Pedro Luis Acuña Alsina

SUCCESS OF DENTAL VENEERS ACCORDING TO PREPARATION DESIGN, CERAMIC MATERIAL AND ADHESIVE TECHNIQUE – A REVIEW

Universidade Fernando Pessoa
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Dissertation presented to Fernando Pessoa University
as part of the requirements to obtain the
degree of Master in Dentistry.
I declare the originality of the Dissertation,

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(Pedro Luis Acuña Alsina)

Porto, 2020

RESUMO

As facetas cerâmicas tornaram-se um procedimento restaurador conservador comum para os dentes anteriores, devido aos elevados resultados estéticos e à relativa previsibilidade a longo prazo. No entanto, a variedade nos desenhos de preparação dentária, nas técnicas de cimentação e nos tipos de materiais restauradores disponíveis, deixa o clínico num dilema quanto à sua utilização.

Esta revisão bibliográfica pretende centrar-se nos conceitos de diferentes desenhos de preparação, nos novos avanços no material cerâmico e implicações da técnica adesiva como fatores importantes relacionados com o sucesso clínico. Para isso foi executada uma pesquisa eletrónica nas bases de dados *PubMed* e *Cochrane Database*.

As facetas feldspáticas e as vidro-cerâmicas têm uma elevada taxa de sobrevivência. As fraturas e as descimentações são as complicações mais frequentes. No que respeita a estudos futuros, são necessários ensaios clínicos randomizados que visem avaliar de forma adequada os fatores envolvidos no sucesso a longo prazo.

Palavras-Chave: Facetas laminadas de porcelana; Arquitetura do preparo; Técnica adesiva; Cerâmica de vidro; Dissilicato de Lítio.

ABSTRACT

Laminate veneers have become a conservative common restorative procedure for anterior teeth, due to high aesthetics outcomes and a relative long-term predictability. However, the diverse preparation designs, cementation techniques and ceramic material types leave the clinician in a dilemma of which approach to use.

This literature review aims to focus on concepts of different preparation designs, new advances in ceramic materials and adhesive technique implications as an important factor related to clinical success. For this, an electronical research was made in PubMed and Cochrane Database.

Glass ceramics and feldspathic veneers have high survival rates. Fractures and debonding are the most frequent complications. With regard for future studies, more randomized clinical trial are needed to accurately assess the factors related to long term success.

Key-words: Porcelain laminate veneers; Preparation design; Adhesive bonding; Glass ceramic; Lithium disilicate.

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ACKNOWLEDGEMENTS

"The root of joy is gratefulness; it is not joy that makes us grateful; it is gratitude that makes is joyful."

Despite the immense challenge of starting a new life in Portugal by leaving my home behind and passing through a very unstable period in my life. Despite the global pandemic events of the past few months, I am grateful. These transitional moments are necessary because they are the preparation for a new growth as human beings, without them we simply do not evolve.

I am really thankful to my beloved wife, mother of my children and my life partner.

To my children for the moments of love they give me every day.

To my parents and sisters for helping me become who I am and be a part of my life.

To my parents in-laws for all the support.

And finally to Dra. Ligia Pereira da Silva for your willingness to always help me in this work.

I feel infinite gratitude to the creative universe that allows me to enjoy the simple things in life.

God Bless Us,

Namaste

TABLE INDEX

LIST OF ABBREVIATIONS

APT – Aesthetic Pre-Evaluative Technique

CAD/CAM – Computer-Aided Design/Computer-Aided Manufacturing

CQ – Camphorquinone

DC – Dual-Cured

DOC – Degree of Conversion

FDI – World Dental Federation

IC – Incisal Coverage

IDS – Immediate Dentin Sealing

LC – Light-cured

MH – Microhardness

mm – Millimeters

MPa – Megapascal

PLV – Porcelain Laminate Veneers

I. INTRODUCTION

An aesthetic smile and good dental appearance are related to self-confidence and success in many areas of life. Nowadays, there has been a steady increase in patients searching for aesthetic dental treatments. Due to their high aesthetic appeal, as well as their proven biocompatibility and long-term predictability, porcelain laminate veneers (PLV) have become a routine minimally invasive restorative procedure for treating the anterior sector. (Granell-Ruiz *et al.*, 2010)

The initial concepts for using tooth-colored shells on anterior teeth can be traced back to a California Dentist, Charles Leland Pincus (1938), who described this technique for the first time in the 1930s. Pincus worked in the US film industry improving the smiles of actors during films shootings. The durability of these first veneers, however, was limited to a few hours, since at that time neither reliable, well-fitting ceramic systems nor reliable adhesive bonding technologies were available. Ceramic veneers became a prominent feature by Dr Calamia, with the establishment of suitable etching processes for dental ceramics, and the use of bondi agents such as silane coupling agent. (Calamia *et al.*, 1983)

Despite the high rate of success above 90% in different clinical retrospective studies failures continue to appear. Some of the problems reported are fractures, debonding, discoloration, microleakage, secondary caries, hipersensivity and marginal stain. (Arif *et al.*, 2019) In 2007, The FDI (World Dental Federation) publishes a criteria for the evaluation of direct and indirect restorations applicable to PLV (Hickel *et al.*, 2010)

Due to the growing demand for this treatment, it is essential that the clinician keeps constantly updating techniques and studying the evolution of materials to be able to adapt treatment plans according to different clinical situations, and thus minimize possible failures. (Edelhoff *et al.*, 2018)

Given the controversy that still lingers around veneers, the aim of this literature review is to collect information in fundamental concepts of different preparations designs, new advances in ceramic materials and adhesive techniques' implications, in order to improve the decision criteria in future clinical practice.

Materials and Methods

Electronical research was made in PubMed and Cochrane Database, focusing in articles written in English and published between 2010 to 2020, using the following keywords in multiple combinations: "Dental Veneers", "Veneers AND Preparation designs", "Ceramic veneers", "Veneers AND Adhesive Technique", "Dental veneers AND Success", "Dental veneers AND Failure", "Lithium Disilicate veneers", "Feldspathic veneers", "Veneers AND Light Curing" and "Veneers AND Dual Curing".

A total of 56 articles that addressed the aim of this literature review were identified (Table 1). Articles that did not meet the study's objective were not included.

