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# Comparison of the shear bond strength of feldspathic veneers cemented to prepared and unprepared bovine anterior teeth: An in-vitro study

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## ABSTRACT

**Statement of problem:** The introduction of minimally invasive or no-preparation veneers (NPVs) has revolutionized restorative procedures by offering the potential to maintain natural tooth structure while achieving aesthetic improvements. Nevertheless, debates emerge about their strength and ability to withstand breaking, which is linked to their extremely thin composition.

**Purpose:** The point of the current review was to assess the shear bond strength (SBS) of the feldspathic veneers cemented to prepared and unprepared anterior bovine teeth to contrast their bond strength and obstruction with crack.

**Material and methods:** Thirty maxillary anterior bovine teeth were randomly divided into groups according to their preparation methods: full-preparation butt-joint in group A, full-preparation butt-joint and polishing with yellow grain diamond burs in group B, and no-preparation (just eliminating the aprismatic enamel with polishing yellow grain diamond burs) in group C. All veneer were carefully bonded to enamel. After preparing the teeth, the feldspathic ceramic veneer was milled, treated, and afterward cemented with a light cure luting composite cement. The samples were thermally cycled for 2500 cycles in 5°C and 55°C water. The shear bond strength was estimated for every tooth of all groups and failure mode was settled by stereomicroscopic assessment

**Results:** The shear bond strength was highest in Group C. There was a significant difference in shear bond strength between groups C and A ($p \leq 0.05$) and between groups C and B ($p \leq 0.05$). Nonetheless, the disparities between groups A and B ($p > 0.05$) did not show any significance. The most frequent type of failures in all groups were mixed failure.

**Conclusions:** Feldspathic veneers without any prior preparation showed the highest shear bond strength. With precise patient selection, no-prep porcelain laminate veneers are an effective and conservative choice for improving the appearance of anterior teeth.

## KEYWORDS

Dental porcelain; Malocclusion; Esthetics; Natural tooth structure; Enamel

## ARTICLE HISTORY

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## Introduction

With the advancement of dental technologies and the growing demand for improving dental aesthetics the use of porcelain veneers is becoming the most conservative treatment option to enhance the patient's smile [1-3]. Porcelain veneers are the ideal conservative treatment option for aesthetic smile rehabilitation indicated for anterior teeth presenting wear, staining, enamel defects, diastemas, malposition, traumas or fractures and shape anomalies [4,5]. Amara M. et al. detailed, over a time of 10 years, a 95% survival rate of feldspathic porcelain veneer cemented to enamel [4]. In a retrospective study that evaluated the long-term survival of feldspathic veneers, Guzman-Perez G. et al. found a 96% survival rate at a 16-year follow-up, showing that this treatment methodology and material are considered predictable [6].

Mihali SG et al. in their retrospective clinical study discovered an overall survival rate of 91.77% for up to 7 years of function, with a failure rate of 8.23% [7]. However, the failure of feldspathic veneer is affected by different factors, for example, tooth surface and morphology, ceramic thickness, type of cement, capability, and preparation technique [8]. It has been shown that the preservation of sufficient enamel structure and the placement of the preparation's margins within the enamel, avoiding any existing composite restorations, are paramount factors for the achievement of good clinical outcomes with porcelain laminate veneers [9,10].

However, failure in veneer treatment can be connected with marginal discoloration, postoperative sensitivity, fracture, and debonding [8]. The four common failure types of porcelain laminate veneers are cohesive, adhesive, mixed and catastrophic fractures. Cohesive failure occurs when a fracture leads to a layer of adhesive remaining on both surfaces. Adhesive failure is an interfacial bond failure between the adhesive and the substrate, hence, the failure occurs in the adhesion system. In the mixed failure, adhesive and cohesive failure take place simultaneously. While in the catastrophic failure, a total fracture of the substrate happens [8].

