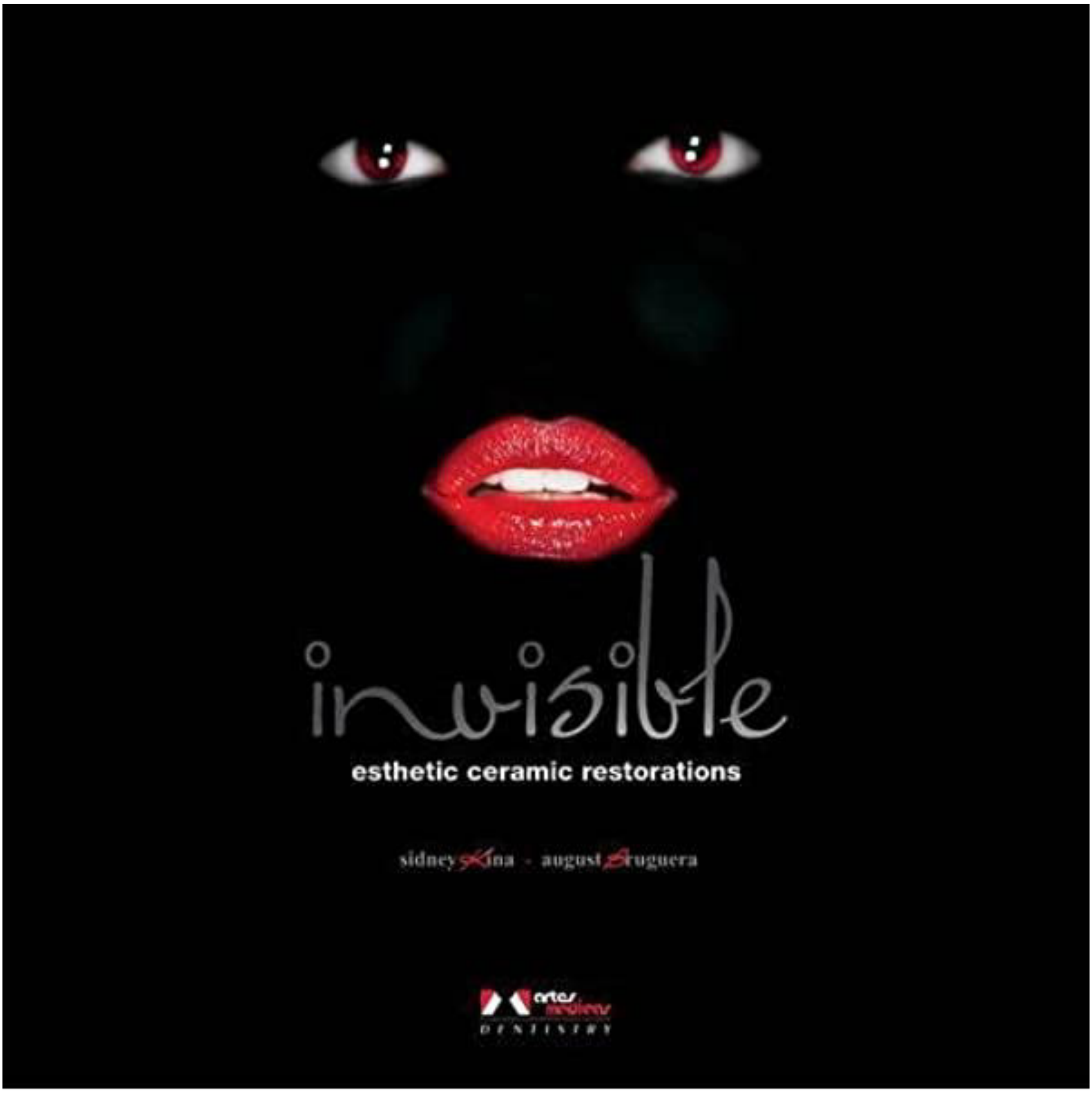
Amelogênese imperfeita é um grupo de doenças hereditárias que causa defeito na formação esmalte dental e mostra heterogeneidade clínica e genética. O esmalte é afetado com alta variabilidade, desde deficiência na formação do esmalte até defeitos no conteúdo mineral e protéico. A formação do esmalte requer a expressão de múltiplos genes que transcrevem proteínas e proteinases importantes para controlar o complexo processo de crescimento dos cristais e mineralização. O fenótipo da AI depende do gene envolvido, sua localização e tipo de mutação, e a conseqüente alteração na proteína. Diferentes padrões hereditários com ligado ao X, autossômico dominante e autossômico recessivo já foram descritos. Mutações nos genes correspondentes da amelogenina, enamelina, e calicreína-4 demonstraram resultar em diferentes tipos de AI. Outros genes críticos para formação do esmalte estão sendo identificados como candidatos a causar AI. O objetivo desse artigo foi investigar na literatura o papel de proteínas e proteinases importantes para formação do esmalte e mutações associadas a AI.

Unitermos: Amelogênese imperfeita; Mutações; Proteínas do esmalte.

INTRODUCTION

Dental enamel, the most highly mineralized structure in the human body, is formed within a unique, extracellular matrix derived through the synthesis and secretion of proteins by the ameloblast cells. Dental enamel differs from other mineralized tissues, such as bone, cartilage and dentine, in that it is noncollagenous, originated from epithelium, and does not undergo resorption and remodeling[16].

Dental enamel formation is divided into secretory, transition, and maturation stages[56]. During the secretory stage, enamel crystals grow primarily in length. The crystallites lengthen at a mineralization front formed near the secretory surfaces of the ameloblast cell. During the maturation stage, mineral is deposited exclusively on the sides of the crystallites, which grow in width and thickness to coalesce with adjacent crystals. The arrangement of ions in dental enamel crystals closely approximates that of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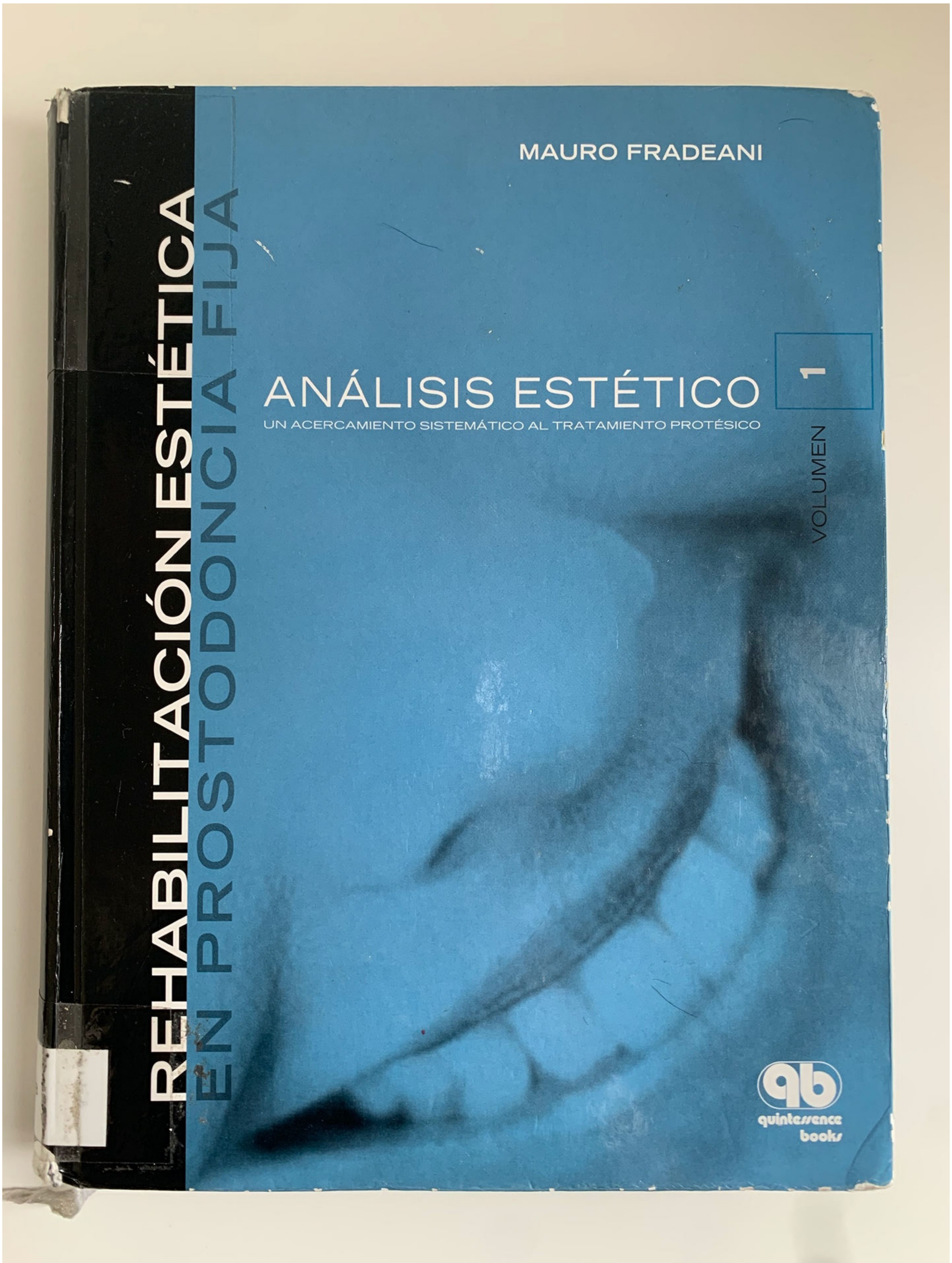
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Porcelain Laminate Veneers: Minimal Tooth Preparation by Design

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A porcelain laminate veneer is one of the most conservative and aesthetic techniques that we can apply when restoring the human dentition. Since their development 25 years ago, interpreting the indications and applying the correct techniques has been key to providing their longevity [1]. Long-term (15- and 20-year) retrospective studies indicated that the success rates of veneers are as high as 94% to 95% percent [2,3]. Tooth preparation is one of the most important considerations in this technique. Bonding to enamel rather than dentin provides the best/strongest bond values when we want to bond porcelain to tooth structure [4–6]. When a porcelain veneer restoration is bordered on all margins by enamel, microleakage or debonding of these restorations is not likely to occur. A main objective of any restorative case involving these restorations is to keep the preparation simple and be conservative in reduction of sound tooth structure.