Table 1 – Article types included in the review

ARTICLE TYPE	NUMBER OF ARTICLES INCLUDED
Meta-analysis and Systematic Reviews	7
Randomized controlled trials	2
Cohort studies	10
Case control	5
Case reports	2
Expert opinion	1
Literature review	8
In vitro research	21

II. DEVELOPMENT

1. Preparation Designs applied to Veneers

According to the FDI the success of PLV is associated to aesthetics, functional and biological factors (Attachments – Figure 1). All of these factors must be controlled by the clinician, through a decision process related with the preparation design, selection of the ceramic material and the type of cement used in an individualized case. (Hickel *et al.*, 2010)

The teeth's preparation design greatly influences the durability of the ceramic restoration. Different opinions have been reported about superior preparation design over others. In fact, due to great materials' variety, preparations design and luting cement, favorable approaches to restore teeth with veneers have been controversial. While the design is governed by strict principles, these preparations can still be extremely flexible in shape, depending on the individual's clinical situation. (Alothman and Bamasoud, 2018)

i. Minimally Invasive Preparations and Enamel Preservation

Some features of preparation designs are highly recommended in the majority of the literature and laboratory studies. The preservation of enamel is a fundamental concept in veneers restorations, less tooth reduction means more adhesion and clinical longevity. (Gurel *et al.*, 2013) The bonding ability of enamel is higher than dentin due to enamel mineral content that provides a mechanical interlocking and a more stable bonding than with dentin. (Tuğcu *et al.*, 2018) In addition, the combination of rigid veneer and flexible dentin may be one reason for the fracture of PLV in long-term clinical use due to the lower modulus of elasticity of dentin. (Karagözoğlu, Toksavul and Toman, 2016)

The majority of cases restored with PLV do not require much tooth preparation but rather enamel recontouring. (Morita *et al.*, 2016) Nevertheless enamel preparation should be contemplated to avoid aprismatic surface of mature unprepared enamel, which is known to offer only a minor retention capacity. (Pini *et al.*, 2012) In the presence of severe discoloration, the preparation depth should be increased to mask the substrate. (Edelhoff *et al.*, 2018)

Preparations for PLV may be divided into three generations (Table 2). Actually, the Aesthetic Pre-Evaluative Temporary Technique (APT) with additive mock-up and silicone index take into account the final contour desired for the veneer resulting in considerably less invasive dental preparations. (Coachman *et al.*, 2014)

Table 2 – Preparations' Generations for Laminate Veneers (Coachman *et al.*, 2014)

GENERATIONS	CHARACTERISTICS
FIRST **Depth Guide Generation**	• Diamond burs of preestablished depths • Standardize measures for reduction • Non-individualized and aggressive preparation
SECOND **Silicone Index Generation**	• Diagnostic wax-up • Silicone Index • Free-hand performance
THIRD **Aesthetic Pre-Evaluate Method (APT)**	• Tooth volume increased • Veneer thickness • Mock up • Mathematic operation

ii. Incisal Coverage (IC)

Although incisal preparation design for ceramic veneers has been widely discussed, there is no consensus on whether incisal reduction is necessary and how much incisal overlap should be provided when an increase in incisal length is required. Not only that but the amount of incisal reduction varies widely from 0.5 millimeter (mm) to 2 mm. (Jordan, 2015)

Incisal preparation can be divided into two broad categories: overlap and nonoverlap. Four common incisal preparation designs that have been described, which are the window (or intraenamel), the feathered edge, the palatal chamfer (or overlapped) and the butt joint (or incisal bevel) (Attachments – Figure 2). 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. Some authors proposed that the type of incisal preparation (overlap or nonoverlap) depends on the buccolingual width of the incisal edge, aesthetic requirements, and the patient's occlusion. This may explain the heterogeneity of incisal preparation designs of ceramic veneers in clinical practice. (Chai *et al.*, 2018)

iii. Marginal and Interproximal designs

Ferrari, Patroni and Balleri (1992) reported the thickness of the enamel layer for 114 anterior teeth and showed that thicknesses in the cervical third of incisors range between 0.3 and 0.5 mm, tapering to zero at the cementoenamel junction. Dentin exposure is more common in cervical areas. In this case, the cementation procedure becomes even more critical because high failure rates in veneers have been associated to large exposed dentin surfaces and the cervical margin has been regarded as a problematic area to achieve perfect marginal adaptation. (Karagözoğlu, Toksavul and Toman, 2016) One analysis indicated that porcelain veneers with margins in dentin or with dentin exposure were more likely to fail than those completely bonded to enamel. (Gurel *et al.*, 2013) Ultraconservative cervical reduction between 0.1 and 0.2 mm should be considered; this would typically preserve between 0.1 and 0.3 mm of cervical enamel thickness. However, this is a demanding clinical technique, challenging the technician with respect to opacity management, shade management and the practicality of finishing such a thin delicate restoration. (Ge *et al.*, 2018)

It is recommended, when possible, that the location of the margin placement be at supragingival or equigingival level. A supragingival preparation margin offers numerous advantages such as maintenance of periodontal health, as it reduces subgingival preparation, overcontoured plaque buildup, and difficulty of cleaning; it also facilitates the molding work, as it can be performed without a gingival retraction cord. In addition, the cervical end is located in the enamel, guaranteeing greater longevity of adhesion, and the aesthetics is not compromised, as the resin cement mimics the ceramic-end-tooth transition. An intrasulcular preparation is suitable for more extensive morphologic changes, for closing interdental spaces such as "black triangles" or for covering exposed dentin/root cement or existing composite fillings. (Morita *et al.*, 2016)

An interproximal extension of the preparation can also be performed to varying degrees, depending on the initial situation and on the restorative objective. Interproximal approach can be divided by increasing levels of invasiveness: (1) Short-wrap design: extended only to the facial margin with a visible adhesive joint, (2) Medium-wrap design: retaining the contact point and with the adhesive joint not visible, penetrating 50% of interdental area, (3) Long-wrap design: removes the contact point, the veneer covers the interdental area (Attachments - Figure 3). (Edelhoff *et al.*, 2018)

While the less invasive, simple, and quick to implement short-wrap design leaves the preparation margins in the visible area, the more frequently employed medium-wrap design hides the preparation margins in the interproximal niches, but stays clear of the contact points. Retaining the contact points results in the width of the existing tooth being preserved, limiting the possibility of altering the tooth length to match the desired width-to-length ratio. (Magne, Gallucci and Belser, 2003) The long-wrap design is significantly more invasive because it opens the contact points. On the other hand, it offers the restorative team considerably more options when it comes to veneer shapes and positions. (Edelhoff *et al.*, 2018)

2. Ceramic Materials

Parisian dentist, Nicholas Dubois de Chemant, introduced ceramics to dentistry, working in combination with a new high-technology porcelain manufacturer in 1774, creating a complete set of porcelain dentures. In the midst of 20th century the evolution was remarkable with the introduction of new ceramic materials and processing technologies as the development of the vacuum firing technology in 1949, the invention of the high-speed handpiece, the discovery of elastomeric impression materials, and the advent of pressing and Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) technologies in the 1980s (Attachments – Figure 4). (Zhang and Kelly, 2017)

Dental ceramics are widely used for aesthetic restorative treatments owing to their desirable characteristics: color stability, translucency, toothlike optical properties, mechanical resistance, durability and compatibility with periodontal tissue. (Marchionatti *et al.*, 2017) They can be classified according to their matrix material, filler and dopant. Three main categories of dental ceramics have been described in the literature:

predominantly glass (feldspathic/porcelain), particle-filled glass (low and intermediate fill) and polycrystalline ceramics (nonglass). (Vargas, Bergeron and Diaz-Arnold, 2011)

Feldspathic, leucite-reinforced and lithium disilicate glass ceramics present a combination of vitreous and crystalline phases and are commonly selected for veneers because of their optical properties and good adhesion to tooth structure due to be acid-sensitive. (Da Cunha *et al.*, 2014) These ceramics can vary from being very translucent to very opaque. The glassier the microstructure, the more translucent the ceramic will appear; on the other side, the more crystalline, the more opaque. (Pini *et al.*, 2012) Clinical studies have shown highly satisfactory long-term results f. (Petridis *et al.*, 2012)

