Introduction

Porcelain laminate veneers (PLVs) are indirect restorations performed by conservative techniques with the purpose of harmonizing the smile, restoring the shape, function, and adequate color of esthetically compromised teeth.[1] Dental ceramic is the material of choice for this type of restoration, as it presents excellent properties, among which color stability,[2] chemical inertia, translucency[3,4] and high capacity to mimic tooth structure[1] as it is the restorative material that most closely resembles the optical properties of teeth.[4]

Tooth preparation for ceramic veneers is more conservative relative to that for all-ceramic crowns,[5] and it is one of the possible variables affecting the success of PLV restorations.[6] Design principles and the simplified techniques for tooth preparation of PLVs were described in several reports,[7] more recent sophisticated methods have integrated additive diagnostic procedures such as the wax-up or mock-up were described[8] and reported as provide more enamel preservation and as a consequence, more predictable bonding, biomechanics, and esthetics.[9,10]

In order to achieve adequate mechanical and optical properties in the final porcelain restoration, the amount of glassy phase and crystalline phase should be optimized. Good translucency requires a higher content of the glassy phase and good strength requires a higher content of the crystalline phase. Hence, the two material phases need to be balanced.[11]

On the other hand, the strength of the ceramic laminates must also be considered for an adequate preparation.[12,13] Different materials with particular characteristics are indicated. Among those most used, feldspathic ceramics have less flexural strength; however, they are more versatile in terms of stratification in layers and thicknesses. The lithium disilicate ceramics have greater flexural strength and can be machined, pressed, and receive ceramic coverings. Both materials can be successfully used, provided that the dental technician masters the characteristics of each material.[1,4]

The success of clinical treatment depends on the perfect combination of colors between the restoration and remaining teeth, and there are many variables involved, like the color of the supporting tooth substructure,[15] thickness, shade and type of ceramic[2] and resin cement[16] in addition to the restorative material's translucency shown by the amount of reflection and scattering of light.[4]

However, long-term clinical success of dental restoration is influenced not only by mechanical property, esthetic quality, and biocompatibility, but also by marginal fit. Through *in vitro* and *in vivo* studies on marginal fit of dental restorations, marginal fit has been proven to be one of the major factors causing secondary caries and periodontal diseases.[17,18]

Thus, the present study will analyze the advantages and limitations of these methodologies, which capable of simplifying clinical protocols and standardizing results of PLVs that have great interest in the profession due to their innovative nature.

Review of literature

Advancements in the field of adhesive dentistry and porcelain technology have broadened the use of porcelain laminate veneers (PLVs) significantly. These original fragile restorations, introduced by *Dr. Charles Pincuss* in 1938, have undergone significant advancement and enhancement over the past few decades, and have now qualified into a predictable restorative concept in terms of longevity, periodontal response and patient satisfaction.[19]

The PLVs have the evident advantage over crowns that optimal esthetics can be achieved with minimal tooth reduction, and the palatal surface of the tooth is unaffected so the incisal guidance is maintained.[20] Another advantage of PLVs is the normal tooth contour in the gingival areas, improving gingival health, and also PLVs have the advantage of having the exact radiographic contrast as dentin which allows diagnosis of alterations in the beneath tooth structure supporting the porcelain.[21]

Disadvantages of the bonded porcelain veneers are the demand for exhausting clinical and laboratory techniques, the laboratory assistance, and the obstacle of repair and unknown life expectancy.[22] For any cemented restoration the weak link is at the restoration/cement/tooth interface, in PLVs the composite luting agent is the weak link in the system. Polymerization shrinkage may create loss of the marginal seal. The thermal expansion coefficient is also different from the tooth structure and the porcelain. Composite resin may wear and the wear will be greater in case of larger gap widths compared to smaller ones. Also dissolution of the resin matrix of composite resin occurs in oral fluids.[23]

Indications of porcelain veneer include enamel hypoplasia, tooth discoloration, and intrinsic staining, fractured teeth, closure of single or multiple diastemas, correction of anatomically malformed anterior teeth and repair of crown and bridge fracture,[24,25] alteration of occlusal relationships, and creation of illusions of change in tooth alignments (instant orthodontics).[26] Thus patients no longer limit their reconstructive efforts to diseased teeth only.