Since the high rate of failures in indirect restorations is related to exposed dentine, the preparation technique is considered the most determining factor for the longevity of porcelain laminate veneers [8]. There are four distinct kinds of veneer preparation regularly utilized and detailed in the

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literature [11]. Firstly, in the window preparation, the tooth is prepared buccally or lingually and the incisal edge is preserved. In the feather preparation the incisal edge is included in the preparation without any reduction of its length. In the bevel or butt-joint preparation the incisal edge is reduced by 0.5 to 1 mm. Finally, in the incisal overlap preparation the preparation of the incisal edge is extended to the palatal surface and reduced by 2 mm [11,12].

In most veneer, a butt joint is utilized to facilitate the seat and the insertion of the veneer; however, for the most part, to decrease the fracture risk of the restoration [8]. In the meantime, a change in outlook in restorative procedures has been brought by the presentation of no-preparation veneers (NPVs), which hold the commitment of safeguarding regular tooth structure while getting identical esthetic results [13]. No-prep/minimally invasive veneer will generally have a thickness of 0.2 to 0.5 mm, while conventional veneers (CVs) ranges from 0.3 to 1 mm [2].

The advantages of the NPVs incorporate the protection of healthy tooth structure and the decrease discomfort or pain during the procedure since their preparation is much of the time gave without the need of anesthesia. Furthermore, the impressions can be taken easily with no need for temporary restorations contrary to conventional veneers. Additionally, NPVs are immediately acknowledged by patients that know about the significant conservation of their natural teeth. Besides, NPVs have a strong biocompatibility with dental substrates, which coincides with their tendency to collect little bacterial plaque and encourage better oral hygiene. As described in the literature, the material of choice for NPVs is feldspathic ceramic [1,2,5,12,13].

This kind of veneer has been enormously improved, because of ongoing advancements of the adhesion systems and in the physical properties of ceramics. In this regard, the CAD/CAM methodology utilizing feldspathic blocks to create this veneer is, the most predictable method. As per Smielak B. et al., the survival rate of no-prep/minimally invasive veneers surpasses that of conventional veneers, over a mean observation time of 9 years [2].

Ultimately, no-prep veneer can be more challenging to realize than conventional veneers and the achievement appears to rely upon a blend of good case selection, position of the margins, sound adhesive principles, clinical and laboratory experience [14]. Eventually, to decide the adequacy of this new sort of veneer preparation, the shear tests are regularly utilized to quantify the bond strength of dental materials since they are easy to perform and require negligible hardware and preparation [8].

The point of the current review was to assess the shear bond strength (SBS) of feldspathic veneers cemented to prepared and unprepared anterior bovine teeth to compare their bond strength and resistance to fracture.

## Materials and Methods

In this review, 30 extracted bovine maxillary anterior teeth with completely intact crowns, and homogeneous mesiodistal width and buccal-palatal thickness were collected. These measurements were performed by a gauge. All teeth were free of caries and restorations[8].

They were, then, cleaned and stored in distilled water at room temperature from the day of extraction until testing to safeguard their hydration. The distilled water was changed every 3 to 4 days [15]. The teeth were randomly divided into 3 groups (n=10) in view of the preparation strategies for full butt-joint preparation (A), full butt-joint preparation and polishing with yellow diamond burs (B), and no-preparation except for just passing polishing diamond burs(C) (Figure 1) [8].

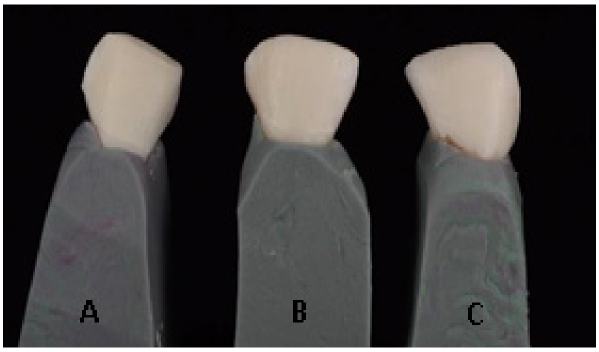


**Figure 1.** Three different types of veneer preparation: block A, B and C representing, respectively, full butt-joint preparation, full butt-joint preparation + polishing and no preparation.

All the following procedures were performed by only one operator.