Surface treatments (etching with hydrofluoric acid) provides an increased surface area, micromechanical retention and a clean surface for adhesive cementation. Application of silane over the etched surface increases the wettability of the resin cement to interact chemically with both the resin matrix and the hydroxylated porcelain surface. Both etching and silanization are recommended. (Vargas, Bergeron and Diaz-Arnold, 2011)

With technological improvement and evolution of dental restorative materials, it is currently possible to produce ultra-thin veneers (thicknesses of 0.1–0.3mm), adhesively cemented on the tooth surface with minimal or no preparation. (Souza *et al.*, 2018)

i. Feldspathic (Predominant Glass Ceramics)

Dental ceramics that best mimic the optical properties of natural teeth are predominantly glassy materials, which derive principally from feldspar-quartz-kaolin triaxial porcelain compositions. It is also known as Porcelain, and it was the first type of ceramic to be used for Dentistry in the 1980s because of its high translucency and ability to provide the "contact lens effect". (Morimoto *et al.*, 2016) Feldspars are primarily composed of silicon oxide (60-64%) and aluminum oxide (20-23%) and are typically modified in different ways to create glass that can then be used in dental restorations. (Zhang and Kelly, 2017)

However, while feldspathic porcelain shows the most desirable aesthetics it also tends to have the lowest mechanical properties, with flexural strength usually from 60 to 70 megapascal (MPa). Due to the nature of glass matrix materials and the absence of core material, veneering porcelains are more susceptible to fracture under mechanical stress. With this material, it is possible to have a thickness of less than 0.5 mm, with or without preparation in enamel. (Pini *et al.*, 2012) Masking heavy discolored teeth can be difficult because porcelain is very translucent. Moreover, it was reported that etching the inner surface of porcelain can cause micro-cracks which can lead to a decrease in its flexural strength and eventually fracture the veneer. (Alothman and Bamasoud, 2018)

ii. Glass Ceramics (Particle Fill Glass)

These materials consist of various amounts and types of particles and a glassy matrix. The inclusion of particles improves the ceramic's physical and mechanical strength, including increased fracture resistance, improved thermal shock resistance and resistance to erosion. As the number of particles increases and the amount of glass decreases, the material's strength increases, but unfortunately some of the translucency and aesthetic properties are diminished. Properties' improvement depends on the crystals' interaction, as well as on the size and amount of crystals. Finer crystals generally produce stronger materials. (Vargas, Bergeron and Diaz-Arnold, 2011) Different fillers are used dispersed throughout the glass, such as aluminum, magnesium, zirconia, leucite, and lithium disilicate. For aesthetic veneers, ceramics reinforced by leucite and lithium disilicate are commonly indicated. (Pascotto *et al.*, 2012)

iii. Leucite Reinforce

The first filler to be used in dental ceramics contained particles of a crystalline mineral called leucite. It is considered a low filled ceramic; their physical strength (164 MPa) is relatively low in comparison with that of other filled glass materials. Leucite can be incorporated without significantly compromising its translucency because the refractive index of leucite is close to that of feldspar, upholding as some of the most aesthetics ceramics. Leucite etches at a much faster rate than the base glass. It is this "selective etching" that creates a myriad of tiny features for resin cements to enter, creating a good micromechanical bond. (Zhang and Kelly, 2017)

iv. Lithium Disilicate

The first dental lithium disilicate ceramic was fabricated from a base glass composition plus some additives for color and fluorescence. It is considered an intermediate filled ceramic and a true glass ceramic with the crystal content increased to approximately 70%. It possesses a flexural strength of 350 MPa and fracture toughness of 2.9 MPa, which were more than twice those of leucite-based glass-ceramics. This material is translucent enough that it can be used for full-contour restorations or for the highest aesthetics and can be veneered with special porcelain. (Pascotto *et al.*, 2012)

3. Adhesive technique

The clinical success of porcelain veneers has been attributed to a durable bond between two materials of similar elastic moduli, that is, porcelain and enamel. (Ge *et al.*, 2018) Since retention of PLV restorations does not rely on mechanical retention principles, durable adhesive luting is crucial for long-term clinical success. (Gresnigt *et al.*, 2017)

i. Resin Cements, Degree of conversion and Marginal Adaptation

Resin-based cements are the most commonly used materials for luting dental veneers, mainly because of their physicochemical properties as low solubility, good aesthetics, and proper bond strength to both tooth substrate and restorative materials. (Novais *et al.*, 2017) These materials can be classified according to their activation modes, since the activation can be chemical (auto-cured), physical (Light-cured – LC) or a combination of both (dual-cured – DC). When restoration thickness is above 1.5-2 mm or its opacity hinders light transmission, the use of dual or chemically cured resin cements has been advocated to attain proper polymerization of resin cements. (de Lopes *et al.*, 2015)

Clinically, there is a preference for LC cements due to a thin cementation line, along with high fluidity and excellent flow grade, facilitating the removal of excess cement. (RK *et al.*, 2016) LC cements are less susceptible to oxidation processes because their aliphatic amines' component results in higher color stability. (Marchionatti *et al.*, 2017)

Inadequate polymerization, characterized by low degree of conversion (DOC), decreases the mechanical properties of cement and increases water sorption and solubility. Furthermore, it was shown that increased amount of residual monomers may cause pulp irritation and irreversible pulpitis. Insufficient DOC can negatively affect mechanical properties, alter dimensional stability and decrease the bonding of resin cements to tooth structures, impairing restorations' clinical longevity. (de Lopes *et al.*, 2015)

The type of ceramics (crystalline structure, size of particles), their thickness, shade (color saturation, pigments), and translucency are factors related to ceramics that can affect the light curing process. Other aspects that affect resin polymerization are the composition and mode of activation of resin cement, as well as the curing light output power, setting time and distance. (Runnacles *et al.*, 2014) Glass ceramic systems, feldspathic, leucite and lithium disilicate systems present translucency that allows light transmission through the restoration to underlying tooth structure. (de Lopes *et al.*, 2015)

Marginal discrepancies can result in undue exposure of luting material to oral fluids, passage of bacteria, molecules or ions between tooth structure and the cemented restoration. (Lin *et al.*, 2012) A non-uniform cement layer can lead to microleakages and this has been associated with complications such as secondary caries, post-operative sensitivity, pulpal inflammation, staining and plaque accumulation. (Ibarra *et al.*, 2007)

ii. Color Stability and Masking Ability

Current LC resin-based composite materials may contain type I and/or II photo-initiators. As a type II photoinitiator, camphorquinone (CQ) requires a co-initiator, such as tertiary amines, to react and create free radicals responsible for initiating photopolymerization. These amines can produce conjugated systems known as color centers or chromosphores, causing a yellowing effect and color discrepancies over time. Type I photoinitiator systems ("amine free"), such as phenylbis (2,4,6-trimethylbenzoyl) phosphin oxide and Ivocerin (germanium-based photoinitiator), have been suggested as alternatives to CQ in dental resin-based materials. These type I photo-initiators do not require an amine-based co-initiator, reducing yellowing over time. (Castellanos *et al.*, 2019) The staining of resin cement may be caused by intrinsic (filler content, material composition or type of activation) and extrinsic factors (sorption of media, stains caused by beverages and food components). Resin materials composed with smaller fillers showed improved color stability. (Espíndola-Castro *et al*., 2020)