Many other considerations come into play as the preparation becomes more aggressive and dentin is involved. A rigid veneer behaves differently when bonded to a rigid surface, such as porcelain, versus a less rigid surface, such as dentin, and the composite cement can only absorb so much of the stresses to which the restoration may be exposed. To minimize effects and possible problems, we should be precise and careful about case selection and tooth preparation [7]. What if the teeth to be treated are not properly aligned? One of the major indications for using porcelain laminate veneer is space management. We are often asked to deal with spaced dentitions, crowded teeth, or a combination of both. The main challenges in these cases are visualizing the aesthetic outcome and providing the best tooth preparation to the ceramist to allow for the best aesthetic result.

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Clinical Performance of Novel-Design Porcelain Veneers for the Recovery of Coronal Volume and Length

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The present study evaluated the clinical performance of bonded porcelain veneers (PV) restoring substantial coronal volume and length in the anterior dentition. Forty-eight PVs were placed in 16 patients, with systematic coverage and reconstitution of the incisal edge, including well-defined anterior guidance. A standardized protocol comprising diagnostic steps that integrate additive waxups and acrylic mockups was used. PVs were fabricated using feldspathic and low-fusing porcelains in a refractory die technique. Incisal overlaps featured freestanding porcelain spans ranging from 1.5 to 5.5 mm. After a mean clinical service of 4.5 years, 13 clinical parameters for each tooth and 4 parameters that applied to persons were recorded. Permutation tests evaluated the effects of margin location, incisal edge span of porcelain, overbite, opposing contact location, and restoration age on ceramic failure and clinical marginal adaptation and seal. At recall, 100% of the veneers were satisfactory with minor interventions. The effect of slight marginal defects and porcelain cracking was negligible. Biologic, periodontal, and esthetic parameters showed excellent results, which were supported by 100% patient-reported satisfaction. All patients felt comfortable with the newly defined anterior guidance. Aging was negligible, and there were no significant effects of margin location ($P > 0.08$), incisal edge span of the ceramic, or overbite ($P > 0.22$) on ceramic failure and marginal performance. Minor alterations of the palatal margin, however, tended to be more frequent compared to facial locations, and were found especially when the opposing tooth contact in centric occlusion was located on the palatal margin ($P = 0.028$). Bonded ceramic restorations represent a reliable, effective procedure to restore extensive coronal volume and length in the anterior dentition. (Int J Periodontics Restorative Dent 2000;20:441–457.)

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Owing to a number of clinical studies, porcelain veneers (PV) have matured into a predictable restorative concept in terms of longevity, periodontal response, and patient satisfaction.[1–5] A number of researchers has gained confidence in bonded ceramic restorations, and the indications for their use have been broadened significantly,[6–11] resulting in newer preparation designs.[8,11,12] Unexplained post-bonding cracks, which initially deterred clinicians from using PVs, have been understood and explored experimentally.[13–15] Internal stress distribution and the parameters responsible for craze-line formation have been investigated, and preparation design has been adjusted accordingly.[15–18]

Based on these considerations, restoration of crown-fractured incisors (Figs 1 and 2) and worn-down dentitions have been proposed as new indications for PVs. This approach has to be considered with special attention because its success and reliability could result in substantial treatment improvements comprising both the medical-

CASE REPORT

Use of Additive Waxup and Direct Intraoral Mock-up for Enamel Preservation with Porcelain Laminate Veneers

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Novel Porcelain Laminate Preparation Approach Driven by a Diagnostic Mock-Up

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ABSTRACT
One critical step in the porcelain laminate technique is the achievement of sufficient ceramic thickness. At least two different strategies for tooth preparation can be found in the literature: (1) earlier simplified techniques included the use of depth cutters guided by the existing tooth surface—however, that approach did not take into consideration alterations of the tooth owing to aging, wear, or loss of enamel and thus led to greater risks for dentin exposures; (2) more recent and sophisticated methods have integrated an additive diagnostic procedure (ie, wax-up or mock-up) to compensate for tooth aging or severe existing loss of tooth substance. This approach allows for more enamel preservation and, as a consequence, more predictable bonding, biomechanics, and esthetics. The present article illustrates in detail the latest development in tooth preparation for porcelain laminates. This technique combines the time efficiency of earliest methods with the rationale and diagnostic foundations of the more recent techniques.

CLINICAL SIGNIFICANCE
Using this new laminate porcelain preparation approach, clinicians should be able to produce not only more accurate preparations, but also higher-quality tooth preparations in a time-efficient fashion.

(*J Esthet Restor Dent* 16:7–18, 2004)

The primary preparation design for porcelain veneers, also called bonded laminates or bonded porcelain restorations (BPRs), should simultaneously allow an ideal marginal adaptation of the final restoration and reflect an optimal adaptation of the hard tissue morphology.[1] Unlike traditional cementation, the adhesive properties and physicochemical characteristics of the resin-based luting composites subject the tooth-restoration interface to substantial stresses. BPRs must be differentiated from traditional cemented crown coverage, especially with regard to retention and resistance form. A minimum amount of preparation geometry is required to facilitate insertion and positioning of the ceramic restoration during the final bonding procedure. The geometric and mechanical parameters of the tooth preparation, however, are of only secondary importance. This allows for maximal preservation of remaining sound mineralized tissue during the tooth preparation procedure and, consequently, a conservative approach (ie, approximately one-quarter the amount of tooth reduction of conventional complete-coverage crowns; Figure 1).[2]

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Predictable and precise tooth preparation techniques for porcelain laminate veneers in complex cases

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Porcelain laminate veneers (PLVs) are one of the most conservative and aesthetic techniques that can be applied when restoring the mouth for improved aesthetics. The longevity of the veneers is good and they are durable, especially if the right indications are in place and the correct techniques are applied (Horn HR, 1983).

The fundamental concept in any restorative case is to keep it simple and to concentrate on just one objective – conservation of the sound tooth structure.

Where the dentine-enamel junctions (DEJ) meet is very important in terms of the structural strength of the tooth: a complex fusion occurs at the DEJ that can be regarded as a fibre-reinforced bond (Lin CP, Douglas WH, Erlandsen SL, 1993).

If preparation is limited to the enamel, there would be insufficient flexibility in the teeth (Magne P, Douglas WH, 1999). If the preparation line passes through the DEJ margin and enters into dentine, while it won't create a major problem, a number of difficulties may occur if one ends up finishing the preparation on large amounts of dentine. This will not only create complex bonding issues on dentine but will also free the 'flexing' factor on the tooth structure (Noack MJ, Roulet J-F, 1987; Van Meerbeek B et al, 1996; Van Meerbeek B et al, 1998).

When the tooth starts flexing, a new phenomenon occurs. Firstly, a tooth that has been aggressively prepared has a tendency to bend and the intention is to bond a veneer – a porcelain material – that is very rigid on top of that. Adhesive luting resin will be used in between those two structures, which will try to absorb all the stresses. If the tooth is subject to different occlusal forces and continues to flex, the luting resin at the margin will slowly start to peel off, and the clinician is likely to be faced with micro-leakage or de-lamination.

To minimise these effects and problems, precision and care must be taken with case selection and tooth preparation (Belser UC, Magne P, Magne M, 1997). The best situation in which to place veneers is when the teeth are perfectly aligned on the dental arch and the facial structures of the teeth are not worn, which happens with age.

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Standard preparation technique

An amount of tooth structure, equivalent to the thickness of the veneer that will be placed on the tooth, should be removed. Since the shape, volume or contours of the tooth will not be changed, standard tooth preparation techniques can be used (Figures 1a, 1b and 1c) (Strub JR, Türp JC, 1999). When the exact depth needed for the porcelain build-up is removed, finishing the restoration should not pose any problems (Figures 2a, 2b and 2c).

The procedure should begin with the use of a depth cutter (Garber DA, Goldstein RE, Feinman RA, 1988; Nixon RL, 1990; Garber DA, 1993), which indicates the exact depth that is to be prepared and which depends on the material selection or the colour of the tooth to be restored (Figures 3a and 3b). Once this is established, the surface of the tooth should be painted a different colour, after which a round-ended fissure bur is used to finalise the facial reduction. The important factor here is that the bur is used at three different angles in order to conform to the facial convexity of the tooth structure. It is only in this way that the dentist can achieve consistent thickness of the porcelain material, i.e. the porcelain build-up.

Once this reduction has been performed, the preparation is finished at the gingival margin and then extended towards the papilla to finish the interproximal elbow preparation. This is important, especially when dealing with discolouration. If the depth is not prepared correctly, the connection between the dark-coloured tooth and the light-coloured porcelain will be visible when seen from an angle, which is clearly not aesthetically pleasing.

To set up for this dogleg preparation, the bur is held at an angle of almost 60° towards the palate. Once the exact depth has been achieved, the bur should be held in an upright position to finish the interproximal preparation (Morley J, 1999). The butt joint preparation of the incisal edge should be omitted to give the laboratory technician enough room to build up the artistic, translucent, opalescence effects, incisal silhouette, etc (Figures 4a and 4b). As in every PLV case, the

Wax-up and mock-up. A guide for anterior periodontal and restorative treatments

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Multiple Diastema Management: An Interdisciplinary Approach

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Multiple maxillary diastemas can pose a difficult esthetic management problem, especially in adult patients. The first course of action in these cases is to evaluate the overall occlusal relationships as they relate to the development of dental facial harmony. In a patient with irregular spaces between maxillary anterior teeth, who has optimal molar relationships and good facial proportions, a space analysis might reveal that there is a tooth-size discrepancy. During diagnosis and treatment planning, the presence or absence of opposing anterior occlusal contacts must be evaluated. If there is sufficient interarch space, the problem may be managed with orthodontic therapy alone. Flared maxillary incisors that are not in contact with the opposing lower incisors can easily be retracted with a simple removable appliance. However, in the presence of stable occlusal contacts without excessive overjet or overbite, restorative procedures become necessary to aid in closure of the anterior spaces.

Over the past decade, porcelain laminate veneers have become a predictable and conservative technique for the minor alignment of teeth, changing tooth size and shape, as well as masking unsightly tooth discoloration. Porcelain offers lifelike esthetics, color, and soft tissue compatibility. The conservative nature of the restorations in which the proximal and occlusal contacts remain largely unaltered does not result in the tooth being weakened and the potential for pulpal involvement and inadvertent alteration of anterior guidance is greatly reduced.

