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Fracture Localisation of Porcelain Veneers with Different Preparation Designs

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Abstract

BACKGROUND: Porcelain veneers are permanent restorations that combine good aesthetic with functionality by minimal destructive techniques.

AIM: This study aimed to investigate the influence of the preparation designs on the fracture localisation.

MATERIAL AND METHODS: Three preparation designs of porcelain veneers fabricated by a method of laying on a fireproof abutment on maxillary central incisor were examined in this in vitro study-feather preparation, bevel preparation and incisal overlap – palatal chamfer. The samples from all three groups were loaded into a universal test machine-TRITECH WF 10056 until damage occurred on the porcelain veneer. Fracture localisation was classified as an incisal, gingival or combination. Data were analysed with statistical programs: STATISTICA 7.1; SPSS 17.0.

RESULTS: In feather preparation, as a consequence of the mechanical force, the most common is the incisal localisation (66.7%), followed by the combined (33.3%), while the gingival fracture localisation is not registered. In bevel preparation, the most common fracture localisation is combined (53.6%), followed by incisal (35.7%) and subsequent gingival localisation (10.7%). In incisal overlap (palatal chamfer), combined and gingival localisation of the fracture is equally recorded in 14.3% of the samples, while the incisal is the most common localisation and is registered in 72.4%.

CONCLUSION: During the study, a statistically significant dependence was found between the localisation of the occurred changes (incisal, gingival and combination) and the three different types of preparation.

Introduction

The use of porcelain veneers as permanent restorations combines good aesthetic and functionality with minimal destructive techniques (Calamia, 1996) [1]. With a wide range of indications, they present a therapeutic alternative in a large number of patients that only want an aesthetic correction or in other situations, when they are used in combination with another type of treatment.

To gain high aesthetic and functional restorations, the mechanical resistance of porcelain veneers is of great importance. They must survive and resist the mastication forces whose average value in anterior teeth ranges from 20 to 160 N [2]. The obtained mean values of fracture resistance overcome the mastication forces [3]. The longevity and the success of the porcelain veneers depend on better stress distribution [4].

The most common causes of failure described in the literature are: debonding, colour change, fracture, marginal defects in the palate-incisal region and increased percentage of poor marginal adaptation in the palate-incisal region [5].

The fracture resilience of a material is defined as the maximum load that the material can withstand until a fracture occurs. The mechanical strength of the ceramics is presented by the force that the material uses to oppose plastic deformations such as fractures or bending. The resistance of the material to the deepening of the cracks and breakages constitutes the mechanical hardness of the ceramics [6]. Ceramics is a rigid material with low tensile strength [7]. Another disadvantage of the ceramics is its inability to twist as well as its tendency to break when exposed to minimal deformation [8].

There are several test methods to evaluate the mechanical properties of dental ceramics, such as tensile test, pressure, bending test, hardness and diametric tensile strength test. It is important to note that different testing methods give different values for the force that causes fracture on the restoration, so making their direct comparison is not always possible. Many factors [9] impact the appearance of the fracture or the debonding of the veneer: shape, thickness, length of restoration, microstructural characteristics and elastic modulus of ceramic material, errors in the clinical phases of the work, surface defects or exposed dentin, errors in the technical manufacturing of the restoration, the magnitude and the direction of the force [10].

So, the mechanical resistance of the veneer depends on the type and the shape of the preparation, which altogether can resist the occlusal and lateral forces of the chewing pressure during mastication. Before the preparation, it is very important to decide whether the incisal edge will be reduced. There are four basic preparation designs depending on the involvement of the incisal edge: Window preparation; Feather preparation; Bevel preparation and Incisal overlap – palatal chamfer.

Until now, there are still insufficient data regarding the best type of veneer preparation. Very few studies have focused on the impact of the preparation design on the success and durability of the restoration, and at the same time, there are some very controversial results. Therefore, in this paper, we investigated the influence of the preparation designs on the fracture localisation.

Material and Methods

Three preparation designs of porcelain veneers fabricated by a method of laying on a fireproof abutment on maxillary central incisor were examined in this in vitro study-feather preparation, bevel preparation and incisal overlap – palatal chamfer.

Because natural teeth show many variations due to age and individual structure, time and place of storage of extracted teeth, and to standardise the size of porcelain veneers, we carried out the test on metal abutments.

Materials used for fabricating the metal abutments and the porcelain veneers are given in Table 1 and Table 2.