Shade matching and masking the color of dark underlying tooth structure are common challenging issues. The color of the tooth/substrate, the thickness and type of ceramic material used and the shade of resin cement selected are all contributing factors that affect the aesthetic outcome of PLV. (Begum *et al.*, 2014)

iii. Immediate Dentine Sealing (IDS)

IDS protocol has been proposed as an effective technique for sealing dentinal tubules in order to prevent or reduce bacterial contamination and tooth sensitivity during the provisionalization phase, while also enhancing the bond strength of the final restoration. The principle of dentin bonding is to create an interphase, also called the hybrid layer, by the interpenetration of monomers into the hard tissues. (Qanungo *et al.*, 2016)

III. DISCUSSION

Concerns related to factors associated with dental veneers' success are rapidly growing. The preparation and design specifications have been recognized as factors affecting the longevity of PLV. Various studies have discussed the effect of preparation designs on veneers' survival comparing clinical cases with and without IC. Some studies reported no statistically significant difference in survival rates between veneers with and without IC, whereas some studies revealed significantly more failures in veneers with coverage compared to those without. Thus, controversy exists and there is no consensus regarding the most indicated preparation design, with or without IC, and the type of palatal design (butt joint or palatal chamfer). (Hong *et al.*, 2017)

Smales and Etemadi (2004) considered IC a protective factor, enhancing restoration survival, improving incisal-edge aesthetics and providing adequate seating for the restoration. In addition, IC can diminish the occurrence of crack lines and fractures on the palatal side, because it provides the restoration with a stronger bulk of porcelain. (Schmidt *et al.*, 2011) On the other hand, Granell-Ruiz *et al.* and Gurel *et al.* reported IC to be a risk factor for failures. Gurel affirmed that IC increased the chance of ceramic laminate veneer failure by 2.3 times. (Granell-Ruiz *et al.*, 2010 and Gurel *et al.*, 2013)

Meta-analysis of a in vitro studies by da Costa *et al.* showed that butt joint incisal preparation design may be more favorable compared with the palatal chamfer design in terms of ceramic fracture and frequency of tooth failure. (da Costa *et al.,* 2013)

Hong *et al.* in a systematic review and metanalysis of clinical studies indicate that preparations with IC exhibit an increased failure risk compared to those without. (Hong *et al.*, 2017) In contrast, Albanesi *et al.* concluded that there was no statistically significant difference between preparations with or without IC. (Albanesi *et al.*, 2016)

Clinical evidence does not show superiority of one incisal preparation design over the other. Randomized longitudinal controlled trials with large study samples are required to show any difference in clinical survival rates and complication rates of ceramic veneers with different preparation designs. This has proved to be challenging in most studies with the difficulty of standardizing patients (age, health, diet), occlusion, the dynamic of intraoral environment, quality of bonding, bonded tooth substrate (enamel versus dentin), tooth vitality and conducting a long-term clinical trial. (Chai *et al.*, 2018)

Many studies investigated the longevity of porcelain veneers. Morimoto *et al.* reported high overall cumulative survival rates for glass ceramic and feldspathic porcelain veneers (89%) in a median follow-up period of 9 years. The estimated survival for glass ceramic was 94% and for feldspathic porcelain 87%. (Morimoto *et al.*, 2016) Aslan, Uludamar and Özkan reported the probability of survival of 413 veneers was 98% after 5 years, 95% at 10 years, 91% at 15, and 87% at 20 years, indicating a very low clinical failure rate. (Aslan, Uludamar and Özkan, 2019) A randomized clinical trial done by Layton and Walton showed similar results, with a survival rate of 96% after 10 years and 91% after 20 years. (Layton and Walton, 2012)

There are other studies which reported a lower survival rate for porcelain veneers. A retrospective study of 2,563 veneers in 1,177 patients done by Burke and Lucarotti reported a survival rate of 53% over 10 years. The material type of the veneers was not reported. Moreover, the study evaluated veneers that were done by general dental service, and thus, it is possible that preparations of teeth did not meet the criteria of specialists' level. (Burke and Lucarotti, 2009) Another retrospective study, done by Shaini, Shortall and Marquis (1997), reported a survival rate of 47% in 7 years. The veneers were done by undergraduate students and staff members at Birmingham University (United Kingdom). The study reported that over 90% of veneers were placed on unprepared teeth, which can be a reason for high failure rate as it is suggested that the bond to aprismatic enamel is much weaker than prepared enamel. (Perdigao and Geraldeli, 2003)

Friedman, in a 15-year clinical observation of 3,500 ceramic veneers, found that most clinical failures (more than 67%) were from veneer fracture. (Friedman, 1998) A dramatic increase in the number of fractures from 5 years (4%) to 10 years (34%) was observed in a prospective 10-year clinical trial by Peumans *et al*. (2004).

Expert opinions have attributed failure to exposed dentin. Exposed dentin is considered undesirable because bonding to dentin is less predictable. Gurel *et al*. carried a longitudinal study, with a 12-year follow-up, in which ceramic veneers were cemented on enamel and showed significantly higher clinical longevity than those cemented on dentin, with success rates of 98.7% and 68.1%, respectively. (Gurel *et al.*, 2013)

Referring at ceramic materials, Petridis *et al*. in a systematic review and metanalysis on survival of ceramic veneers made of different materials found no statistically significant difference between feldspathic and glass-ceramic materials. (Petridis *et al.*, 2012) Layton, Clarke and Walton report estimated cumulative survival for feldspathic veneers to be 95.7% at 5 years, when bonded to enamel substrate. (Layton, Clarke and Walton, 2012)

New advances in ceramic materials are promising for the future of veneers. Recently, highly translucent zirconia ceramics have been developed to improve the material's opaqueness. Its main difficulty are in situations of little mechanical retention of preparation since polycrystalline zirconia is chemically inert and cannot be etched by hydrofluoric acid (4–10%), which implies a less effective adhesion when compared to silica-based ceramics (acid-sensitive). (Kusaba *et al.*, 2018)

Adequate polymerization is crucial in determining the longevity of resin bonded ceramic restorations. LC and DC resin cements are directly affected by the thickness of the restoration. Martins, Vasques and Fonseca evaluated the influence of thickness in LC process and DOC. Specimens of 0.5 mm did not present statistical differences related to the control group, and for specimens of 1.0, 1.5, 2.0 and 3.0 mm, there was a statistical difference showing evidence that the thickness of the ceramic material interfered in the resin's cement DOC. (Martins, Vasques and Fonseca, 2019)