Figure 1. Initial frontal view showing large midline diastema and smaller lateral spaces.

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Full veneer versus traditional veneer preparation: A discussion of interproximal extension

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Statement of problem. Traditional veneer preparation has come to represent an almost universally accepted guideline of veneer preparation. It calls for an interproximal finish line at or just into the contact point. However, in certain situations, such an approach can have functional and esthetic limitations.
Purpose. This article reviews those functional and esthetic limitations and discusses an alternative technique, the full veneer preparation. The advantages and disadvantages of this approach are discussed in relation to veneer cases with malaligned teeth, diastema, discoloration, black spaces, restorations, and/or veneers next to crowns. (J Prosthet Dent 1997;78:545-9.)

With its introduction in the early 1980s, porcelain laminate veneers redefined conservative cosmetic dental treatment. Initially, practitioners focused on whether these thin, fragile porcelain shells would bond on the tooth, resist fracture under load, and keep from leaking. With a clear consensus that they have been successful,[1,2] porcelain laminate veneers now are evolving into more functionally and esthetically dynamic restorations.

Much of the rapid acceptance of this technique can be attributed to the ease and simplicity of the original, traditional veneer preparation design. However, this article suggests that alternative preparations designs, specifically the full veneer approach, should be considered in certain situations to maximize the functional and esthetic results possible with porcelain veneers. In particular, the advantages and disadvantages of this approach are discussed in relation to veneer cases with malaligned teeth, diastema, discoloration, black spaces, restorations, and/or veneers next to crowns.

TRADITIONAL VENEER PREPARATION

The traditional proximal veneer preparation design extends to the interproximal stopping facial to the contact (Fig. 1). It attempts to maintain all bonding surfaces in enamel, provide a positive seat for cementation, and hide margins interproximally without removing contacts.[1,3-6] This traditional preparation outline allows a simple, quick, and conservative reduction of tooth structure. Because all prepared surfaces are in enamel and contacts are left undisturbed, the traditional veneer preparation also precludes the need for temporization. Because of the relative ease of the preparation and the lack of temporaries, these "ideal" guidelines of veneer preparation have become almost universally accepted.

Fig. 1. Traditional veneer preparation design, 0.5 mm facial and 1.5 mm incisal reduction, interproximal finish line facial to contact.

To hide the veneer-tooth interface and to improve retention by bonding at right angles to the direction of displacement, many practitioners now extend preparations into the contact area. Christensen[7] suggests preparing halfway through the contact and Garber[8] recommends two thirds as a more appropriate depth. However, neither one mentions extension through the entire contact.

FULL VENEER PREPARATION

The advantages of hiding margins and increased retention are also obtained if the preparation design breaks interproximal contact and continues to the lingual. The term *full veneer* can be used to describe this style of preparation (Fig. 2),[9] which highlights the continuum of design between a traditional veneer and an all-ceramic crown. The full veneer preparation is continued to the lingual extent of the tooth to break contact on one or both sides and allow the laboratory technician ample

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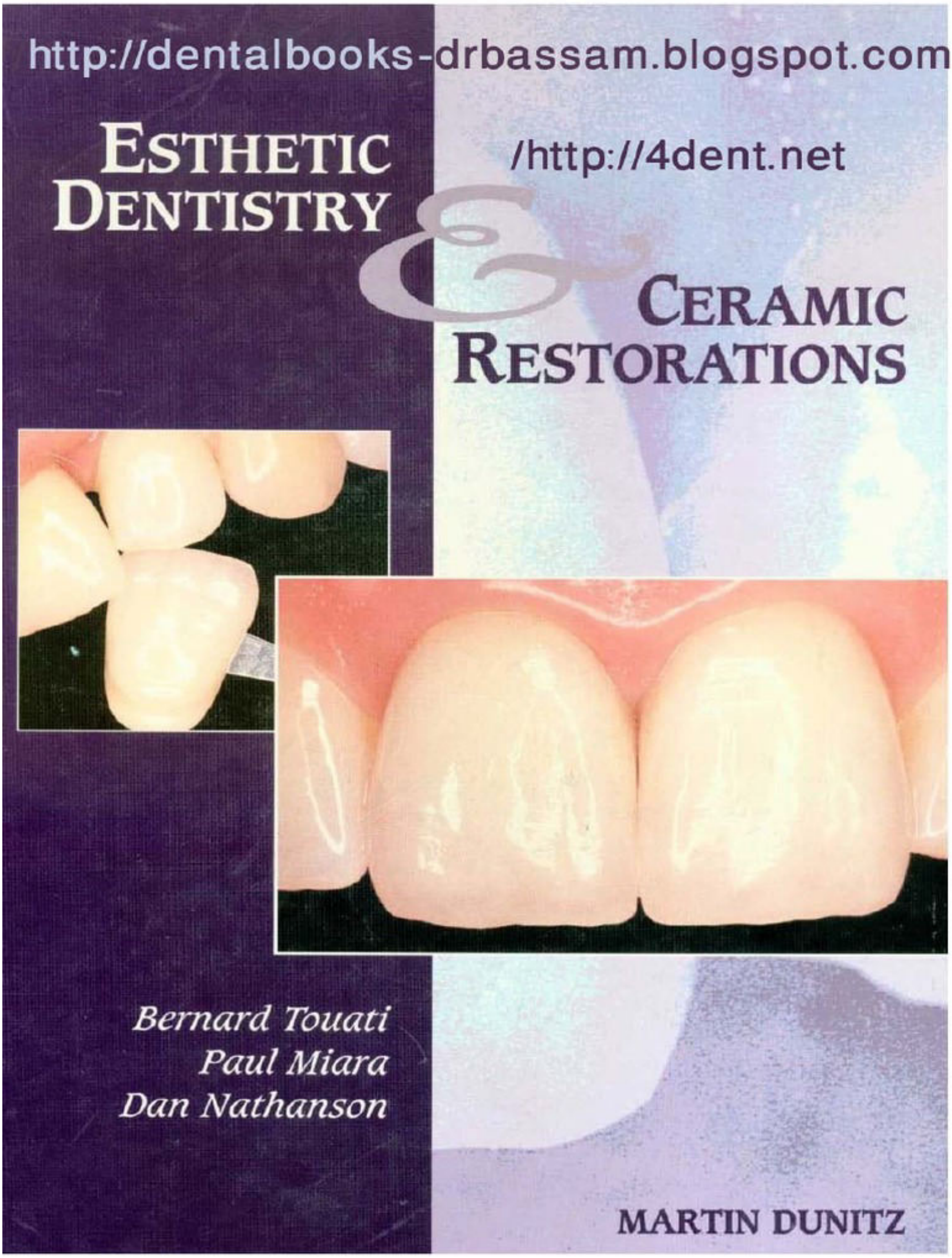
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Additive Contour of Porcelain Veneers: A Key Element in Enamel Preservation, Adhesion, and Esthetics for Aging Dentition

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Esthetics and function are equal concerns when restoring the anterior dentition. Modern concepts in restorative dentistry have brought new solutions through bonded porcelain veneers that are stress distributors and involve the crown of the tooth as a whole in supporting occlusal force and masticatory function. This recovery of the original biomechanics of the intact tooth, the biomimetic principle, is particularly valuable when considering the restoration of an aging dentition. Both function and appearance are affected by the senescent changes of the aging teeth. Erosion and surface wear lead to a progressive thinning of enamel, ultimately leading to increased crown flexibility and higher surface strains. It appears therefore that the restoration of tooth volume will not only re-establish the original and youthful appearance of the smile but will also allow the biomimetic recovery of the crown. The final treatment outcome strongly depends on the therapeutic approach chosen, the driving force of which should be the preservation of the thin remaining enamel. While a number of preparation techniques will expose dentin to a great extent, the principle of enamel preservation can still be fulfilled by the use of a specific approach. This article describes a treatment method which includes the use of a diagnostic template. This type of work strategy, documented with clinical cases, integrates additive wax-ups and acrylic mock-ups. The latter will provide a significant amount of diagnostic information and economy of tooth substrate, the importance of which cannot be overestimated in the completion, functionality, and longevity of the final restoration.

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Numerous clinical studies[7,8,10,12,13,23,26,28,29,33,34] have revealed the good clinical performance of porcelain laminate veneers (PVs). Based on these promising evaluations and motivated by the principle of tooth preservation, a new range of indications for PVs has been defined,[4,19] including cases of crown-fractured incisors[1,2] and worn down anterior dentitions.[36,37] PVs permit, above all, avoidance of the use of a conventional type of fixed prosthetic restoration and maintenance of tooth vitality in spite of a severe breakdown of tooth structure. Such enhanced applications of PVs have marked a turning point in restorative dentistry, generating considerable improvements involving both the biological aspect (ie, economy of sound tissues) and the socio-economical requirements (ie, decrease of costs when compared to traditional and more invasive prosthetic treatments). At the other end of this spectrum, more cosmetic indications for PVs have emerged as a result of patients' growing esthetic expectations (Figs 1a and 1b). Even though it does not constitute a primary objective in dental medicine, oral esthetics requires special consideration. Modification of form, position, and color of anterior teeth generate significant effects on the smile,

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A photoelastic study of stresses on porcelain laminate preparations

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The development of an acid etch technique 30 years ago introduced an era of a molecular dentistry known as *bonding*.[1] The use of a strong inorganic acid on tooth enamel removes cations, leaving a surface of organic interstices for mechanically bonding resins. Composites could then be directly applied to the etched enamel surfaces of the teeth and eventually bonded as restorations to mask discolorations, close diastemas, and correct the alignment of teeth.[2] Nevertheless, composites are susceptible to stain, wear, and plaque accumulation. Conversely, porcelain laminates retain a lifelike vitality, are resistant to stain and wear, and remain color stable.

Porcelain laminates are possible by application of hydrofluoric acid to etch the porcelain, which prepares the surface for mechanical bonding.[3] Bond strength can be further increased by using an organosilane coupling agent on the etched porcelain before bonding to create a chemical union between the composite and the laminate.[4,5]

Although many porcelain laminates have been placed on teeth without facial reduction, tooth preparation is suggested to control overcontouring at the gingival margin.[3,6] Depending on preparation design, stresses developed within the laminates and teeth can be modified, thereby minimizing the potential for failure. This investigation examined the effect of different preparations on the magnitude and distribution of the stresses under varying loads.