PLVs are more durable and have superior esthetics; if they are bonded with an accurate adhesive technique and good oral hygiene care is established, long-term survival rate of PLVs is very high. [27]

Clinical performance of PLV's:

Fradeani et al in 2005[27] studied the clinical performance of PLVs. Forty-six patients were restored with 182 PLVs over 12 years; the survival probability was 94.4%. Three of a total five fractured PLVs were instantly recemented. Color match, porcelain and marginal integrity were mostly reasonable. Marginal discoloration was rated as acceptable.

Granell-Ruiz et al in 2010 [25] evaluated the clinical results of 323 PLVs over a period of 8 years. The survival rate of a fracture was 94% for simple design restorations, whereas the survival rate was 85% rate in the case of functional design restorations, the degree of patient satisfaction was considered to be excellent in 97.1% of the cases. It was concluded that PLVs are a predictable treatment option that offer excellent results.

Beier and Dumfahrt in 2012[28] studied the clinical value, success rate, and expected survival rate of anterior 318 PLVs placed in 84 patients constructed by feldspathic porcelain and leucite heat pressed ceramic. The mean examination time was 118.72 months and concluded that PLVs offer an expected, conservative, and extremely successful restoration. The survival probability at 10 years was 93.5%, the main reason for failure was fracture of the ceramic which associated with para-function (bruxism) and nonvital abutment teeth.

PLVs preparation designs:

Design principles and tooth preparations methods for PLVs were evaluated in several reports.[7,23,29–36] Although preceding suggestions for tooth preparation were minimal or no tooth substance loss, recent studies revealed that this approach is infrequent in current general dental perform.[37–39] However, most researchers agree on the essential to minimally invasive preparation procedure.[32,33,40–43]

In an effort to improve the bond strength of the resin composite to the tooth surface, preparation is required to remove the aprismatic surface of mature unprepared enamel, which offers only a minor retention capacity.[23,44] In addition and when possible, the preparation should be maintained completely in enamel to achieve an optimal bond with the porcelain veneer. Although the outcomes of the most recent generation dentin adhesive systems are extremely promising, the bond strength of porcelain bonded to enamel is still superior and more durable when compared with the bond strength of porcelain bonded to dentin.[23,30,45] Thus, one of the main objectives of the technique is to maintain the entire contour in intact enamel whenever possible, because the better the adhesion between the veneer and the prepared tooth, the better the stress distribution in the system enamel–composite–ceramic.[44]

Care must be taken, that insufficient tooth reduction could lead to an over contoured final restoration, excessive bulk in the gingival portion of the restoration changes the emergence profile and could initiate gingival inflammation and overcontouring in the incisal part of the restoration alters the protrusive relationship, promotes atypical incisal loading of the veneer, creates subsequent fracture and produces poor aesthetic outcome.[7] Whilst deeper preparations could expose dentin[46] and may contribute to undesirable microleakage**.**[43,47]

The preparation of the teeth greatly also influences the durability and color translucency of the ceramic restoration, since the tooth preparation will determine the inner superficial contour and the thickness of the ceramic material. This stage is established by the evaluation of the condition of the teeth, the indications of the clinical situation, and the material chosen (feldspathic or glass ceramic).[44,48]

Traditionally, at the cervical third; a chamfer finish line is placed at the level of the gingival crest of the anterior teeth. As it is hard to obtain a preparation with proper depth while preserving intact enamel in this area; preparation has to be approximately 0.3 mm. At the medium third, the preparation may achieve 0.5–0.8 mm.[1,44] However, controversy exists as whether to cover the incisal edge or not in these preparations.