Results obtained in many studies showed that the thinner the ceramic material interposed between the resin cement and the light source, the higher the DOC. As expected, increased ceramic thickness resulted in greater loss of irradiance. It has been observed that a thickness greater than 1.0 mm drastically reduces the DOC of DC or LC resins. However, in most cases the thickness of porcelain veneers is approximately 0.3 to 0.9 mm. (Martins, Vasques and Fonseca, 2019)

Soares, da Silva e Fonseca showed that the effect of ceramic restorations' shade was less significant than its thickness when they compared among different shades (A1, A2, A3, A3 and A3.5) and different thicknesses (0, 1, 2 and 4 mm). (Soares, da Silva e Fonseca, 2006)

Some studies have evaluated whether the curing modality of the resin cement influenced the results of DOC. A decreased DOC and microhardness (MH) for the DC resin group with an increase of ceramic thicknesses is consistent in some studies. (Cho *et al.*, 2015) Meng, Yoshida and Atsuta demonstrated that ceramic thickness had a significant effect on hardness of DC resin cements, especially when ceramic thickness was more than 4 mm. They also mentioned that the auto-cure components of DC resin cements did not produce significant compensation with regards to mechanical properties when LC is diminished with greater ceramic thicknesses and that polymer structure of the DC resin cements mainly depended on the intensity of light irradiation. (Meng, Yoshida and Atsuta, 2008)

Novais *et al.* found higher DOC and bond strength values in DC resin cements over ceramic of 1.0 mm thick. (Novais *et al.*, 2017) Scotti *et al.* and Hoorizad *et al.* reported similar polymerization levels and comparable DOC for LC and DC cements in 1.5 mm ceramic thickness. (Scotti *et al.*, 2016 and Hoorizad *et al.*, 2017) For Cho *et al.* the DC resin cement resulted in a significantly lower DOC and MH values for 1.2 mm thickness.

(Cho *et al.*, 2015) Martins, Vasques and Fonseca found that LC cements produced a significantly higher DOC than DC cements. (Martins, Vasques and Fonseca, 2019)

The color stability of the luting agents influences the aesthetic result of ceramic restorations, which is a determinant of long-term success. In vitro studies have indicated that DC resin cements undergo greater color alteration than LC cements, which is usually attributed to the oxidation of aromatic tertiary amines present on the DC cements. (Marchionatti *et al.*, 2017)

According to Marchionatti *et al.* the color stability of ceramic laminate veneers was similar for both the polymerizing modes. At 24 months, 40% and 20% of restorations presented unacceptable color changes for LC and DC modes, respectively. Marginal discoloration was observed from 1 year. At 24 months, 40% and 30% of veneers presented slight marginal discoloration for LC and DC modes, respectively. (Marchionatti *et al.*, 2017). Evaluating alternative photoinitiators, Castellanos *et al.* concluded that resin cements significantly change color over time, regardless of the photoinitiator. (Castellanos *et al.*, 2019)

IV. CONCLUSIONS

Ceramic laminate veneer restorations offer a reliable and effective conservative treatment option for enhancing the aesthetics of anterior teeth based on the high survival rate found for both porcelains and glass-ceramics.

With regard to research implications for future studies, it proves necessary to conduct more randomized prospective clinical studies, with comparison of techniques, cavity preparations, and materials, greater details about samples, link to censorship and drop outs and, furthermore, separate assessment of success and survival rates.

If the practitioner pays close attention to details and indications are carefully observed, the relative few difficulties that have been encountered may be circumvented and the prospects for long-term success are very high.

V. BIBLIOGRAPHY

Albanesi, R. B. *et al.* (2016). Incisal coverage or not in ceramic laminate veneers: A systematic review and meta-analysis. *Journal of Dentistry*. Elsevier Ltd, pp. 1–7.

Alothman, Y. and Bamasoud, M. S. (2018). The success of dental veneers according to preparation design and material type. *Open Access Macedonian Journal of Medical Sciences*. Open Access Macedonian Journal of Medical Sciences, pp. 2402–2408.

Arif, R. *et al.* (2019). Retrospective evaluation of the clinical performance and longevity of porcelain laminate veneers 7 to 14 years after cementation. *Journal of Prosthetic Dentistry*. Mosby Inc., 122(1), pp. 31–37.

Aslan, Y. U., Uludamar, A. and Özkan, Y. (2019). Clinical performance of pressable glass-ceramic veneers after 5, 10, 15, and 20 years: A retrospective case series study. *Journal of Esthetic and Restorative Dentistry*. Blackwell Publishing Ltd, 31(5), pp. 415–422.

Begum, Z. *et al.* (2014). Effect of Ceramic Thickness and Luting Agent Shade on the Color Masking Ability of Laminate Veneers. *Journal of Indian Prosthodontist Society*. Springer India, 14, pp. 46–50.

Burke, F. J. T. and Lucarotti, P. S. K. (2009). Ten-year outcome of porcelain laminate veneers placed within the general dental services in England and Wales. *Journal of Dentistry*. J Dent, 37(1), pp. 31–38.

Calamia, J. *et al*. (1983). Etched porcelain facial veneers: a new treatment modality based on scientific and clinical evidence*. The New York Journal of Dentistry*. 53(6), pp. 255-259.

Castellanos, M. *et al.* (2019). Effect of Thickness of Ceramic Veneers on Color Stability and Bond Strength of Resin Luting Cements Containing Alternative Photoinitiators. *The Journal of Adhesive Dentistry*. 21(1), pp. 67–76.

Chai, S. *et al.* (2018). Incisal preparation design for ceramic veneers: A critical review. *Journal of the American Dental Association*, 149(1), pp. 25–37.

Cho, S. H. *et al.* (2015). Effect of Different Thicknesses of Pressable Ceramic Veneers on Polymerization of Light-cured and Dual-cured Resin Cements. *The Journal of Contemporary Dental Practice*, 16(5), pp. 347–352.

Coachman, C. *et al.* (2014). The Influence of Tooth Color on Preparation Design for Laminate Veneers from a Minimally Invasive Perspective: Case Report. *International Journal of Periodontics & Restorative Dentistry*. Quintessence Publishing, 34(4), pp. 453–459.

da Costa, D. C. *et al.* (2013). A meta-analysis of the most indicated preparation design for porcelain laminate veneers. *Journal of Adhesive Dentistry*, 15(3), pp. 215–220.

Da Cunha, L. F. *et al.* (2014). Esthetic, occlusal, and periodontal rehabilitation of anterior teeth with minimum thickness porcelain laminate veneers. *Journal of Prosthetic Dentistry*. Mosby Inc., 112(6), pp. 1315–1318.

de Lopes, C. de C. A. *et al*. (2015). Degree of conversion and mechanical properties of resin cements cured through different all-ceramic systems. *Brazilian Dental Journal*. Associacao Brasileira de Divulgacao Cientifica, 26(5), pp. 484–489.

Edelhoff, D. *et al.* (2018). Anterior restorations: The performance of ceramic veneers. *Quintessence International*, 49(2), pp. 89–101.

Espíndola-Castro, L. F. *et al.* (2020). In Vitro Evaluation of Physical and Mechanical Properties of Light-Curing Resin Cement: A Comparative Study. *European Journal of Dentistry*. Georg Thieme Verlag, 14(1), pp. 152–156.