METHODS AND MATERIAL

Four photoelastic models 2.5 times the size of an average central incisor were fabricated. The teeth were constructed in photoelastic materials simulating dentin (PL-2, Photolastic Division Measurements Group, Raleigh, N.C.) and enamel (PL-1, Photolastic Division Measurements Group). The average enamel thickness was described by Shillingburg and Grace.[7] One tooth

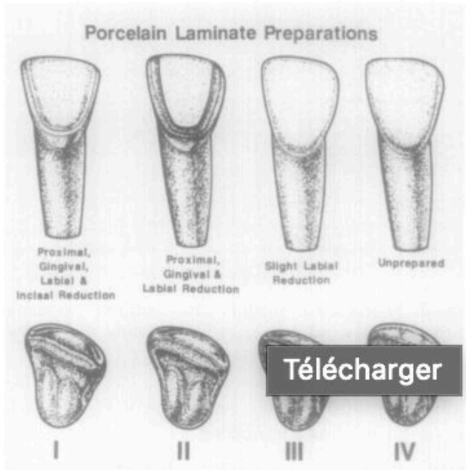

Fig. 1. Porcelain laminate preparations from most extensive *(I)* to no tooth reduction *(IV)*.

was prepared with a 1 to 1.25 mm reduction of the labial surface, which extended to the midproximal surfaces and represented a 0.4 to 0.5 mm reduction of a normal tooth. The incisal edge was reduced 1.25 mm with the labioincisal angle rounded. The cavosurface angles were 90 degrees to ensure that the laminate would be fabricated with a peripheral butt joint (Fig. 1).[8] The second model was prepared in the same manner with the exception of the incisal reduction. The third incisor was minimally prepared by slightly roughing the labial surface to a depth of 0.5 to 0.7 mm, and the fourth incisor remained unprepared.

Photoelastic laminates were fabricated from the same material used for the enamel simulation inasmuch as enamel and porcelain exhibit similar moduli of elasticity. The laminates were joined to the models with a compatible reflective adhesive (PC-6, Photolastic Division Measurements Group) (Fig. 2). A thin laminate made for the unprepared tooth resulted in an overcontoured facial surface.

In each instance 80 pounds of load was applied incisally (Fig. 3). Four load directions were applied to the four laminates, (1) central vertical, (2) distal vertical,

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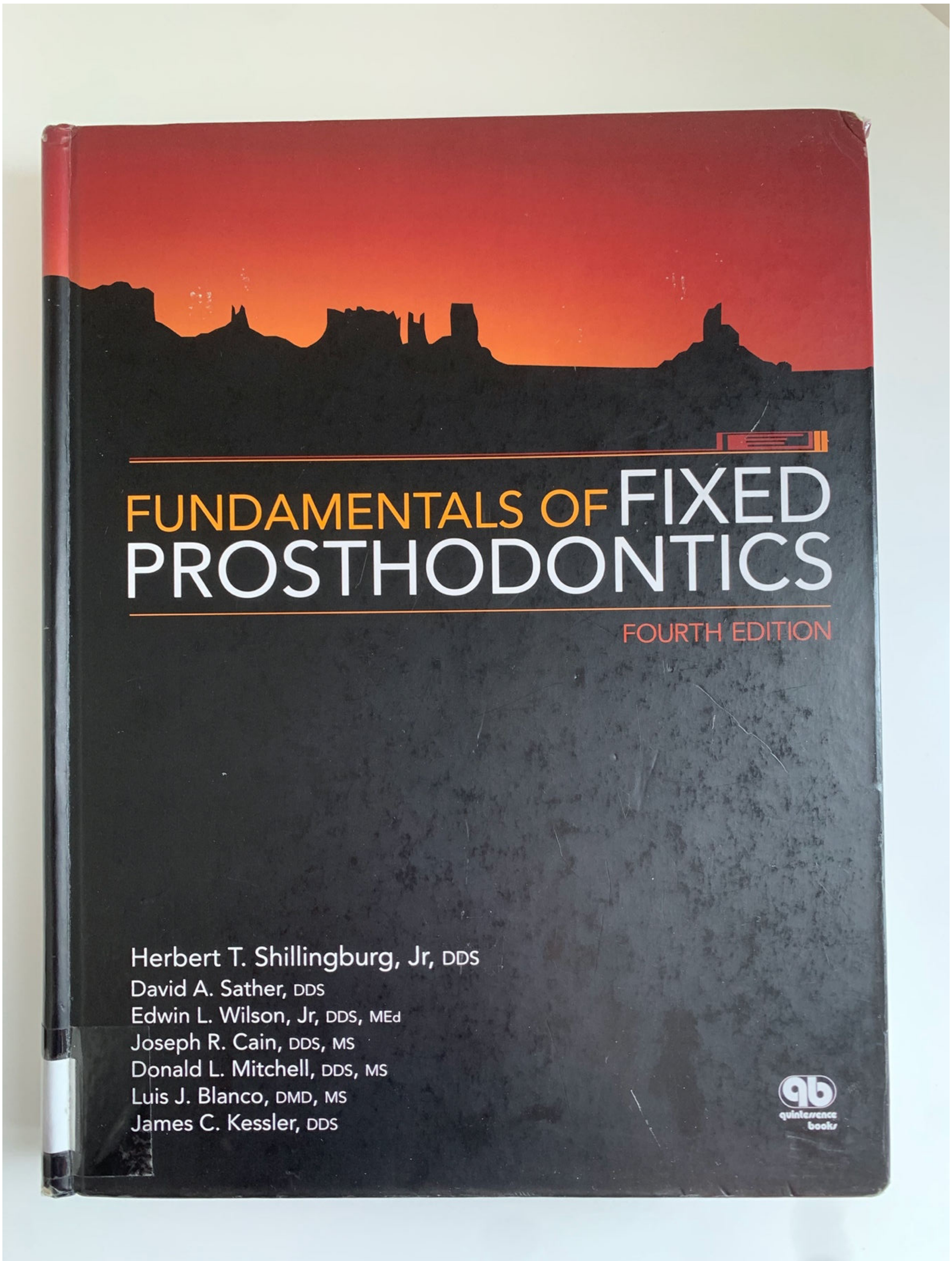
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Long-Term Survival of Porcelain Laminate Veneers Using Two Preparation Designs: A Retrospective Study

Roger J. Smales, MDS, DDSc[a]/Soheila Etemadi, DDS, MDS[b]

Purpose: This study evaluated the long-term survival of anterior porcelain laminate veneers placed with and without incisal porcelain coverage. ***Materials and Methods:*** Two prosthodontists in a private dental practice placed 110 labial feldspathic porcelain veneers in 50 patients; 46 veneers were provided with incisal porcelain coverage, and 64 were not. The veneers were evaluated retrospectively from case records for up to 7 years (mean 4 years). ***Results:*** At 5, 6, and 7 years, the cumulative survival estimates were 95.8% for veneers with incisal porcelain coverage and 85.5% for those without incisal coverage. The difference was not statistically significant. Six of the nine failures occurred from porcelain fracture in the veneers without incisal coverage. ***Conclusion:*** Although there was a trend for better long-term survival of the veneers with incisal porcelain coverage, this finding was not statistically significant. *Int J Prosthodont 2004;17:323–326.*

The porcelain laminate veneer is now a frequently prescribed restoration for anterior teeth.[1] Substantially less tooth preparation is required than for conventional esthetic complete crown preparations,[2] which accords with the practice philosophy of minimally invasive dentistry. The long-term clinical success of porcelain veneers depends on careful case selection, treatment planning, tooth preparation, laboratory veneer fabrication, and adhesive bonding procedures.[3] The apparent ease and speed of tooth preparation, combined with less-than-ideal laboratory and bonding procedures, may lead to unsatisfactory clinical performance of the veneers.[4] Most studies[5–25] on the clinical survival of porcelain veneers have been for less than 5 years, with survival rates from 48% to 100% reported. Few of these studies use life table methods to estimate restoration survival.[6,11,13,17]

Four types of incisal tooth preparations for porcelain veneers have been described[1,24]: window (intraenamel), leaving an intact incisal enamel edge; feathered, leaving an incisal edge in enamel and porcelain; beveled, with the incisal edge entirely in porcelain; and overlapped, with the porcelain extended further onto the palatal aspect of the preparation as a chamfer. The window and feathered incisal edge preparations cannot produce an increased tooth length or highly translucent incisal edge in worn teeth. Unsightly incisal margins and enamel and porcelain chipping have also been noted with these preparations.[16,21]

Using two-dimensional photoelastic stress analysis, one study reports that window preparations can withstand higher axial stresses than feathered and overlapped designs.[26] However, another study using three-dimensional photoelastic stress analysis reports that incisal overlapping reduces stress in the veneer most effectively.[27] Another in vitro study found that higher fracture loads are required for failure of beveled than overlapped and feathered veneer designs.[28] Using a finite element method, a beveled or overlapped design with a palatal minichamfer shows lower tensile stresses than an overlapped design with a long chamfer extending into the palatal concavity, where tensile stresses are concentrated.[29] Several clinical studies report either better results from incisal porcelain coverage or no significant differences when comparing

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Update to Preparation Design and Clinical Concepts Using the LeSage Veneer Classification System

1

Brian P. LeSage

Contents

1.1 Introduction

Porcelain veneers had long been considered to be only an esthetic solution. However, their range of indications has been steadily increasing, making ceramic veneers a highly viable alternative to classic, far more invasive forms of restorative treatment. Today, veneers can be used to handle esthetics (discolored teeth, fractured and worn teeth, diastemas, dental defects, etc.) and to restore the biomechanics of the dentition, as well as many other indications.

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Establishing a Classification System and Criteria for Veneer Preparations

Brian LeSage, DDS

Abstract: The concept of no- or minimal-preparation veneers is more than 25 years old, yet there is no classification system categorizing the extent of preparation for different veneer treatments. The lack of veneer preparation classifications creates misunderstanding and miscommunication with patients and within the dental profession. Such a system could be indicated in various clinical scenarios and would benefit dentists and patients, providing a guide for conservatively preparing and placing veneers. A classification system is proposed to divide preparation and veneering into reduction—referred to as space requirement, working thickness, or material room—volume of enamel remaining, and percentage of dentin exposed. Using this type of metric provides an accurate measurement system to quantify tooth structure removal, with preferably no reduction, on a case-by-case basis, dissolve uncertainty, and aid with multiple aspects of treatment planning and communication.