### Tooth preparation

To give veneer equivalent thickness, the reduction of the buccal surface and incisal edge was similar in the two groups A and B. The buccal surface was reduced by 0.3 mm at the cervical third and 0.5 mm at the middle and incisal third. For butt-joint incisal preparation, 0.5 mm of the incisal length was reduced utilizing diamond burrs under abundant water irrigation. After the preparation of each group, the burs were discarded, and new burs were used. In both groups, the margins' preparation was located buccally to the proximal contact and the cervical finish lines were established 1 mm above the cementoenamel junction (CEJ) [8].

Depth-cutting burs of 0.3 mm and 0.5 mm were utilized to direct the preparation and chamfer diamond burrs were utilized to refine the preparation and mark the finish lines. The prepared samples of groups B were furthermore polished with fine diamond burrs (yellow grain). Moreover, the samples allocated in group C were not prepared; however, to get an ideal surface for bonding in this group, the teeth were smoothed with polishing diamond burrs to just eliminate the aprismatic enamel. All preparations in all groups were meticulously limited to enamel [8].

For all prepared and unprepared teeth of all groups, a digital impression was taken with an intraoral scanner (3Shape TRIOS, Copenhagen, Denmark). Later, all veneer were designed on a dental CAD computer software (DentalCad 3.0 Galway, Archimedes Exocad, Darmstadt, Germany) with a 1.5 mm increase of the incisal edge, a 0.04 mm space for the resin cement, and a veneer thickness of 0.5 mm. The Standard Triangle Language (STL) files of the designed veneer were, then, sent to dental laboratory (Zirconart dental laboratory, Cornellá de Llobregat, Barcelona) to mill the final restorations (Figure 2) [8].



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Later, feldspathic veneer were milled for all specimens of all groups utilizing monolithic feldspathic blocks (Triluxe forte; VITABLOCS, VITA Zahnfabrik, Germany) [8].

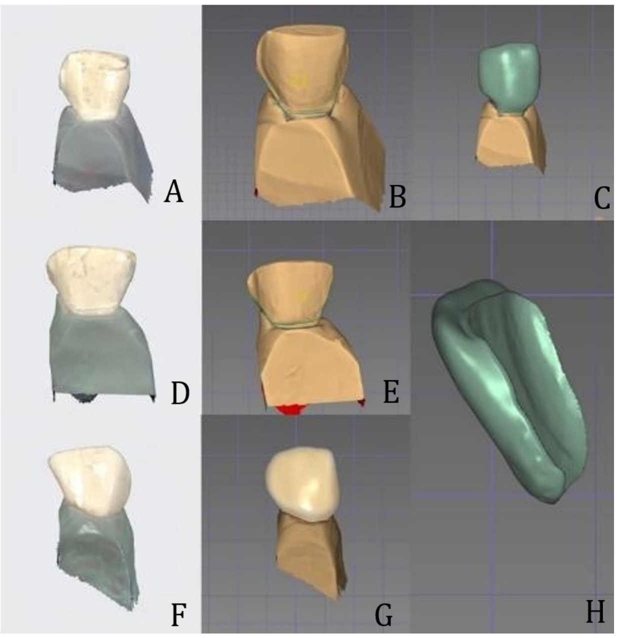


**Figure 2. (a)** Digital scan of a specimen from group A. (b) Margin determination of a preparation from group A on Exocad software before designing the veneer. (c) Design of a specimen's veneer from group A. (d) Digital scan of a specimen from group B. (e) Margin determination of a preparation from group B on Exocad software before designing the veneer. (f) Digital scan of a specimen from group C. (g) Design of a specimen's veneer from group C. (h) STL file of a veneer design sent to the dental laboratory for milling.

All the prepared and unprepared teeth in all groups were cleaned, rinsed, and dried. Later, the teeth were etched with 36% phosphoric acid (DeTrey Conditioner 36; Dentsply Sirona, Germany) for 30 seconds, rinsed for 30 seconds, and carefully dried. One coat of a three-step dental adhesive (OptiBond FL; Kerr, USA) was applied and gently air-dried [12,16].