Ferrari, M., Patroni, S. and Balleri, P. (1992). Measurement of enamel thickness in relation to reduction for etched laminate veneers. *International Journal of Periodontics and Restorative Dentistry*. 12(5), pp. 407-413.

Friedman, M. (1998). A 15-year review of porcelain veneer failure--a clinician's observations. *Compendium of Continuing Education in Dentistry*. 19(6), pp. 625-638.

Ge, C. *et al.* (2018). Effect of tooth substrate and porcelain thickness on porcelain veneer failure loads in vitro. *Journal of Prosthetic Dentistry*. Mosby Inc., 120(1), pp. 85–91.

Granell-Ruiz, M. *et al.* (2010). A clinical longitudinal study 323 porcelain laminate veneers. Period of study from 3 to 11 years. *Medicina Oral, Patologia Oral y Cirugia Bucal*, 15(3).

Gresnigt, M. M. M. *et al.* (2017). Effect of luting agent on the load to failure and accelerated-fatigue resistance of lithium disilicate laminate veneers. *Dental Materials*. Elsevier Inc., 33(12), pp. 1392–1401.

Gurel, G. *et al.* (2013). Influence of Enamel Preservation on Failures Rates of Porcelain Laminate Veneers. *The International Journal of Periodontics and Restorative Dentistry*. Quintessence Publishing, 33(1), pp. 31–39.

Hickel, R. *et al.* (2010). FDI World Dental Federation: Clinical criteria for the evaluation of direct and indirect restorations-update and clinical examples. *Clinical Oral Investigations*, 14(4), pp. 349–366.

Hong, N. *et al.* (2017). Effect of preparation designs on the prognosis of porcelain laminate veneers: A systematic review and meta-analysis. *Operative Dentistry*. Indiana University School of Dentistry, pp. E197–E213.

Hoorizad, G. *et al*. (2017) Evaluation of the Effect of Porcelain Laminate Thickness on Degree of Conversion of Light Cure and Dual Cure Resin Cements Using FTIR. *Journal of Dentistry (Shiraz University)*. 18(1), pp. 30-36.

Ibarra, G. *et al.* (2007). Microleakage of porcelain veneer restorations bonded to enamel and dentin with a new self-adhesive resin-based dental cement. *Dental Materials*, 23(2), pp. 218–225.

Jordan, A. (2015). Clinical aspects of porcelain laminate veneers: considerations in treatment planning and preparation design. *Journal of California Dental Association*. 43(4), pp 199-202.

Karagözoğlu, I., Toksavul, S. and Toman, M. (2016). 3D quantification of clinical marginal and internal gap of porcelain laminate veneers with minimal and without tooth preparation and 2-year clinical evaluation. *Quintessence International*. Quintessence Int, 47(6), pp. 461–471.

Kusaba, K. *et al*. (2018). Effect of preparation design on marginal and internal adaptation of translucent zirconia laminate veneers. *European Journal of Oral Sciences*. Blackwell Munksgaard, 126(6), pp. 507–511.

Layton, D., Clarke, M. and Walton, T. (2012) A systematic review and meta-analysis of the survival of feldspathic porcelain veneers over 5 and 10 years. *International Journal of Prosthodontist*. 25(6), pp. 590-603.

Layton, D. and Walton, T. (2012). The up to 21-year clinical outcome and survival of feldspathic porcelain veneers: accounting for clustering. *International Journal of Prosthodontist*. 25(6), pp. 604-612.

Lin, T. M. *et al.* (2012). Fracture resistance and marginal discrepancy of porcelain laminate veneers influenced by preparation design and restorative material in vitro. *Journal of Dentistry*, 40(3), pp. 202–209.

Magne, P., Gallucci, G. and Belser, U. (2003). Anatomic crown width/length ratios of unworn and worn maxillary teeth in white subjects. *Journal of Prosthetic Dentistry*. Mosby Inc., 89(5), pp. 453–461.

Marchionatti, A. M. E. *et al.* (2017). Color stability of ceramic laminate veneers cemented with light-polymerizing and dual-polymerizing luting agent: A split-mouth randomized clinical trial. *Journal of Prosthetic Dentistry*. Mosby Inc., 118(5), pp. 604–610.

Martins, F. V., Vasques, W. F. and Fonseca, E. M. (2019). How the Variations of the Thickness in Ceramic Restorations of Lithium Disilicate and the Use of Different Photopolymerizers Influence the Degree of Conversion of the Resin Cements: A Systematic Review and Meta-Analysis. *Journal of Prosthodontics*. Blackwell Publishing Inc., 28(1), pp. e395–e403.

Meng, X., Yoshida, K. and Atsuta, M. (2006). Hardness development of dual-cured resin cements through different thicknesses of ceramics. *Dental Materials Journal*, 25(1), pp. 132–137.

Meng, X., Yoshida, K. and Atsuta, M. (2008). Influence of ceramic thickness on mechanical properties and polymer structure of dual-cured resin luting agents. *Dental Materials*, 24(5), pp. 594–599.

Morimoto, S. *et al.* (2016). Main Clinical Outcomes of Feldspathic Porcelain and Glass-Ceramic Laminate Veneers: A Systematic Review and Meta-Analysis of Survival and Complication Rates. *The International Journal of Prosthodontics*. Quintessence Publishing, 29(1), pp. 38–49.

Morita, R. et al (2016). Minimally Invasive Laminate Veneers: Clinical Aspects in Treatment Planning and Cementation Procedures. *Case Report Dentistry*. Article ID:1839793.

Novais, V. *et al.* (2017). Degree of conversion and bond strength of resin-cements to feldspathic ceramic using different curing modes. *Journal of Applied Oral Science*. Faculdade de Odontologia de Bauru, 25(1), pp. 61–68.

Perdigao, J. and Geraldeli, S. (2003). Bonding Characteristics of Self-etching Adhesives to Intact versus Prepared Enamel. *Journal of Esthetic and Restorative Dentistry*. Wiley, 15(1), pp. 32–42.

Petridis, H. *et al.* (2012). Survival of ceramic veneers made of different materials after a minimum follow-up period of five years: a systematic review and meta-analysis. *European Journal of Esthetics Dentistry*. 7(2), pp.138-152.

Peumans, M. *et al*. (2004). A prospective ten-year clinical trial of porcelain veneers. *Journal of Adhesion Dentistry*. 6(1), pp. 65-76.

Pincus, C. (1938) Building mouth personality. *Journal of California Dental Association* 14, pp 125–129

Pini, N. *et al*. (2012). Advances in dental veneers: materials, applications, and techniques. Clinical, Cosmetic and Investigational Dentistry. *Dove Medical Press Ltd*., 4, p. 9.

Qanungo, A. *et al.* (2016). Immediate dentin sealing for indirect bonded restorations. *Journal of Prosthodontic Research*. Elsevier Ltd, pp. 240–249.

Runnacles, P. *et al.* (2014). Degree of conversion of a resin cement light-cured through ceramic veneers of different thicknesses and types. *Brazilian Dental Journal*. Associacao Brasileira de Divulgacao Cientifica, 25(1), pp. 38–42.