LEARNING OBJECTIVES

- discuss the advantages of no-preparation and minimal-preparation veneers
- understand why there is a need for a classification system to categorize the extent of preparation for different types of veneer treatment
- describe factors affecting tooth preparation for esthetic restorations

Nonmaleficence is often discussed and debated in healthcare.[1] No longer is it acceptable to over-prepare teeth for convenience or lack of understanding of alternative treatments. Minimally invasive dentistry is not merely a simple obligation, but a professional duty.[1] The media-inspired preoccupation with looking and feeing younger obligates healthcare providers to balance ethics with literature-based information and clinical experiences to meet patient demands.[2] Clinical evidence is needed to provide the standard of care required to comply with and support nonmaleficence.[1,2]

The concept of no-preparation or minimal-preparation veneers is more than 25 years old, yet there is no classification system categorizing the extent of preparation for different veneer treatments.[2] Such a system could be indicated in various clinical scenarios and benefit dentists and patients, guiding conservative veneer preparation and placement.[2]

Interest in conservative treatments has increased significantly since veneering was introduced as an additive technique in the 1980s as an alternative to full-coverage crowns.[3,4] Placed with little to no preparation, veneers were bonded directly to

Fig 1.

Fig 1. Illustrations demonstrating Class I veneer preparations requiring little to no tooth structure removal. Facial reduction allowing for 95% to 100% of the enamel remaining, and no dentin should be exposed.

Original Contributions

Incisal preparation design for ceramic veneers

A critical review

Sy Yin Chai, BDSc; Vincent Bennani, DDS, PhD; John M. Aarts, BEd, MHealSci;
Karl Lyons, BDS, MDS, PhD

ABSTRACT

Background. The authors reviewed and identified the evidence for the various incisal preparation designs for ceramic veneers.

Types of Studies Reviewed. The authors searched MEDLINE with PubMed and Ovid to identify any articles in the English language related to the topic up through March 2017 using a combination of key words: "porcelain veneer or ceramic veneer or dental veneer or labial veneer" AND "preparation," NOT "composite veneer," NOT "crown," NOT "implant," NOT "fixed partial denture or bridge or denture," NOT "porcelain-fused-to-metal," NOT "marginal gap or fit."

Results. In vitro studies showed that the palatal chamfer preparation design increases the risk of developing ceramic fractures. The butt joint preparation design had the least effect on the strength of the tooth.

Conclusions. Surveys show the 2 most common incisal preparation designs provided are butt joint and feathered-edge. Clinical studies have identified that incisal ceramic is the most common location of ceramic fracture. In addition, there is a lack in standardization of the modeling structures and type of finite element analysis.

Practical Implications. The evidence seems to support the use of butt joint over palatal chamfer incisal preparation design. Fracture or chipping is the most frequent complication and the risk increases with time. Incisal ceramic is the most common location of ceramic fracture.

Key Words. Veneer preparation; porcelain laminate; incisal edge; teeth.

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The dental literature has long reported various descriptions of different preparation designs for ceramic veneers.[1-7] In general, the preparation for ceramic veneers can be divided into buccal surface preparation (no preparation, minimal preparation, conservative, or conventional preparation); proximal finish (slice or chamfer margin); incisal preparation (overlap or nonoverlap); and cervical preparation (chamfer or knife edge).[8-10]

Although the incisal preparation design for ceramic veneers has been widely discussed, there is no consensus on whether incisal reduction is necessary and how much of the incisal overlap should be provided when an increase in incisal length is not required.[10-14] Not only that but the amount of incisal reduction varies widely from 0.5 millimeter[1] to 2 mm.[13] In retrospect, many recommendations for the incisal preparation design are likely based on either clinical experience or anecdotal reports.[1-7,15-19]

Incisal preparation can be divided into 2 broad categories: overlap and nonoverlap. Four common incisal preparation designs that have been described are the window (or intraenamel), the feathered edge, the palatal chamfer (or overlapped), and the butt joint (or incisal bevel) (Figure 1). The window and the feathered-edge preparation designs belong to the nonoverlap category, and the butt joint and the palatal chamfer designs belong to the overlap category.[4,14]

The demand for ceramic veneers has increased drastically in both general and specialist dental practice from an increase in esthetically driven patients, and from veneers' clinical success and conservative nature.[12,20] The evolution of bonding systems, ceramic materials, and fabrication methods, particularly pressed and computer-aided design and computer-aided-manufacturing (CAD/CAM) technology, have changed the way we approach these restorations.

Stresses Within Porcelain Veneers and the Composite Lute Using Different Preparation Designs

Kevin G. Seymour, BDS, MSc, PhD, DRD, George P. Cherukara, BDS, MClinDent, and Dayananda Y.D. Samarawickrama, BDS, PhD

Purpose: The purpose of this study was to investigate compressive and tensile stresses in porcelain and composite at the labial marginal region of porcelain veneer restorations using chamfer, shoulder, or knife-edge labial margin designs with labial window or incisal overlap incisal preparation designs.

Methods: Porcelain veneer models were constructed and loaded with (1) a 200-N, 45° palatal load to simulate functional loading, and (2) a horizontal labial loading of 200 N to mimic trauma. Maximum tensile and compressive stresses were recorded within the labial marginal region of both porcelain and composite lute.

Results: Under the 45° palatal load, stresses within the palatal marginal porcelain were chiefly compressive, and stresses for the knife-edge designs as much as 42% less than for shoulder designs. Incisal overlap preparations were generally associated with less compressive stress within both porcelain and composite than the window preparation. When a labial load was applied, tensile stresses were as much as 25 times greater for the chamfer and shoulder designs compared with the knife-edge design. Labial loading also resulted in an increase in tensile stresses within the composite lute, and stresses were again lowest within the knife-edge margin design.

Conclusions: Under the limitations of this study, using the incisal overlap preparation, porcelain veneers with knife-edge labial margins could better sustain occlusal loading without fracture.

J Prosthodont 2001;10:16-21.

INDEX WORDS: ceramic, preparation, margin, tensile, compressive

SINCE THEIR introduction by Pincus[1] in the late 1930s, porcelain veneer restorations have become predictable in dental practice because of advancements in porcelain[2-4] and composite resin technology.[5,6] A meta-analysis of 9 studies of porcelain veneer longevity[7] revealed a pooled survival over 3 years of 92%. These figures compare with others who report survival rates of approximately 90% range for as long as 6 years.[8,9]

For optimum veneer esthetics, appropriate intra-enamel facial tooth preparation is necessary to obtain an acceptable emergence profile, veneer strength, and restoration retention.[10,11] A recommended depth of this preparation should be 0.5 mm to provide for a well-adapted veneer both from the clinical and the technical standpoints, and modified chamfer, shoulder, and knife-edge gingival margin designs have been suggested. However, some authors have questioned whether this preparation depth would stay within the enamel,[12] because 2 mm incisal to the cemento-enamel junction enamel may be only 0.3 or 0.4 mm thick on maxillary central and lateral incisors, respectively. Deeper preparations could expose dentin and contribute to undesirable microleakage.

Incisal edge tooth preparation may also be desirable depending on the necessity to alter the tooth length and facio-lingual width. If the incisal edge is not to be modified, a window preparation has been suggested.[13] Such preparation requires adequate tooth structure bulk and strength incisally or occlusally, as is found with maxillary canines or posterior teeth. When the incisal edge is thin or the inciso-cervical morphology requires alteration, preparation overlap onto the lingual surface would be indicated.

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Original Article

Enamel Thickness After Preparation of Tooth for Porcelain Laminate

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Abstract
Objective: In this investigation the thickness of enamel in the gingival, middle, and incisal thirds of the labial surface of the anterior teeth were measured regarding preparation of the teeth for porcelain laminate veneers.
Materials and Methods: Part one, 20 extracted intact human maxillary central and lateral incisors ten of each were selected. The teeth were imbedded in autopolimerize acrylic resin. Cross section was preformed through the midline of the incisal, middle and cervical one-third of the labial surface of the teeth. The samples were observed under reflected stereomicroscope and the thickness of enamel was recorded. Part II, the effect of different types of preparation on dentin exposure was evaluated. Thirty maxillary central incisor teeth were randomly divided into two groups: A: Knife-edge preparation. B: Chamfer preparation.
All samples were embedded in autopolimerize acrylic resin using a silicon mold. The samples were cut through the midline of the teeth. The surface of the samples were polished and enamel and dentin were observed under the stereomicroscope.
Results: Data were analyzed by ANOVA-one way test. The results of this study showed that the least enamel thickness in the central incisor was 345 and in lateral incisor is 235 μ this thickness is related to the one-third labial cervical area. Maximum thickness in maxillary central and lateral incisors in the one-third labial incisal surface was 1260 μ and 1220μ, respectively. In the second part of the study, the tendency of dentinal exposure was shown with the chamfer preparation, but no dentinal exposure was found in the knife-edge preparation. The differences between groups were significant ($p<0.05$).
Conclusion: The knowledge of enamel thickness in different part of labial surface is very important. The thickness of enamel in the gingival area does not permit a chamfer preparation. The knife edge preparation is preferable in gingival area.
Key Words: Thickness; Knife Edge; Chamfer; Laminate; Porcelain

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INTRODUCTION

The use of porcelain laminate veneer restorations as an effective and minimally invasive restoration has been well established [1, 2].

The long-term clinical success of porcelain veneers depends on careful case selection, treatment planning and tooth preparation. The technique requires a shallow reduction of the

A finite element analysis of the effect of different margin designs and loading positions on stress concentration in porcelain veneers.

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ABSTRACT

Background: During mastication, stress may concentrate in points in the porcelain veneer which may lead to clinical failure. This study examined whether different finishing lines and different loading positions affect the bond of the porcelain veneers.

Materials and methods: A 2- dimensional finite element model was made. Location and magnitude of maximum Von Mises and shear stresses were calculated in porcelain veneer.