As a result, basically four types of incisal tooth preparations have been advocated for veneers:[49]

- Window (intraenamel), leaving an intact incisal enamel edge.
- Feather edge, leaving an incisal edge in enamel and porcelain. Here, the veneer is taken up to the height of the incisal edge but the edge is not reduced.
- Beveled with incisal edge, entirely in porcelain. The bucco-palatal bevel is prepared across the full width of the preparation and there is some reduction of the incisal length of the tooth and overlapped with the porcelain extended into the palatal aspect of the preparation as a chamfer.
- Incisal butt preparation, instead of wrapping over the palatal aspect, the incisal edge is prepared with a 1 mm incisal reduction for a shoulder. This is advocated for better esthetics, stress distribution and positive seating.

Garber in 1993[42] indicated that incisal reduction may be the most critical factor in the long-term fracture resistance of the PLVs. The type of incisal reduction selected depends on two factors: Whether the tooth needs to be lengthened beyond its existing length and the labio-lingual width of the incisal edge. It is important not to terminate the incisal preparation in a butt-joint at a point where torque stresses occur, so as to avoid fracture of the restoration in this area.

Incisal edge tooth preparation depending on the necessity to alter the tooth length and labio-lingual width. If the incisal edge is not to be modified, a window preparation has been suggested. Such preparation requires adequate tooth structure bulk and strength incisally, as found in maxillary canines. Also, patients with minimum horizontal overlap the feather edge design is more suited because vertical component of force is more here. Palatal wrap around design should not be attempted here because it offers poor fracture resistance under vertical loading.[43] There are different reports as to whether the incisal edge should be included in the preparation for PLVs.

Hui et al in 1991[50] demonstrated that an overlapped design will convey maximum stress on the PLVs and increases the risk of cohesive fracture. A window design withstood axial stress most favorably in this investigation. It was concluded that where strength is essential, the most conservative type of veneer, namely the feather edge preparation, was the design of choice.

Castelnuovo et al in 2000[6] reported that elimination of the palatal chamfer for PLVs with incisal butt joints resulted in stronger restorations and simplified tooth preparation. It was also suggested that the labio-lingual path of insertion allowed easier seating of multiple PLVs and eliminated the risk for fracture of thin, unsupported palatal ceramic ledges.

On the other hand, ***Hahn et al in 2000***[51] studied the influence of the incisal preparation on the loadability of teeth restored with PLVs. In the first group, only the facial surface was prepared. In the second group, the preparation included a rounded incisal edge and a distinct chamfer lingually. The third group served as an unprepared control. It was found that preparation of the incisal edge exhibited the lowest fracture resistance. When prepared only facially, PLVs reached the strength of unprepared teeth.

Peumans et al in 2000[23] reviewed the most important parameters determining the long-term success of PLVs such as the tooth preparation, the selection and type of the adhesive system, the quality of marginal adaptation, the resistance against microleakage, the periodontal response, and the esthetic characteristics of the restorations. Regarding the incisal preparation, the window, the overlapped incisal edge and the feathered incisal preparation, they considered the overlapped incisal preparation is the most favorable; as it makes the restoration more resistant to incisal fractures. And it was concluded that microleakage can be minimised by locating the preparation margins of the veneer in enamel and by selecting a highly filled luting composite.

Seymour et al in 2001[43] investigated compressive and tensile stresses within PLVs and the composite lute at different preparation designs: with chamfer, shoulder, or knife-edge margins and either a labial window or incisal overlap preparation. It was concluded that; Stresses within the porcelain were chiefly compressive with palatal loading, stresses in porcelain and composite were chiefly tensile with labial loading, and that using the incisal overlap preparation; PLVs with knife-edge labial margins could better sustain occlusal loading without fracture.

Walls et al in 2002[52] would not recommend the window preparation, as it is very difficult to mask the incisal finish line of the restoration. As this style of PLVs is used to improve the appearance of teeth, the introduction of an esthetic defect would be inappropriate.