The porcelain veneer was etched with 9.6% hydrofluoric acid gel (Porcelain Etch Gel; Pulpdent, USA) for 60 seconds, washed with water, cleaned with 36% phosphoric acid (DeTrey Conditioner 36; Dentsply Sirona, Germany), rinsed for a second time with water and carefully air-dried. Ceramic veneer was silanated (Monobond Plus; Ivoclar Vivadent, Lichtenstein) then cemented by using light cure luting composite cement (Variolink Stylish LC; Ivoclar Vivadent, Liechtenstein). The restorations were seated with finger pressure and photopolymerized with a LED curing light (Smartlite Focus; Dentsply Sirona, Germany) with a wavelength range of 440-520 nm and a radiant emittance of 1100 mW/cm2 for 5 seconds, as a pre-polymerization [12,16].

After that, the excess of cement was removed, and the specimens were photopolymerized for 40 seconds on all surfaces [8]. Then, the roots of the teeth were embedded in a self-cure acrylic resin (Paladur Clear; PALA, Kulzer, Germany) with cylinder shape plinths (Figure 3) [8].

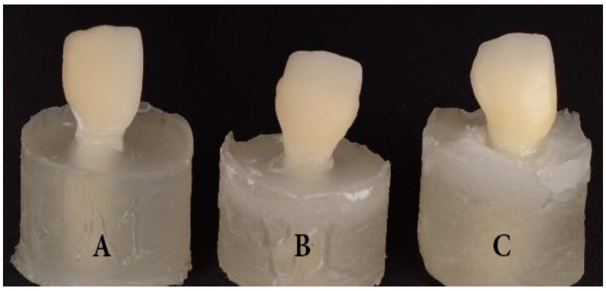


**Figure 3.** Three specimens from group A, B and C restored with a milled monolithic feldspathic veneer and embedded in a clear cylinder shape self- cure acrylic resin.

Before the fracture test, the bonded specimens were thermally cycled for 2500 cycles in 5°C and 55°C water (Poly Sciense, USA), simulating, to the greatest extent possible, the real intraoral conditions [17].

Then, every specimen was mounted on a metal holder in an Instron universal testing machine (INSTRON, USA). All the specimens in all groups were tightened and stabilized to ensure that the loading pin was positioned properly on the junction between tooth and ceramic veneer, 1 mm from the incisal edge and at a 90° angle to the palatal surface of the tooth and applying a shear force on the restoration (Figure 4). The load was applied at a crosshead speed of 0.5 mm/min until the failure occurred. The ultimate load leading to failure was recorded in Newtons (N). The means and standard deviations (SD) were calculated. The failure modes were classified to cohesive, adhesive, mixed and catastrophic failure based on the fracture pattern that was observed under stereomicroscope at 20× magnification [8].

The statistical analyses were performed by using Statgraphics Centurion version 18 (Statgraphics Technologies Inc., USA) programs. The ANOVA test was used to analyze the differences in the mean values of shear bond strength among the three groups. Fisher's LSD test was employed to evaluate any difference among the groups and $p \leq 0.05$ was adopted as statistical significance [8].

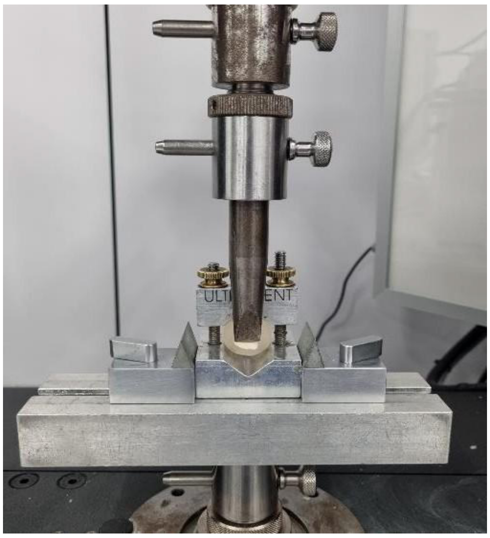

**Figure 4.** Instron universal testing machine. The pin is applied on the palatal surface of the veneer, 1mm from the incisal edge and with a 90° angle with the axis of the tooth.



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## Results

The mean shear bond strength levels for the groups are summarized in Table 1 and Figure 5.