Results: Stress was concentrated in the butt finishing line more than the deep chamfer and chamfer finishing lines. Stress was concentrated in the incisal portion more than in the cervical portion of the porcelain veneer. The incisal loading exerted stress more than the bonding strength of the bonding agent, and more than the cervical and middle third loading.

Conclusion: The best stress distribution was formed around the deep chamfer finishing line. Clinical failure is inevitable in the butt finishing line and incisal loading. Incisal edge fracture of the porcelain veneer may be due to debonding of the bonding agent to the enamel and later fracture of the porcelain veneer

Keyword: Finite element, porcelain veneers (J Coll Dentistry 2005; 17(2):8-12)

INTRODUCTION

Porcelain veneers are used to treat discolored teeth, or teeth with minimal loss of the incisal edge. [1, 2]

The success rate of porcelain veneers was clinically evaluated to range from 75-100% [3-7]. Factors affecting long term success of porcelain veneers are age, gender of the patient and fabrication techniques [6]. The use of rubber dam isolation or number of years in service did not influence the rate of success. Therefore, failure in porcelain veneers seems to be associated with changes in bonding condition and / or the magnitude of incisal load [8].

The advanced bonding agents and techniques have given high bonding strength, hence improving bond of the porcelain veneer efficiently to the tooth structure.

The marginal design of the finishing line was studied to verify the stress concentration by the use of 2 dimensional finite element analysis [9, 10], but none emphasized clearly on the degree of stress concentration on different finishing lines and nearby points.

The purpose of this study was to examine the distribution of stresses in porcelain veneers in different tooth preparation finishing line designs (cervically and incisally) according to different positions of masticatory force loading.

MATERIALS AND METHODS

The finite analysis was conducted using the ANSYS 5.4 finite element package (Swanson Analysis System, Housten, Pennsylvania) with a pentium 4 processor (2.4 GHz).

Two dimensional finite element models of porcelain veneers on teeth with intermediate layers of bonding agent, and composite resin were designed according to the size of an average maxillary central incisor. The abutment was considered to be homogenous.

The dimensions of the preparation for the porcelain veneers were drawn according Rufenacht in1992, where 0.3 mm was prepared cervically, 0.5 mm in the middle and 0.7 mm incisally. The porcelain veneer preparation was all within enamel.

Three types of finishing lines incisally and cervically were drawn to create models and as follows:

Group I: Butt finishing line.

Group II: Deep chamfer finishing line.

Group III: Chamfer finishing line.

The composite resin was drawn to be 100 um thick [12] and the bonding agent was 1 um thick. [8]

The model was divided into 5 main areas representing porcelain laminate, composite cement layer, enamel bonding layer, enamel and dentine, while the pulp was assumed as a nul element (Fig. 1).

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Five-year clinical performance of porcelain laminate veneers

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Objective: The clinical performance of porcelain laminate veneers was evaluated at 5 years. **Method and materials:** One hundred eighty-six porcelain laminate veneers were placed in 61 patients, aged 18 to 70 years, by a single operator following the same clinical procedure. At the 5-year recall, esthetics, marginal integrity, marginal discoloration, fracture rate, and patient satisfaction were recorded. **Results:** At recall 98.4% of the veneers were satisfactory without intervention. The retention rate was excellent, the fracture rate was very low, and the maintenance of esthetics was superior. Patient satisfaction was very high. **Conclusion:** Porcelain laminate veneers offer a reliable and effective procedure for the conservative and esthetic treatment of anterior teeth. *(Quintessence Int 2002;33:185–189)*

Key words: clinical performance, esthetics, fracture, marginal adaptation, marginal discoloration, porcelain veneer

CLINICAL RELEVANCE: The porcelain laminate veneer restoration preserves the maximum of the patient's natural tooth substance, but appropriate patient selection and a meticulous clinical procedure are needed to ensure success.

The porcelain laminate veneer is a conservative alternative to complete coverage for improving the appearance of an anterior tooth. Laminate veneers have evolved over the last several decades to become one of esthetic dentistry's most popular restorations.[1–4]

A porcelain laminate veneer is an extremely thin shell of porcelain applied directly to the tooth structure. Tooth preparation is minimal, remaining within enamel. The restoration derives its strength from the ability of a resin composite resin luting agent with a silane coupling agent to bond with etched porcelain and etched enamel.[5–8]

Indications for porcelain laminate veneers include enamel hypoplasia, tooth discoloration, intrinsic staining (such as tetracycline staining), fractured teeth, closure of diastemas, and correction of anatomically malformed anterior teeth.[2,4,9] When patients are selected appropriately, this method of restoring teeth appears promising, although few long-term results have been reported.[1,10–12]

The purpose of this study was to add to the knowledge of resin-bonded ceramic veneers by evaluating the clinical quality of such restorations over the medium to long term.

METHOD AND MATERIALS

The study population consisted of 61 patients. There were 38 women and 23 men, ranging in age from 18 to 70 years (Table 1). The 61 patients had been provided with 186 ceramic veneers between February 1993 and December 1994. The distribution of the 186 ceramic veneers is shown in Table 2. The teeth to be treated showed either slight-to-moderate intrinsic discoloration or surface enamel defects (Fig 1). Subjects with minimal staining or with signs of excessive incisive (occlusal) forces were excluded from the study.

All procedures were performed by one investigator. Teeth were prepared and all materials were mixed and used according to the recommendations of the manufacturers. Shades were matched with the Vita-Lumin Vacuum shade guide (Vita Zahnfabrik).

The facial enamel of the teeth was reduced by 0.3 to 0.5 mm with a tapered round-ended diamond bur

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A comparative assessment of the strengths of porcelain veneers for incisor teeth dependent on their design characteristics.

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An in vitro study, using dynamic stress analysis and two dimensional photo-elasticity, carried out to relate the strength of porcelain veneers fabricated to three different designs, demonstrated that the 'window' type of preparation was the strongest compared with 'overlapped' and 'feathered' designs. It also confirmed that the strength of the veneer was not proportional to its thickness. It can be concluded that where strength is an important prerequisite, the most conservative type of veneer, namely the 'window' preparation, is the design of choice.

Key words: laminate; tooth preparation; enamel; palatal concavity; contact area

This study aimed to assess the clinical performance of lithium disilicate restorations supported by natural teeth or implants. Eight hundred sixty lithium disilicate adhesive restorations, including crowns on natural teeth and implant abutments, veneers, and onlays, were made in 312 patients. Parafunctional patients were included, but subjects with uncontrolled periodontitis and gingival inflammation were excluded. Veneers up to 0.5 mm thick were luted with flowable composite resin or light curing cements, while dual-curing composite systems were used
with veneers up to 0.8 mm thick. Onlays up to 2 mm in thickness were luted
with flowable composite resins or dual-curing composite cements. Crowns up
to 1 mm in thickness were cemented with self-adhesive or dual-curing resin cements. The observational period ranged from 12 to 72 months, with a mean follow-up of 3 years. The mechanical and esthetic outcomes of the restorations were evaluated according to the modified California Dental Association (CDA) criteria. Data were analyzed with descriptive statistics. Twenty-six mechanical complications were observed: 17 porcelain chippings, 5 fractures, and 4 losses
of retention. Structural drawbacks occurred mainly in posterior segments, and monolithic restorations showed the lowest number of mechanical complications. The clinical ratings of the successful restorations, both monolithic and layered, were satisfactory according to the modified CDA criteria for color match, porcelain surface, and marginal integrity. The cumulative survival rates of lithium disilicate restorations ranged from 95.46% to 100%, while cumulative success rates
ranged from 95.39% to 100%. All restorations recorded very high survival and success rates. The use of lithium disilicate restorations in fixed prosthodontics proved to be effective and reliable in the short- and medium-term. (Int J Periodontics Restorative Dent 2014;34:XX–XX. doi: 10.11607/

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Dynamometric assessment of the mechanical resistance of porcelain veneers related to tooth preparation: A comparison between two techniques

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Statement of problem. There is little agreement regarding a palatal extension of the preparation for porcelain veneers, as it represents a more invasive technique than a preparation limited to the facial surface of a tooth.

Purpose. The purpose of this study was to detect the stress in maxillary anterior teeth restored with porcelain veneers and compare the resistance to fracture of porcelain veneers prepared using different preparation designs.

Material and methods. Forty-five maxillary anterior teeth were restored with porcelain veneers and divided into 9 groups as follows: Ca, canines with no preparation; Ca-Ch, canines with palatal chamfer preparation; Ca-W, canines with window preparation; LI, lateral incisors with no preparation; LI-Ch, lateral incisors with palatal chamfer preparation; LI-W, lateral incisors with window preparation; CI, central incisors with no preparation; CI-Ch, central incisors with palatal chamfer preparation; CI-W, central incisors with window preparation. Shear-flexural fracture tests were performed. The fractured specimens were subjected to scanning electron microscope (SEM) analysis. Data were statistically analyzed with univariate analysis of variance and the Tukey post hoc test for multiple comparisons (α=.05).

Results. The following mean fracture load values (N) were recorded: Ca, 395 ± 6; Ca-Ch, 310 ± 8; Ca-W, 322 ± 8; LI, 309 ± 8; LI-Ch, 242 ± 6; LI-W, 225 ± 8; CI, 298 ± 8; CI-Ch, 255 ± 8; CI-W, 221 ± 6. The SEM analysis showed that both adhesive and cohesive fractures were primarily concentrated at the cervical region. Statistical analysis showed that both the type of tooth and the design of the preparation significantly influenced the resistance to fracture of the restored teeth (P<.001).

Conclusion. The chamfer preparation is recommended for central incisors, whereas the window preparation showed better results for canines. Both preparations can be adopted in the restoration of lateral incisors.
(J Prosthet Dent 2006;95:354-63.)

CLINICAL IMPLICATIONS

This study provides data regarding the mechanical performance of and the guidelines for different porcelain veneer preparations used to restore different maxillary anterior teeth. A chamfer preparation is recommended for central incisors, whereas a window preparation is recommended for canines. Both techniques can be used for lateral incisors.