Schmidt, K. K. *et al.* (2011). Influence of preparation design and existing condition of tooth structure on load to failure of ceramic laminate veneers. *Journal of Prosthetic Dentistry,* 105(6), pp. 374–382.

Scotti, N. *et al.* (2016). Effect of Lithium Disilicate Veneers of Different Thickness on the Degree of Conversion and Microhardness of a Light-Curing and a Dual-Curing Cement. *The International Journal of Prosthodontics*. Quintessence Publishing, 29(4), pp. 384–388.

Shaini, F. J., Shortall, A. C. C. and Marquis, P. M. (1997). Clinical performance of porcelain laminate veneers. A retrospective evaluation over a period of 6.5 years. *Journal of Oral Rehabilitation*. Wiley-Blackwell, 24(8), pp. 553–559.

Smales, R. J. and Etemadi, S. (2004). Long-term survival of porcelain laminate veneers using two preparation designs: a retrospective study. *Internation Journal of Prosthodontics*. 17(3), pp. 323-326.

Soares, C. J, Da Silva, N. R. and Fonseca, R. B. (2006). Influence of the feldspathic ceramic thickness and shade on the microhardness of dual resin cement. *Operative Dentistry*. Indiana University School of Dentistry, 31(3), pp. 384–389.

Souza, R. *et al.* (2018). Ultrathin monolithic zirconia veneers: Reality or future? report of a clinical case and one-year follow-up. *Operative Dentistry*. Indiana University School of Dentistry, 43(1), pp. 3–11.

Tuğcu, E. *et al.* (2018). Marginal Adaptation and Fracture Resistance of Lithium Disilicate Laminate Veneers on Teeth with Different Preparation Depths. *The International Journal of Periodontics & Restorative Dentistry*. Quintessence Publishing, 38(Suppl), pp. s87–s95.

Vargas, M. A., Bergeron, C. and Diaz-Arnold, A. (2011). Cementing all-ceramic restorations: Recommendations for success. *Journal of the American Dental Association*. American Dental Association, 142, pp. 20S-24S.

Zhang, Y. and Kelly, J. R. (2017). Dental Ceramics for Restoration and Metal Veneering. *Dental Clinics of North America*. W.B. Saunders, pp. 797–819.

VI. ATTACHMENTS

Figure 1: FDI (World Dental Federation): Clinical criteria for the evaluation of direct and indirect restorations applicable to veneers (Hickel *et al.*, 2010).

			Score				
			1	2	3	4	5
			Clinically excellent/ very good	Clinically good	Clinically sufficient/ satisfactory	Clinically unsatisfactory	Clinically poor
A. Esthetic properties.	1. Surface luster.		1.1 Luster comparable to enamel.	1.2.1 Slightly dull, not noticeable from speaking distance. 1.2.2 Some isolated pores.	1.3.1 Dull surface but acceptable if covered with film of saliva. 1.3.2 Multiple pores on more than one third of the surface.	1.4.1 Rough surface, cannot be masked by saliva film, simple polishing is not sufficient. Further intervention necessary. 1.4.2 Voids.	1.5 Very rough, unacceptable plaque, retentive surface.
	2. Staining.	a. Surface.	2a.1 No surface staining.	2a.2 Minor surface staining, easily removable by polishing.	2a.3 Moderate surface staining that may also present on other teeth, not esthetically unacceptable.	2a.4 Unacceptable surface staining on the restoration and major intervention necessary for improvement.	2a.5 Severe surface staining and/or subsurface staining, generalized or localized, not accessible for intervention.
		b. Margin.	2b.1 No marginal staining.	2b.2 Minor marginal staining, easily removable by polishing.	2b.3 Moderate marginal staining, not esthetically unacceptable.	2b.4 Pronounced marginal staining; major intervention necessary for improvement.	2b.5 Deep marginal staining, not accessible for intervention.
	3. Color match and translucency.		3.1 Good color match, no difference in shade and/or translucency.	3.2 Minor deviations in shade and/or translucency.	3.3 Distinct deviation but acceptable. Does not affect esthetics: 3.3.1 more opaque; 3.3.2 more translucent; 3.3.3 darker; 3.3.4 brighter.	3.4 Localized deviation that can be corrected by repair: 3.4.1 too opaque; 3.4.2 too translucent; 3.4.3 too dark; 3.4.4 too bright.	3.5 Unacceptable. Replacement necessary.
	4. Esthetic anatomical form.		4.1 Form is ideal.	4.2 Form is only slightly deviated from the norm.	4.3 Form deviates from the norm but is esthetically acceptable.	4.4. Form is affected and unacceptable esthetically. Intervention/correction is necessary.	4.5 Form is unsatisfactory and/or lost. Repair not feasible/ reasonable. Replacement needed.
B. Functional properties.	5. Fracture of material and retention.		5.1 No fractures/cracks.	5.2 Small hairline crack.	5.3 Two or more or larger hairline cracks and/or material chip fracture not affecting the marginal integrity or approximal contact.	5.4.1 Material chip fractures which damage marginal quality or approximal contacts. 5.4.2 Bulk fractures with partial loss (less than half of the restoration).	5.5 (Partial or complete) loss of restoration or multiple fractures.
	6. Marginal adaptation.		6.1 Harmonious outline, no gaps, no white or discolored lines.	6.2.1 Marginal gap (< 150 µm), white lines. 6.2.2 Small marginal fracture removable by polishing. 6.2.3 Slight ditching, slight step/flashes, minor irregularities.	6.3.1 Gap < 250 µm not removable. 6.3.2. Several small marginal fractures. 6.3.3 Major irregularities, ditching or flash, steps.	6.4.1 Gap > 250 µm or dentin/base exposed. 6.4.2. Severe ditching or marginal fractures. 6.4.3 Larger irregularities or steps (repair necessary).	6.5.1 Restoration (complete or partial) is loose but in situ. 6.5.2 Generalized major gaps or irregularities.
	7. Approximal anatomical form.	a. Contact point.	7a.1 Normal contact point (floss or 25 µm metal blade can pass).	7a.2. Contact slightly too strong but no disadvantage (floss or 25 µm metal blade can only pass with pressure).	7a.3. Somewhat weak contact, no indication of damage to tooth, gingiva or periodontal structures; 50 µm metal blade can pass.	7a.4 Too weak and possible damage due to food impaction; 100 µm metal blade can pass.	7a.5 Too weak and/ or clear damage due to food impaction and/or pain/gingivitis.
		b. Contour.	7b.1 Normal contour.	7b.2 Slightly deficient contour.	7b.3 Visible deficient contour.	7b.4 Inadequate contour. Repair possible.	7b.4 Insufficient contour requires replacement.
	8. Patient's view.		8.1 Entirely satisfied with esthetics and function.	8.2 Satisfied. 8.2.1 Esthetics. 8.2.2 Function, eg minor roughness.	8.3 Minor criticism but no adverse clinical effects. 8.3.1 Esthetic shortcomings. 8.3.2 Some lack of chewing comfort. 8.3.3 Unpleasant treatment procedure.	8.4 Desire for improvement. 8.4.1 Esthetics. 8.4.2 Function, eg tongue irritation. Reshaping of anatomical form or refurbishing is possible.	8.5 Completely dissatisfied and/or adverse effects, including pain.