In another study, ***Hekimoglu et al in 2004***[53] evaluated the microleakage characteristics of PLVs with two different preparation designs; (window and incisal edge overlapped). It was concluded that the window preparation was more effective in term of prevention of microleakage at the incisal margin than the overlapped type preparation, and were of similar degree of microleakage at the cervical margin.

Smales and Etemadi in 2004[54] evaluated the long-term survival of PLVs placed with and without incisal porcelain coverage. Most of the failures occurred from porcelain fracture in the veneers without incisal coverage. It was concluded that although there was a trend for better long-term survival of the PLVs with incisal coverage, this finding was not statistically significant.

Christensen in 2006[55] observed that PLVs prepared with margins closely on the chewing surface of the incisal edge may develop chips on the incisal edge; it was recommended to place of incisal margins slightly lingual to the incisal edge but not into the centric stop of the opposing arch of teeth; configured as a “butt” joint.

Zarone et al in 2006[56] compared the resistance to fracture of PLVs in maxillary anterior teeth with different preparation designs; (chamfer with palatal overlap and the window). The following was concluded: The central and lateral incisors prepared with the overlap design showed higher resistance to fracture than those prepared with the window design.

Canines prepared with the window design were more resistant to fracture than those prepared with the overlap preparation. Both the type of tooth and the preparation design influenced the resistance to fracture of the restored teeth. Significant differences were evident between sound and prepared teeth. The reduction of resistance to fracture was approximately 20% when comparing teeth restored with porcelain veneers with non-restored teeth. Porcelain fractures occurred primarily at the cervical region. An overlap preparation was recommended for central incisors, whereas a window preparation for canines. Both designs can be used for lateral incisors.

Whereas, ***Stappert et al in 2007***[57] investigated the influence of preparation design and mouth motion fatigue on the marginal accuracy of PLVs. The preparation designs were; window preparation, butt joint, and wrap around. It was found that fatigue led to a significant decrease of marginal accuracy in all preparation design groups. Wrap around demonstrated higher marginal gap values than the other two groups. No significant differences were found between window and butt joint.

Cötert et al in 2009[58] observed forty patients who had received 200 PLVs in order to estimate the influence of categorical covariates related to the restoration design (localization, vitality, preparation depth, incisal, proximal, and gingival finishings, and surrounding tissue type) on the survival rates. It was concluded that the overlapped incisal edge, supragingival preparations, and intact enamel as the bordering tissue had significantly positive effects on the overall survival rate.

Khatib et al in 2009[59] evaluated the fracture load of thirty PLVs fabricated with IPS Empress CAD and IPS e-max CAD ceramic veneer materials, and prepared with three different designs (window, butt-joint, and incisal overlap). It was concluded that PLVs with butt-joint preparation design were the strongest and showed the highest values in the fracture load test.

Mirra and El-Mahalawy in 2009[60] investigated the fracture strength and microleakage of PLVs with different preparation designs (feather edge, butt joint, and wrap around). It was concluded that the highest fracture strength was found in butt joint design and microleakage was found to be higher in cervical margin than incisal in the three different designs and highest in palatal margin of wrap around than feather edge and butt joint.

Shetty et al in 2010[61] reviewed both clinical and non-clinical studies to determine the survival rates of PLVs based on different incisal preparation designs. The search strategy involved MEDLINE, BITTORRENT. It was concluded that: window preparation was the most conservative type, incisal coverage was better than no incisal coverage; incisal overlap was preferred for healthy normal tooth with sufficient thickness, in butt preparation no long-term follow-up studies have been performed as yet. And Incisal butt preparation was preferred for worn and fractured teeth.

Akoglu and Gemalmaz in 2011[12] evaluated the fracture load and the mode of failure of PLVs with preparations on either enamel or dentin. They reported that PLVs with preparation designs entirely on dentin with

4 mm incisal reduction yielded lower fracture loads than those prepared with 2 mm incisal reduction, and veneers with 2 mm incisal reduction exhibited fracture resistance similar to that of intact teeth for preparation designs supplied on both enamel and dentin.