Table 1: Materials used for fabrication of metal abutments

Material	Manufacturer
Low-viscous floating additional curing vinyl (A)-pouring silicone Doubling	WP Dental
Alloy Wiron 99	Bego

An extracted human maxillary central incisor was selected on which initially we performed feather preparation, carried out according to all the principles of porcelain veneering preparations. On the same tooth, appropriate bevel and incisal overlap (palatal chamfer) preparations were carried out, and proper silicone moulds were made.

Table 2: Materials used for fabrication of porcelain veneers

Material	Manufacturer
Low-viscous floating additional curing vinyl (A)-pouring silicone Doubling	WP Dental
Carbon-free phosphate bonded precision casting investment for crowns Polivest and Polisol	Polident
Sintered into a furnace for firing and pressing dental ceramics - multiagent Press	Densply
Feltspat ceramics Duceram Kiss	Degudent
Self-adhesive resin cement relyxtm U200	3M ESPE

To standardise the experimental samples, the thickness control of the manufactured veneers was performed using a dental calliper, measuring the bucopalatal diameter of the tooth in three points. Also, the length of the veneers was controlled.

Figure 1: Testing the samples with universal test machine (Tritech of 10056) and their fracture localisation

Literature data for fracture resistance of porcelain veneers indicate a lack of standardised and unique methodology of measurement, and it is likely due to the complex geometric shape of the restorations. The samples from all three groups were fixated in a special highly alloyed stainless-steel holder and loaded into a universal test machine (cyclic/stress path triaxial system TRITECH WF

10056) until damage occurred on the experimental sample.

The pressure was directed at an angle of 45 degrees and with a speed of movement from 0.5 mm/min until the moment of the first crack/fracture or damage on the experimental sample. This force was defined as the fracture force of the veneer. The changes that occurred were registered with Olympus microscope SZ2-ILST. Fracture localisation was classified as an incisal, gingival or combination (Picture 1).

Data were analysed with statistical programs: STATISTICA 7.1; SPSS 17.0;

Results

The research includes 90 samples of porcelain veneers specially prepared for the experiment and divided into three groups:

Group I-30 porcelain veneers with feather preparation;

Group II-30 porcelain facets with bevel preparation;

Group III-30 porcelain veneers with incision overlap (palatal chamfer) preparation.

The samples from all three groups are subjected to mechanical strength testing of mechanical resistance, which leads to changes such as peel and fracture. Fracture localisation is classified as an incisal, gingival or combination.

In Group I, the mechanical force causes combined localisation in 33.3% of the samples; incisal localisation is the most common and appears in 66.7%; gingival localisation is not registered at all.

The percentage difference recorded between the combined fracture localisation versus the incisal according to the Difference test is statistically insignificant for $p > 0.05$ ($p = 0.2473$).

In Group II, a gingival fracture localisation is recorded in 10.7% of the samples; followed by an incisal localisation in 35.7%; combined localisation is the most common and appears in 53.6%.

The percentage difference registered according Difference test is statistically significant for $p < 0.05$ between gingival localization versus combined and incisal ($p = 0.0267$, $p = 0.0006$); percentage difference between combined versus incisal localization is statistically insignificant for $p > 0.05$ ($p = 0.1779$).

In group III, combined and gingival localisation of the fracture is equally recorded in 14.3% of the samples, while the incisal is the most common localisation and is registered in 72.4%.

The percentage difference recorded between combined and gingival localisation versus incisal according to Difference test is statistically significant for $p < 0.05$ ($p = 0.0000$) (Table 3).

Table 3: Legend of fracture localisation

Localisation	I Group		II Group		III Group	
	N	%	N	%	N	%
Incisal	4	66.7	10	35.7	21	72.4
Combined	2	33.3	15	53.6	4	14.3
Gingival			3	10.7	4	14.3
Total	6	100.0	28	100.0	29	100.0

During the study, a statistically significant dependence was found between the localisation of the occurred changes (incisal, gingival, and combination) and the three different types of sample preparation (Pearson Chi-square: 11.2217, df = 4, $p = 0.024182$) (Figure 2).

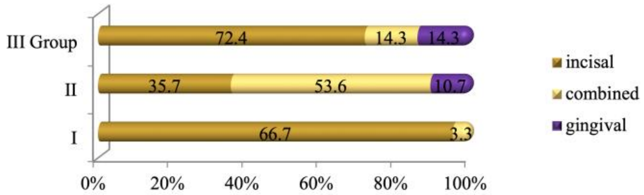

Figure 2: Fracture localisation of porcelain veneers with different preparation designs

Discussion

The use of porcelain veneers as a permanent restoration combines good aesthetics and functionality with minimal destructive techniques (Calamia, 1996) [1]. Different types of preparation designs are described in the literature for this type of restoration. The actuality of the problem, the more frequent use of the veneers in the daily clinical practice requires clarification and a clear definition of the type of preparation that will improve the features of the fixed prosthetics.