The ANOVA statistical test revealed significant differences in mean shear bond strength values among the groups ($p \leq 0.05$). Group C displayed the most elevated shear bond strength (157.54 ± 76.25 N), followed by group B (86.82 ± 63.21 N) and finally group A (80.36 ± 68.82 N). A statistically significant difference was found between groups C and A ($p \leq 0.05$) and between groups C and B ($p \leq 0.05$). However, the differences between groups A and B were not statistically significant ($p > 0.05$) (Figure 5) and (Table 1).

**Table 1.** Comparison of the shear bond strength (SBS) of the different groups A,B and C. (*) Indicates statistically significant difference. (ns) Indicates no statistically significant difference. Significance level set at $p \leq 0.05$.

| Type of preparation | Mean SBS (±SD) (N) | ANOVA (*p*- value) | Comparison Fisher's LSD (*p*- value) |
|---|---|---|---|
| Full butt-joint preparation (Group A) | 80.36 (±68.82) | | Vs. Group B (0.8371) (*ns*) |
| Full butt-joint preparation + Polishing (Group B) | 86.82 (±63.21) | 0.0357 | Vs. Group C (0.0313) (*) |
| No preparation (Group C) | 157.54 (±76.25) | | Vs. Group A (0.0197) (*) |

Figures 6 & 7 demonstrate the mode of failures in all groups. In group A the most recurrent type of failure was the mixed failure (50%). Similarly, in group B, 60% of the total failures were mixed. However, the most observed type of failure in group C was the catastrophic failure (Figure 6 and 7).

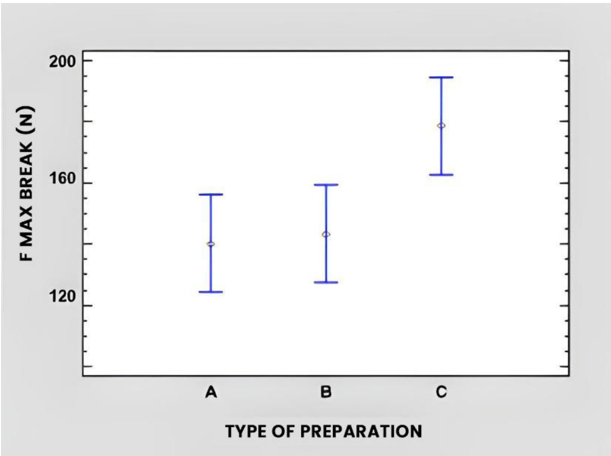


**Figure 5.** Comparison of the shear bond strength between the three groups A, B and C. F MAX BREAK: is the maximum load leading to failure recorded in Newtons (N).

Adhesive failures were more common in group A (20 %) than in groups B (10 %) and C (0%). Furthermore, cohesive failures were more frequent in group A (20%) than in groups B (0%) and C (0%) (Figure 6 and 7).