(table continues on the next page)

		1 Clinically excellent/ very good	2 Clinically good	3 Clinically sufficient/ satisfactory	4 Clinically unsatisfactory	5 Clinically poor
C. Biologic properties.	9. Postoperative (hyper-)sensitivity and tooth vitality.	9.1 No hypersensitivity, normal vitality.	9.2 Minor hypersensitivity for a limited period of time, normal vitality.	9.3.1 Moderate hypersensitivity. 9.3.2 Delayed/mild sensitivity; no subjective complaints, no treatment needed.	9.4.1 Intense hypersensitivity. 9.4.2 Delayed with minor subjective symptoms. 9.4.3 No clinical detectable sensitivity. Intervention necessary but not replacement.	9.5 Intense, acute pulpitis or nonvital tooth. Endodontic treatment is necessary and restoration has to be replaced.
	10. Recurrence of caries, erosion, abfraction.	12.1 No secondary or primary caries.	12.2 Small and localized: 1. Demineralization; 2. Erosion. 3. Abfraction.	12.3 Larger areas of 1. Demineralization; 2. Erosion; 3. Abrasion/abfraction, dentin not exposed. Only preventive measures necessary.	12.4.1 Caries with cavitation and suspected undermining caries. 12.4.2 Erosion in dentin. 12.4.3 Abrasion/abfraction in dentin. Localized and accessible, can be repaired.	12.5 Deep caries or exposed dentin that is not accessible for repair of restoration.
	11. Periodontal response (always compared to a reference tooth).	10.1. No plaque, no inflammation, no pockets.	10.2. Little plaque, no inflammation (gingivitis), no pocket development. 10.2.1 Without/ 10.2.2 with overhangs, gaps, or inadequate anatomical form.	10.3. Difference up to one grade in severity of PBI compared to baseline and compared to control tooth. 10.3.1 Without/ 10.3.2 with overhangs, gaps, or inadequate anatomical form.	10.4. Difference of more than one grade of PBI in comparison to control tooth or increase in pocket depth > 1 mm requiring intervention. 10.4.1 Without/ 10.4.2 with overhangs, gaps, or inadequate anatomical form.	10.5 Severe / acute gingivitis or periodontitis. 10.5.1 Without/ 10.5.2 with overhangs, gaps, or inadequate anatomical form.
	12. Oral and general health.	11.1 No oral or general symptoms.	11.2 Minor transient symptoms of short duration; local or generalized.	11.3. Transient symptoms, local and/or general.	11.4 Persisting local or general symptoms of oral contact stomatitis or lichen planus or allergic reactions. Intervention necessary but no replacement.	11.5. Acute/severe local and/or general symptoms.

Figure 2: Incisal Preparation Designs (Chai *et al.*, 2018).

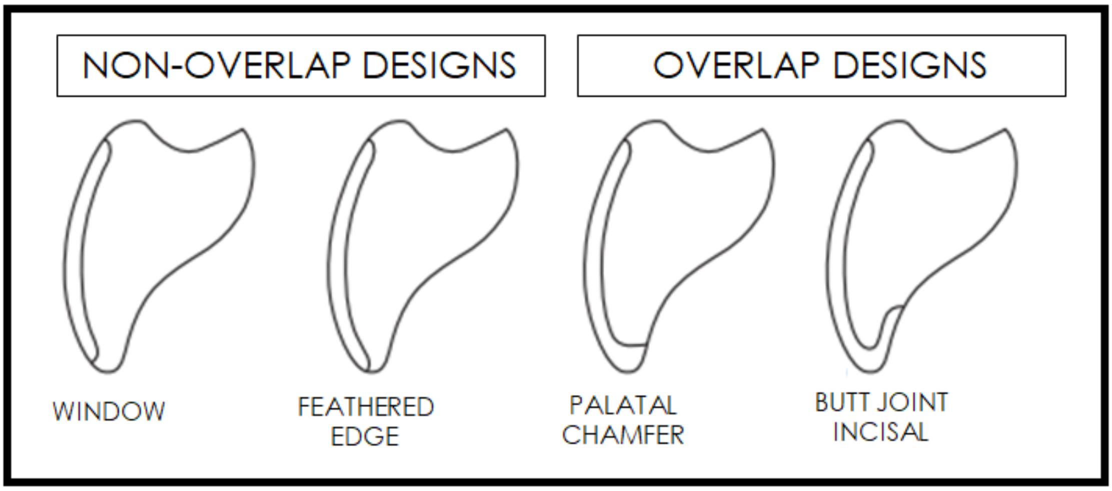

Figure 3: Preparation design options for the interproximal extension. From left to right, these have increasing levels of invasiveness. Short-wrap design: easy to implement, but with a visible adhesive joint. Medium-wrap design: retaining the contact point and with the adhesive joint not visible. Long-wrap design: with removal of the contact point and a deeper (approximately two-thirds) interproximal preparation (Edelhoff *et al.*, 2018).

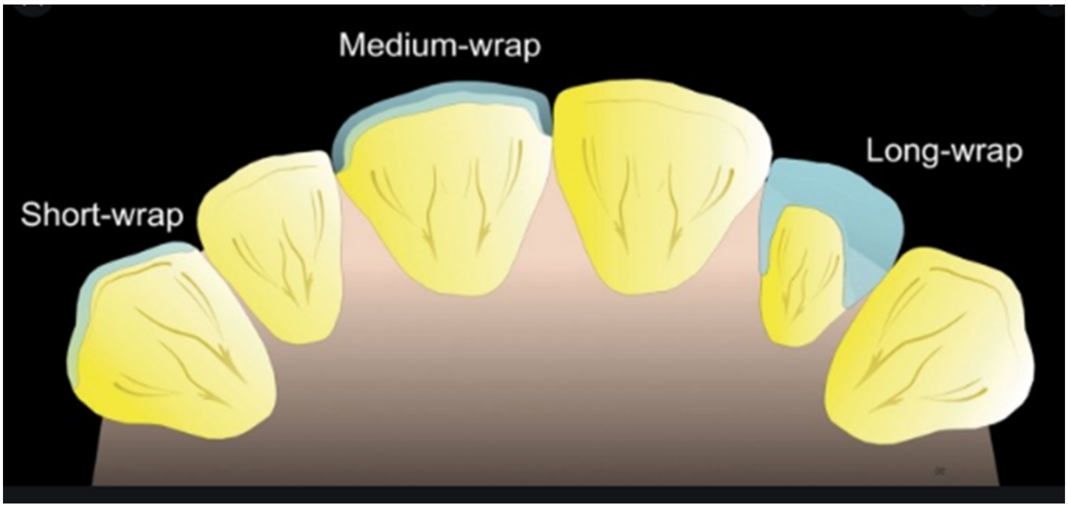

Figure 4: Timeline of the development of Dental Ceramics and their processing technologies (Zhang and Kelly, 2017).