Eashwaran et al in 2011[62] evaluated the shear bond strength of PLVs prepared by two different designs (feather edge and overlap). It was concluded that PLVs preparation without incisal involvement would be a better design as the palatal extension did not contribute to the strength of the restoration but only had an adverse effect.

Da Costa et al in 2013[63] evaluated the fracture strength of PLVs with different preparation designs and observed the correlation between the preparation performed and the type of failure, by means of Meta analysis. It was concluded that the butt joint is the type of preparation which least affects the strength of the tooth and the chamfer type is more susceptible to ceramic fracture.

Gurel et al in 2013[64] estimated that a survival rate of 99% was observed for PLVs with preparations confined to enamel and 94% for PLVs with enamel only at the margin, it was stated that PLVs when bonded to enamel provide a safe and predictable treatment option that preserve tooth structure.

Prasanth et al in 2013[65] investigated PLVs with three designs (Feather edge, incisal butt joint and palatal chamfer); fracture load and mode of failure were evaluated. It was revealed that feather edge design offered better fracture resistance followed by incisal butt joint design and palatal chamfer design, in cases where incisal reduction is required such as fractured incisal edge, butt joint design is ideal. Incisal reduction should not be done unless it is specifically indicated. Feather edge design offered easy tooth preparation, veneer fabrication and cementation.

Guess et al in 2014[66] investigated the long-term performance of PLVs with two preparation designs. Twenty-five patients were supplied with 42 PLVs (butt-joint margin) and 24 PLVs (palatal wrap around). The 7-year survival rate was 100% for palatal wrap around restorations and 97.6% for (butt-joint) restorations. Both preparation designs can be considered reliable treatment options for anterior teeth with extended deficits.

The PLVs materials and techniques of fabrication:

A simplistic way to classify the ceramics used in construction of PLVs is the processing technique into:

- Build up;
- Heat pressed ceramics;
- Machineable CAD/CAM ceramics.

The buildup technique:

PLVs have undergone significant evolution nowadays; their use has extended further than a simple covering for anterior teeth to include coverage of coronal tooth structures. Feldspathic veneers are formed by layering glass-based (silicon dioxide) powder and liquid materials. Silicon dioxide, also referred to as silica or quartz, contains different amounts of alumina. When these aluminum silicates are found naturally and contain various amounts of potassium and sodium, they are referred to as feldspars. Feldspars are mainly composed of silicon oxide (60%–64%) and aluminum oxide (20%–23%), and are typically modified in different ways to create glass which used in dental restorations.[67,68] Thus, porcelain veneer consists of fluorapatite crystals (fluoride-containing calcium phosphate, $Ca_5(PO_4)3F$) in an aluminum-silicate glass that may be layered on the core to create the final morphology and shade of the restoration. The fluorapatite crystals contribute to the optical properties of the veneering porcelain. Feldspathic porcelain provides high esthetic value and demonstrates optimal translucency, just like natural dentition. By using a layering and firing process, ceramists developed veneers that could be made as optically close to natural teeth as possible.[68]

Ceramic fired over a refractory die is the oldest and still widespread method for constructing a porcelain piece. This technique presents the following advantages: very sophisticated effects of color and translucency can be gained through a full-thickness layering technique; conventional feldspathic porcelains can be used; and when combined with hydrofluoric acid etching and silanization, they show highly consistent bonding to resins.[69,70]

Feldspathic porcelain’s mechanical properties are low, with flexural strength usually from 60 to 70 MPa; due to the nature of the glass matrix and the lack of core material, the veneering porcelains are much more liable to fracture under mechanical stress. Therefore, a good bond in combination with a stiffer tooth substructure (enamel) is critical to strengthen the restoration.[68] Currently, needs for less-invasive treatments and higher levels of esthetics have increased the indication of feldspathic