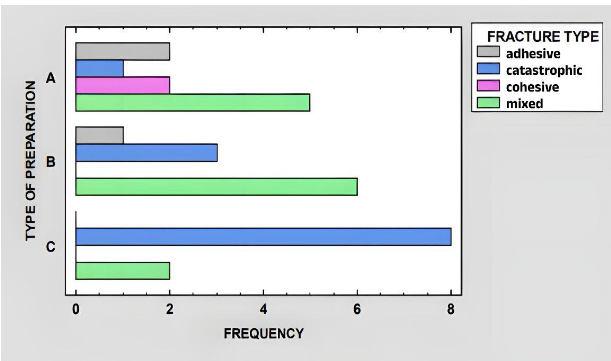


**Figure 6.** Fracture type frequencies across Groups A, B and C.

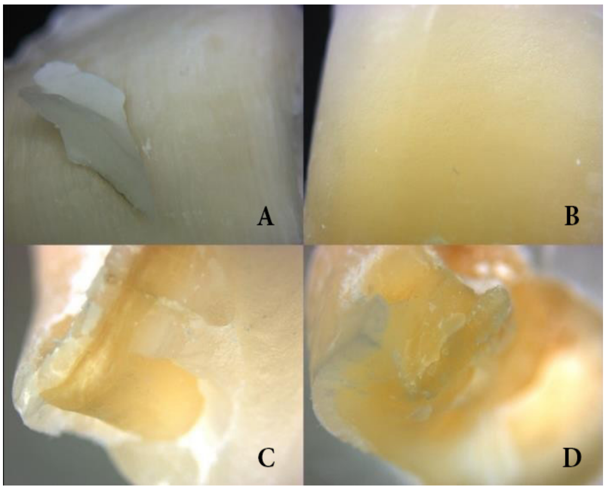


**Figure 7.** Fracture patterns observed under stereomicroscope at 20× magnification. Classified as cohesive, adhesive, mixed and catastrophic failures. Represented respectively in (A), (B), (C) and (D).

## Discussion

The present in-vitro study used three different types of preparation and compared the fracture toughness of feldspathic veneers by recording the shear bond strength. Based on the result of this review, no-preparation veneer yielded the most elevated shear bond strength with a mean value of 157.54 N. These outcomes concur with the results reported by Alavi A.A. et al. and Castelnuovo J. et al., where they exhibited that the enamel thickness directly affected the failure of the veneer [8,15].

Among the studied preparations, the no-preparation method saved more enamel than the other two preparation types. Subsequently, the kind of tooth design and substrate impacted the shear bond strength of the porcelain veneer. Because of the noticed least shear bond strength in group A, which corresponds with an increased risk of dentine exposure, it is recommended to avoid exclusively bonding porcelain laminate veneer restorations to dentine. When dentine exposure happens during the preparation, enough enamel should be protected to keep up with safe bonding and to gain maximum bond strength. Ideally, margins preparation should be placed on intact enamel [18]. Zhu J. et al. displayed in their



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review, that the shear bond strength of the veneer bonded to 100% enamel (almost 20 MPa) was two times as high as the veneer cemented to 0% enamel (almost 10 MPa). Consequently, cementing to 100% enamel was the most dependable and predictable treatment, giving the most elevated SBS values. Regardless, enamel conservation of 40% is the fundamental threshold value during tooth preparation for ceramics laminate veneer (CLVs) to guarantee sufficient bond strength [19].

From one viewpoint, ceramic veneer with incisal butt-joint preparations offer a few clinical benefits by simplifying the tooth preparation, the ceramic veneer fabrication, the control, and the insertion of the veneer during the cementation [15]. Then again, NPVs have additionally many advantages: maintain healthy tooth structure, decrease the pain and discomfort during preparation, biocompatibility, no requirement for anesthesia and for temporary restorations which can fall or break and be uncomfortable for the patient [1,2,5,12,13].

As explain in the literature, the material of choice for NPVs is feldpathic cereamic to offer both great esthetic and minimal thickness. feldpathic veneers are ideal for the retoration of anterior teeth when significant enamel reamins on the tooth and are ususally used when there is a low flexure and stress risk assessment [20].

This sort of veneer has been significantly improved, because of ongoing advancements in the bonding systems and in the physical properties of ceramics. Consequently, the CAD/CAM methodology utilizing feldspathic blocks to create this veneer is, up until this point, the most predictable method [21,22]. High quality no-prep veneer can be more challenging to realize than conventional veneer and the achievement appears to rely upon a mix of good case selection, margin's position, sound adhesive principles, clinical, and laboratory experience. Besides, the cementation and the placement of the NPVs are more technique sensitive since the tooth presents no insertion path or support [14]. The ongoing review uncovered that fully prepared group A brought about lower shear bond strength (80.36± 68.82N) contrasted with the fully prepared and polished group B (86.82±63.21N). This study's discoveries contrasted from past research. The last option accentuated the significance of micromechanical retention and resin micro-tags formation on the tooth surface by trying not to polish for successful bond. Despite the fact that, the distinction between these two groups was statistically not significant, it appears to be that polishing can further develop the bond strength [8].