During the last decade, due to growing patient demand for esthetic restorations and more conservative trends in restorative dentistry, the use of porcelain veneers has become a widespread, reliable, and successful technique for restoring discolored, worn, malformed, or fractured teeth.[1] Many factors influence the long-term success of porcelain veneers, such as tooth surface, porcelain thickness, type of luting agent and adhesive system, marginal adaptation, periodontal response, tooth morphology, functional and parafunctional activities, and the geometry of the preparation.[1] Regarding tooth morphology, the palatal concavity and the incisal areas of maxillary anterior teeth are considered to be high stress concentration areas during tooth function[2,3]; this fact is physiologically compensated for by having increased enamel thickness in these zones.[4] The enamel removed during tooth preparation should be compensated for with a material having enamel-like properties to restore the original biomechanical behavior of a tooth.[4]

Preparation design and geometry are possible variables involved in the ultimate success of a restoration. To achieve the best adhesion, it is desirable to have at least 50% to 70% of the enamel surface available for the etching procedures.[5] Dumfarhrt and Schaffer[6] found that 52% of the preparations for porcelain veneers caused exposure of dentin at the level of the gingival margin.

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Survival Rate, Load to Fracture, and Finite Element Analysis of Incisors and Canines Restored With Ceramic Veneers Having Varied Preparation Design

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Clinical Relevance

Fracture loads of canines and maxillary central incisors are not affected by the veneer preparation design (eg, conservative or conventional preparation with palatal chamfer). However, conventional preparation generated higher tensile stress in the ceramic veneer.

SUMMARY

Purpose:To evaluate the survival rate, success rate, load to fracture, and finite element analysis (FEA) of maxillary central incisors and canines restored using ceramic veneers and varying preparation designs.

Materials and Methods:Thirty human maxillary central incisors and 30 canines were allocated to the following four groups (n=15) based on the preparation design and type of tooth: Gr1 = central incisor with a conservative preparation; Gr2 = central incisor with a conventional preparation with palatal chamfer; Gr3 = canine with a conservative preparation; Gr4 = canine with a conventional preparation with palatal chamfer. Ceramic veneers (lithium disilicate) were fabricated and adhesively cemented (Variolink Veneer). The specimens were subjected to 4 × 10^6 mechanical cycles and evaluated at every 500,000 cycles to detect failures. Specimens that survived were subjected to a load to fracture test. Bidimensional models were modeled (Rhinoceros 4.0) and evaluated (MSC.Patrans 2005r2 and MSC.Marc 2005r2) on the basis of their maximum principal stress (MPS) values. Survival rate values were analyzed using the Kaplan-Meier test ($\alpha = 0.05$) and

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Influence of tooth preparation design on the stress distribution in maxillary central incisors restored by means of alumina porcelain veneers: A 3D-finite element analysis

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KEYWORDS
Porcelain veneers;
3D-finite element analysis;
Preparation design;
Window technique;
Chamfer with palatal overlap preparation;
Biomimetic

Summary *Aim*. The present study aimed at providing 3D-FEA engineering tools for the understanding of the influence of tooth preparation design on the stress distribution and localization of critical sites in maxillary central incisors restored by means of alumina porcelain veneers under functional loading.
Methods. A 3D-FEM model of a maxillary central incisor is presented. An arbitrary chewing static force of 10 N was applied with an angulation of 60 and 125° to the tooth longitudinal axis at the palatal surface of the crown. The model was considered to be restored by means of alumina porcelain veneers with different tooth preparation designs. The differences in occlusal load transfer ability of the two restorative systems are discussed.
Results. The maximum Von Mises equivalent stress values were observed in the window restorative system for both 125 and 60° load angulations. When the chamfer with palatal overlap preparation was simulated, the stress distributed uniformly in the cement layer, whereas in the window preparation the stress mainly occurred in the incisal area of the cement layer.
Significance. When restoring a tooth by means of porcelain veneers, the chamfer with palatal overlap preparation better restores the natural stress distribution under load than the window technique.

Introduction

According to the principles of so-called 'minimal intervention dentistry' and due to the growing

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Fracture load and mode of failure of ceramic veneers with different preparations

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Statement of problem. Fracture is a clinical failure modality for ceramic veneers. Whether design of tooth preparation can affect the strength of ceramic veneers remains controversial.

Purpose. This in vitro study evaluated fracture load and mode of failure of ceramic veneers, with 4 tooth preparation designs, that were bonded on extracted human maxillary central incisors. Identical parameters were also measured on unrestored intact teeth for comparison.

Material and methods. Fifty maxillary central incisors were randomly divided into 5 equal groups. Each group was assigned a different tooth preparation design: (1) no incisal reduction, (2) 2 mm incisal reduction without palatal chamfer (butt joint), (3) 1 mm incisal reduction and 1 mm height palatal chamfer, (4) 4 mm incisal reduction and 1 mm height palatal chamfer, and (5) unrestored (control). Forty teeth were prepared to accommodate ceramic veneers of equal thickness and incisocervical length. Stone dies were fabricated and veneers made from IPS Empress ceramic. Ceramic veneers were bonded and all teeth mounted in phenolic rings with epoxy resin. Fracture loads were recorded with a mechanical testing machine.

Results. Mean fracture loads (SD) in kgf were as follows: group 1, 23.7 (6.11); group 2, 27.4 (9.63); group 3, 16.4 (3.44); group 4, 19.2 (6.18); and group 5, 31.0 (10.38). Modes of failure were also analyzed for both ceramic veneers and teeth. One-way ANOVA with multiple comparisons revealed 3 significant subsets: groups 1-2-5, groups 4-1, and groups 3-4 ($P<.05$). Groups 1 and 2 had no ceramic veneer fractures; group 3 had 3 ceramic veneer fractures, and group 4 had 6 ceramic veneer fractures.

Conclusion. Groups 1 and 2 recorded the greatest fracture loads that were comparable to an unrestored control. (J Prosthet Dent 2000;83:171-80.)

CLINICAL IMPLICATIONS

Elimination of a palatal chamfer for ceramic veneers with incisal butt joints resulted in stronger restorations and simplified tooth preparation. The faciopalatal path of insertion allowed easier simultaneous seating of multiple veneers that eliminated the risk of fracture of thin unsupported palatal ceramic ledges. Impressions provided a master cast that reproduced a clear palatal finish line and flat incisal wall and incisal reduction facilitated desirable characterization of ceramic veneers at the incisal third surfaces.

Ceramic veneers, which have become a popular, well-accepted, and perceptive dental procedure, were introduced to dentistry during the late 1920s and 1930s.[1,2] The clinical survival rate of ceramic veneers bonded to enamel has been predictable.[3] Observation periods of ceramic veneers reported in the literature range from 18 months up to 15 years.[3-5] One study reported that 93% of 3500 ceramic veneers placed over a 15-year period were rated as successful, whereas 7% were considered failures.[3]

Ceramic veneers are indicated for teeth with moderate discoloration[6-8] caused by tetracycline, fluoride, age,[9] and amelogenesis imperfecta.[1] Thus, ceramic veneers are chosen to provide excellent esthetics.[10-12] Ceramic veneers can also be selected for the restoration of traumatized, fractured, and worn dentition (Fig. 1).[7-9]

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Longevity and failure load of ceramic veneers with different preparation designs after exposure to masticatory simulation

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Statement of problem. Laminate veneers are widely used in the management of unesthetic anterior teeth. However, limited information is available regarding the influence of preparation design on longevity of ceramic veneers.

Purpose. This study evaluated the influence of preparation design on longevity and failure load of ceramic veneers bonded to human maxillary central incisors after cyclic loading and thermal cycling in a dual-axis masticatory simulator.

Material and methods. Sixty-four caries-free maxillary central incisors were divided into 4 groups (n = 16). The control group remained unprepared (NP). For Group WP, a window preparation was made. Specimens in Group IOP were prepared with an incisal overlap of 2 mm without palatal chamfer. For Group CVP, specimens were prepared with a complete-veneer design of 3-mm incisal reduction and 2-mm palatal extension. Forty-eight IPS Empress 1 ceramic veneers were bonded adhesively with dual-polymerizing composite (Variolink II). All specimens were subjected to cyclic mechanical loading (1.2 million cycles, cycle frequency 1.3 Hz, invariable palatal load 49 N) and thermal cycling (5°C-55°C, dwell time 60 seconds, 5500 cycles) in a masticatory simulator. Failure was defined by bulk fracture of a specimen. Subcritical crack patterns were observed. Surviving specimens were loaded in a universal testing machine until fracture. The failure-load values (N) (1.5 mm/min crosshead speed) were automatically recorded by controlling software. Statistical analysis of data was performed by Kruskal-Wallis analysis of variance (α=.05) and pairwise Wilcoxon rank sum tests (α=.05).

Results. Three specimens from group NP, 1 specimen each from the WP and CVP groups, and 2 specimens from group IOP fractured during fatigue. After 1.2 million cycles, the highest crack rates were observed for complete veneers and originated in the palatal concavity extending to the facial surface. The median (interquartile range = $x_{.25}$-$x_{.75}$) failure loads (N) were as follows: NP 713.3 (404.4-777.1), WP 549.5 (477.5-597.7), IOP 695.3 (400.0-804.6), and CVP 519.2 (406.1-732.9). No significant differences in longevity and failure load were demonstrated between natural teeth and teeth restored with ceramic veneers (P=.555).

Conclusion. Maxillary teeth restored with the 3 types of IPS Empress 1 veneers showed fracture resistance similar to that of unprepared incisors (P=.555). (J Prosthet Dent 2005;94:132-9.)

CLINICAL IMPLICATIONS

Within the limits of this in vitro investigation, the use of adhesively luted IPS Empress 1 veneers prepared according to the 3 different preparation designs demonstrated adequate stabilization of residual tooth structure. Crack pattern analysis showed a higher risk of subcritical crack development when the indenter impact was located on the palatal ceramic surface. Therefore, the palatal contact point position of the antagonist should remain on the natural tooth structure after preparation. In particular, this is important for complete veneer preparations.

The demand for more durable and esthetic anterior dentition has resulted in an increase in the use of porcelain veneers during the past decade.[1,2] With an observation period ranging from 1 month to 15 years, longitudinal evaluations of porcelain veneers have shown excellent results, including a low prevalence of debonding, microleakage, fracture, and caries.[1-6] In the early use of porcelain laminate veneers, clinicians suggested minimal or no preparation.[7,8] Currently, tooth preparation is recommended to achieve long-term success,[9-11] maximize esthetics, improve fracture resistance, and maintain soft tissue health.[12] In addition,

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The failure load of CAD/CAM generated zirconia and glass-ceramic laminate veneers with different preparation designs

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Statement of problem. Fracture of feldspathic porcelain laminate veneers represents a significant mode of clinical failure. Therefore, ceramic materials that withstand a higher load to fracture, especially for patients with parafunctional habits, are needed.