Porcelain veneers are biocompatible with stable colour and shape and minimal risk of gingival irritation (Coyne & Wilson [11], Shaini, Shortall & Marquis [12]). No other type of prosthetic therapy would save so much tooth substance such as porcelain veneers which also are characterised by great tolerance towards gingival tissues. In terms of aesthetics, porcelain veneers have all the necessary prerequisites for a highly aesthetic restoration. We can use them to correct not only the colour, but also the form and the position individually or on a group of teeth.

In our study, porcelain veneers of the central maxillary incision were made. However, the test was performed on stainless-steel metal abutments to standardise the samples. In this way, we also eliminated some of the disadvantages of natural teeth, such as variations in size, shape and individual structure conditioned by the patient's age [13], the place and the time of storing extracted teeth, and the strength of the adhesive bond on the biomechanical behavior of the porcelain veneer [14].

Most studies investigate the mechanical resistance of porcelain veneers cemented to natural teeth. Alghazzawi T. et al., [15] used resin abutments in their in vitro study instead of natural teeth. The elastic modulus of composite abutments (E = 12 GPa) is close to that of dentine (E = 18.6 GPa) and is significantly different from the metal (E = 200 GPa). But in those cases, during the test of the mechanical resistance of the porcelain veneers, a fracture of abutments appeared. According to Hui et al., [16], the strength values that cause the porcelain veneer fracture are higher if the test is done on natural teeth rather than on the composite abutments [17], [18], [19], [20], [21], [22], [23].

To eliminate this factor, we worked on metal abutments, which reduced the possibility of a fracture to a minimum. In this case, the adhesive bond with the composite cement [3] cannot be achieved.

The fracture resistance of one restoration is influenced by the material and the technique of production. In the literature, different values of the force that causes fracture of the porcelain veneer depending on the type of ceramics used, are found. At the same time, there are conflicting results on whether one preparation design is superior to others when it comes to the fracture resistance of these gracile fixed prosthetic constructions.

According to Hui et al., (1991) [16], the stress concentration is incisal in the untreated teeth and window preparation. In cases where the incisal edge is involved, stress is distributed through the tooth.

Most in vitro tests for crown fracture [24] found that the fracture occurred at the point of pressure [25] on the test machine. It was concluded that occlusal force causes a fracture [26], [27] in porcelain crowns at the contact spot and provided the basis for many in vitro tests [28] and analyses [29], [30]. However, the type and localisation of the occurred change in clinical function [31] does not always coincide with those obtained in vitro findings [25], [32], [33].

Analysis of the type of change that occurs during the fracture of porcelain veneers showed different types of failure for different ceramic materials. In 50%, a cervical fracture of the tooth itself appeared, without the porcelain veneer being damaged. The type of change in YPSC (partially stabilised zirconium dioxide) in 100% of the samples is a cervical fracture of the tooth [34]. The cause may be the increased rigidity of the tooth and the material, causing a concentration of stress in the cervical part. Cervical fracture of incisors at static load is described by other authors [19], [20]. Zirconium veneers usually remained intact after the examination because they were able to resist the stress that is transferred from the tooth to the restoration. If strength exceeds the endurance limit of the tooth tissue, a tooth fracture occurs. Several studies have confirmed that stress is concentrated on the adhesive surface between composite cement [35] and enamel [36]. The shear strength causes movement of the veneer and effect of compressive stress in the weakest parts (incisal or gingival) [37]. This causes microcracks that propagate and affect the occurrence of fracture or debonding of porcelain veneers [38].

In conclusion, during the study, a statistically significant dependence was found between the localization of the occurred changes (incisal, gingival and combination) and the three different types of preparation.

In feather preparation, as a consequence of the mechanical force, the most common is the incisal localization (66.7%), followed by the combined (33.3%), while the gingival fracture localization is not registered.

In bevel preparation, the most common fracture localization is combined (53.6%), followed by incisal (35.7%) and subsequent gingival localization (10.7%).

In incisal overlap (palatal chamfer), combined and gingival localization of the fracture is equally recorded in 14.3% of the samples, while the incisal is the most common localization and is registered in 72.4%.

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