Likewise, this study exhibited that the preparation type and the amount of existing tooth structure will essentially affect the load to failure of the ceramic veneer. However just two kinds of veneer preparation including the conventional butt-joint preparation and the recently described no-preparation have been explored. Hence, further investigations, looking at additional sorts of veneer preparation, are required [20]. Some articles, as of Schmidt K.K. et al., demonstrated that utilizing a palatal chamfer margin configuration fundamentally increased the load to failure contrasted with a shoulder finish line [23]. Others concluded that no distinctions were found between the failure risk of the palatal chamfer preparations and the butt-joint preparations. Nonetheless, the fracture resistance of the teeth prepared with the two strategies was like one another [24].

Also, Castelnuovo J. et al. detailed that the ceramic veneer with 2.0 mm of incisal butt-joint and feathered incisal edge as utilized for the NPVs, were the strongest. Besides, they expressed that the palatal chamfer didn't give increased strength for feldspathic veneers [15]. Regardless, the material of choice for the ceramic veneer should be analyzed completely during the treatment planning. On account of fractured teeth with up to 4.0 mm of missing tooth structure or on account of parafunctional occlusion or malocclusion, felspathic ceramic veneer can't be utilized to reestablish the anterior dentition and different materials should be opted [15].

This in-vitro study showed, in dissonance with the experiment of Zlatanovska K. et al., that the most widely observed fatigue failure in porcelain veneer in all groups was mixed failure. Besides, the prepared groups presented higher cohesive and adhesive failure rates than the no-prep group. However, the non-prep group displayed an 80% rate of catastrophic failure. This event could be attributed to the high quality of bonding in the no-prep group, resulting in the failure of the tooth. Moreover, further examinations and research should be performed [25].

As well, to have a sufficient resistance to shear forces, the type of cement is highly effective factor in the bonding between the restorations and the tooth substrate [17]. Consequently, Öztürk E. et al. demonstrated that the kind of resin cements dual cure or light cure didn't influence the shear bond strength of the porcelain laminate veneer restorations [18].

In the current review, the total-etch method was utilized to cement the veneer. Then again, Duymuş Z.Y. et al. showed that the samples cemented utilizing the total-etch technique had the most minimal shear force value (18.79 ± 4.48 MPa). The way that total-etch resin cement had a lower resistence to shear strength could be credited to its high solubility in water. Thusly, self-adhesive resin could be preferred during the cementation, since its application strategy is simpler than self-etch or total-etch methods [17]. The discoveries of the ongoing review depend on an in-vitro experimental project. Accordingly, the results must be cautiously generalized to oral (in-vivo) environment. A porcelain laminate in the oral environment is exposed to saliva, bacteria, and a few sorts of chemothermal and mechanical factors, for example, fast changes of the pH, warm and cold food or drinks, forces, function, mastication, and pulp pressure [8]. Consequently, by thermocycling the samples for 2500 cycles in 5°C and 55°C water, the specimens were exposed as much as possible to the intraoral conditions [17].

Additionally, the samples used in this study were bovine anterior teeth and their enamel structure and shape could differ from the human teeth. Subsequently, the bonding on bovine teeth could be different than the bonding on human teeth [22,26,27]. In addition, all the procedures in the ongoing review were performed by just one operator, standardizing, to the fullest extent, the three groups [8].

Certainly, further in-vivo and in-vitro examinations with bigger sample sizes are important to confirm these findings in a clinical context and build up their clinical importance. While in-vivo studies are fundamental for surveying veneer performance, the multitude of variables involved can complicate the identification of the precise causes of failures [8].



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## Conclusions

The in-vitro study led to several key conclusions. First, no-prep porcelain veneers (NPVs) are effective for the aesthetic restoration of anterior teeth with proper patient selection. Second, NPVs align with modern aesthetic dentistry principles, offering high biocompatibility, excellent aesthetics, and being a conservative option for patients refusing tooth preparation. Third, the no-preparation method demonstrated the highest shear bond strength for feldspathic veneers. Additionally, polishing these restorations can enhance their bond strength. Mixed failures were the most common fatigue failure type across all groups. However, cohesive and adhesive failures were more frequent in the prepared groups, whereas catastrophic failures were more prevalent in the no-prep group.

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## Disclosure statement

No potential conflict of interest was reported by the authors.

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