Purpose. The purpose of this study was to examine the correlation of material (zirconia, TZP, glass-ceramic, IEC, and feldspathic porcelain, FP) design (incisal overlapped preparation, IOP, and three-quarter preparation, TQP), and fracture mode to failure load for veneers supported by composite resin abutments.

Material and methods. A typodont tooth prepared with 2 designs (IOP, TQP) and the corresponding 2 definitive dies were used to fabricate the composite resin abutments (30 for IOP and 30 for TQP). Ten veneer specimens for each system (Y-TZP, IEC, and FP), were fabricated for each design. The veneers were cemented, invested, and tested in compression until failure by using a universal testing machine. Significant differences were evaluated by 2-factor ANOVA (α=.05).

Results. No statistical mean load difference was noted between the preparation designs for Y-TZP (IOP: 244 ±81 and TQP: 224 ±58 N), IEC (IOP: 306 ±101 and TQP: 263 ±77 N), and FP veneers (IOP: 161 ±93 and TQP: 246 ±45 N). No statistical difference in the mean load was found among the 3 veneer materials for each preparation design except between IEC (306 ±101 N) and FP (161 ±93 N) veneers for TQP.

Conclusions. Preparation design did not influence the failure load of the veneer materials. Zirconia veneers were the least likely to fracture but the most likely to completely debond; feldspathic porcelain veneers exhibited the opposite characteristics. (J Prosthet Dent 2012;108:386-393)

Clinical Implications

Zirconia veneers demonstrated, in vitro, the ability to withstand higher load before fracture than glass-ceramic and feldspathic porcelain laminate veneers, which supports expanded clinical applications.

Crown preparation involves significant removal of tooth structure (63% to 73%)[1] and may cause pulpal irritation and irreversible pulpitis.[2] Laminate veneers are more conservative than crowns[3] and maintain the biomechanics of the original tooth with a similar stress distribution and a success rate of approximately 93% over 15 years of clinical use.[4]

The most frequent failure modes associated with laminate veneers are fracture or debonding,[4] although the magnitude and direction of the load greatly influence their long-term success.[5] Several studies have indicated that stress concentrates at the adhesive interface between the luting ce-

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Tooth preparation for ceramic veneers: when less is more

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CLINICAL ARTICLE

WILEY

Protocol for a new concept of no-prep ultrathin ceramic veneers

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Abstract

Objectives: No-prep veneers, although ideally considered the best option because of tooth structure maximum preservation, have been frequently criticized for some potential limitations including esthetic outcomes and periodontal complications.

Clinical considerations: A new protocol to optimize no-prep veneers restorations is presented. A key point of the proposed technique is to identify optimal margins' positions: margin is positioned in the point of maximum convexity of teeth, avoiding the over contouring of traditional no-prep veneers.

Conclusion: The procedure can be appreciated for the marginal accuracy and the resulting aesthetic stability. The case reports show that properly managed no-prep veneers can have biologically healthy and aesthetically pleasant tooth-restoration transitions and emergence profiles.

Clinical Significance

High-quality no-prep veneers can be more challenging to realize than conventional veneers and the success seems to depend on a combination of good case selection, margins' position, sound adhesive principles, clinical, and laboratory experience.

KEYWORDS
ceramic, dental adhesion, no-prep veneer

1 | INTRODUCTION

Ceramic veneers are frequently presented as the major class of clinical conservative modalities in aesthetic dentistry.[1,2] The so-called *"no-prep"* approaches have been described for more than 10 years in literature[3–8] and ideologically reiterate the methodologies of 1980s, when veneers were introduced as conservative, additive restorative procedures for which slight or no preparations were required.[9,10] Nevertheless, lack of clear-cut guidelines for technical procedures and for case selection has often led to confusion and misunderstandings.[11] Frequently, no-prep veneers, although ideally considered the best option because of tooth structure maximum preservation, were essentially criticized for some potential limitations including esthetic outcomes and periodontal complications as a consequence of overcontoured teeth that could alter the emergence profiles.[11,12]

Indeed, no-prep veneers could have biologically healthy and optically beautiful margins and emergence profiles if properly selected and managed. Some interesting papers focused on no-prep veneers case selection process are available[13–16]; conversely clinical studies often do not provide enough technical information on clinical and laboratory perspectives.

In this article, a new protocol to optimize no-prep veneers restorations (called CH NO-PREP VENEERS) is presented. A key point of the proposed technique is to identify optimal margins' positions: margin is positioned in the point of maximum convexity of teeth, avoiding the over contouring of traditional no-prep veneers (Figure 1). Dental maximum convexity works as a natural finishing line for veneer. In this way, veneer cannot change dental profile after cementation.

2 | CASE SELECTION

For patients who visually may be aspirants for no-prep veneers rehabilitations, an additive-only wax-up should be prepared; a silicone matrix

The case for moderate "guided prep" indirect porcelain veneers in the anterior dentition. The pendulum of porcelain veneer preparations: from almost no-prep to over-prep to no-prep

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Effect of luting composite shrinkage and thermal loads on the stress distribution in porcelain laminate veneers

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Statement of problem. Cyclic thermal fatigue has demonstrated a significant influence of the thicknesses of luting composite and ceramic in crack propensity of porcelain laminates.
Purpose. This study was conducted to define potentially involved parameters for crack development in porcelain laminates bonded to teeth. Finite element modeling was used to evaluate the respective effects of luting composite shrinkage and significant thermal changes.
Material and methods. A buccolingual cross-section of a maxillary incisor was digitized and used as a template to generate a single 2-dimensional mesh, including all the different restorative designs. Luting composite shrinkage was simulated at a baseline temperature of 20°C. The effect of thermal loads from 20°C to 5°C and from 20°C to 50°C was assessed with and without preexisting composite shrinkage.
Results. Shrinkage of the luting composite alone generated important compressive forces on the ceramic, either at the restoration surface or interface. Compression intensity was related to geometry and ratio of thicknesses between the ceramic and luting composite (CER/CPR). Lower ratios produced higher compression forces in the ceramic. When thermal loads were combined to the composite shrinking forces, the stress pattern was significantly changed only for the experimental conditions with the lowest CER/CPR ratio. Temperature increase reduced compressive stresses and exacerbated tensile stresses. Thermal loads were simulated alone (situation of an "ideal nonshrinking" luting composite) and generated mainly tensile stresses in the ceramic, which intensity was again modulated by the CER/CPR ratio and the local geometry of composite and ceramic. Because of ceramic brittleness, these tensile forces were more detrimental than the high compression created by composite shrinkage alone. The stress pattern was not influenced by the incisal length of the veneer but rather by the facial thickness of ceramic. The worst record made with a shrinking luting agent (500 µm of luting composite, lowest CER/CPR ratio, 5°C) was much less harmful than the worst record made with a hypothetical "nonshrinking" luting material.
Conclusions. The ratio of the thickness of cement and luting composite appears to have a relevant influence on the stress distribution in porcelain laminates. Restorations that are too thin, combined with poor internal fit, resulted in higher stresses at both the surface and interface of the restoration. Because of its precompressed state given by composite shrinkage, ceramics performed better with regard to temperature-induced tensile forces. (J Prosthet Dent 1999;81:335-44.)

CLINICAL IMPLICATIONS

Because of the problem of enamel thickness and restorative material bulk, porcelain veneers represent a challenge for both the clinician and the dental technician. An ideal situation provides the restoration with a favorable configuration, namely, a high ceramic/composite ratio of thicknesses (CER/CPR > 3). This study demonstrated that this ratio appears to have a relevant influence on the stress distribution in porcelain laminates due to both the curing contraction of the luting composite and the thermal expansion coefficient mismatch of the restorative materials. Facial and cervical locations would be the most critical areas of the restoration if the ceramic was not overcontoured as a compensation for the insufficient space. When the porcelain is thinned to reproduce the natural contour of the tooth, only a good internal fit of the restoration (approximately 100 µm) will prevent the CER/CPR ratio to drop below a critical value.

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Esthetic Rehabilitation of Worn Anterior Teeth with Thin Porcelain Laminate Veneers

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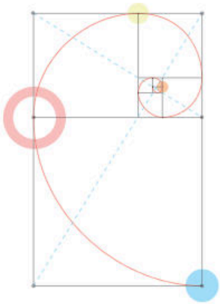

Revisiting the Design of Minimal and No-Preparation Veneers: A Step-by-Step Technique

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ABSTRACT The concept of minimal preparation is more than 25 years old. Interest in conservative treatments is being revisited as dentistry embraces thinner ceramic veneers and adhesive bonding agents that keep preparations in enamel. Experience and professional knowledge help determine appropriate treatments based on patients' clinical situations and esthetic demands. This article reviews the veneer modality, its role as a conservative treatment, and the protocol to be implemented to ensure proper treatment planning and material selection.

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Dentists and their patients today are increasingly exposed to marketing messages about no-preparation, thin, and minimal-preparation veneers. Some of this information may only be hype that is designed to entice patients into obtaining treatment or to motivate dentists to incorporate a new restorative material into their armamentarium. Regardless, the age of interest in conservative treatments and minimal intervention is being revisited and the public is demanding the preservation of their natural tooth structure.[1]

The concept of no preparation or minimal preparation is more than 25 years old.[1] Veneers were first introduced as an additive technique and designed as a conservative method of restoring teeth, providing an option other than full-coverage crowns.

In the early 1980s, Calamia introduced the innovative concept of bonding thin pieces of porcelain to teeth.[2] Treatments with this modality initially were done with no or little preparation, and with the veneers placed on the facial surface of the tooth.[3]

These original veneers were approximately 0.5 mm in thickness, tapering down to practically nothing at the margins. The newer, thin veneers available today claim thicknesses of less than 0.5 mm and can be fabricated down to a minimum thickness of 0.3 mm.[1]

Calamia and his colleagues later observed that with veneers placed without any preparation, the veneers were too thick and periodontal problems occurred as a result of the overcontoured teeth (i.e., change in emergence profile).[4] As a result, patients were notified of the need for diligent home care in order to preserve the health of gingival tissues.