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Comparison of Fracture Resistance of Conventional Composite Veneers with Novel Veneer Preparation Design- In Vitro Study

Roma Zulfiqar[1*], Fazal Ur Rehman Qazi[1], Gobind Ram[2], Sajid Hussain[1], Naresh Kumar[3], Shuja Aslam[4] and Junaid Mahmood[5]

[1]Department of Operative Dentistry and Endodontic, Dr. Ishrat Ul Ebad Khan Institute of Oral Health Sciences, Dow University of Health Sciences, Karachi, Pakistan
[2]Department of Oral and Maxillofacial Surgery, Dr. Ishrat Ul Ebad Khan Institute of Oral Health Sciences, Dow University of Health Sciences, Karachi, Pakistan
[3]Department of Operative Dentistry and Endodontics, Bhitai Dental and Medical College, Mirpurkhas, Pakistan
[4]Department of Operative Dentistry and Endodontics, Muhammad Dental College, Mirpurkhas, Pakistan
[5]Applied Chemistry Research Center, Pakistan Council of Scientific and Industrial Research Labs Complex, Karachi, Pakistan

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***Corresponding Author:**
Roma Zulfiqar
Department of Operative Dentistry and Endodontics, Dr. Ishrat Ul Ebad Khan Institute of Oral Health Sciences, Dow University of Health Sciences, Karachi, Pakistan
aquraius04@gmail.com

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ABSTRACT

The patient's primary concern or need for good and pleasing esthetics of anterior teeth has increased. With the progression in the restorative field, multiple treatment options exist for patients' complaints. Composite veneering is one of the suitable and an appropriate treatment option with classic properties that is a good mechanical property, bend strength, abrasion resistance, and longevity of direct anterior restoration. **Objectives:** To compare fracture resistance of conventional and novel veneer preparation (a modified form of feather edge preparation)design in the indirect composite veneer method. **Methods:** In Vitro, a comparative study was conducted at the Department of Operative Dentistry and Endodontics Dr. Ishrat Ul Ebad Khan Institute of Oral Health Sciences, Dow University of Health Sciences Karachi time duration of six months by using a non-probability consecutive sampling technique. Data analysis was performed using SPSS version 26.0. The independent sample T-test was applied to compare the fracture resistance between the two procedures. **Results:** In terms of fracture load performance, the Conventional Veneer group had an average fracture load of 309.7 ± 126.3 N, compared to 335.5 ± 136.14 N in the Novel Veneer group. Although the Novel Veneer group showed a higher mean fracture load, this difference was statistically significant (p=0.005). **Conclusion:** It was concluded that increasing fracture resistance of the prepared materials with new preparation designs trends in the present study, however, the obtained data were statistically significant(p-value 0.005).

INTRODUCTION

The fracture resistance of composite veneers is one of the significant parameters that affect the effectiveness and durability of rehabilitative dental interventions [1]. As the need for cosmetic dental treatments grows, there is a consequent trend towards composite veneers as an option for restoring anterior teeth [2]. However, the ideal bond strength as well as resistance to fracture is crucial for the longevity of these veneers. The various preparation designs of the tooth have been investigated to establish if they improve or alter the composite veneer's fracture resistance – conventional and novel designs [3, 4]. These preparation designs can substantially alter the biomechanical functionalities of the veneers and consequently distinguish the degree of the fracture. Among properties, fracture resistance is considered to be critical for defining the stability of the dental veneers [5].

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There is a strong relation between a patient's dental appearance and psycho-social status, hence choosing the appropriate restoration to upgrade the patient's esthetics, likewise, it emphatically affects the patient's self-confidence and lifestyle [6, 7]. Naturally malformed teeth such as enamel hypoplasia, peg-shaped lateral incisors, sensitivity due to hypo-mineralization, abrasion, and erosion in all these cases composite veneer gives good results [8-10]. A veneer is a shell with a fine and shiny surface. Composite veneers can be used directly and indirectly called direct composite veneer and indirect composite veneer, respectively. Direct composite veneer requires minimal preparation of tooth surface and composite material is directly used on the prepared tooth surface and cured by composite curing light (LED). Indirect composite veneer on the other hand is fabricated in the laboratory on a die prepared on the silicone impression taken from the patient's mouth and then bonded to the prepared tooth structure with the help of different resin cements [11-13]. The properly performed composite veneer gives the patient satisfactory results [14-16]. Composite veneers have a common and significant problem of debonding and fracture of veneer. In this study, a novel veneer preparation was used and compared with conventional veneer preparation to overcome major issues of deboning and fracture strength.

This study aims to introduce novel methodologies or preparation designs that haven't been explored previously. This could include differences in material composition, preparation techniques, or testing protocols. While this study might address the long-term durability and performance of the veneers.

METHODS

In Vitro Comparative Study was conducted at the Department of Operative Dentistry and Endodontics Dr. Ishrat Ul Ebad Khan Institute of Oral Health Sciences, Dow University of Health Sciences Karachi and the duration of the study was six months (18th January to 17th July 2023) after approval from the research ethics committee of Dow university of health sciences (IRB-2791/DUHS/EXEMPTION/2022/16). Samples were collected from the Oral and Maxillofacial Surgery Department. Veneer preparation was done at the Department of Operative Dentistry and Endodontics, while a strength testing test was performed at the Pakistan Council of Scientific and Industrial Research (PCSIR)Laboratory Complex, Karachi, Pakistan. Patient selection was made at the time of extraction of teeth for study purposes, based on patients having ages of 20 to 60 years, periodontal compromised anterior teeth, and extraction due to trauma, staining, and RCT failure of anterior teeth. Veneer includes properly cured and without defect, marginal or surface discrepancy were included and patients having developmental defects, hypoplastic tooth, carious tooth, and worn out tooth were excluded and veneer excludes teeth not able to lute properly and broken during luting. Inclusion criteria were based on anterior teeth, premolars were included and the study excluded individuals with developmental defects, hypo-plastic teeth, and grossly carious teeth. The sample size was calculated from an online calculator open Epi using pass version 15 based on a 95% confidence interval and 96% power of the test.Mean $\pm$ SD of fracture load [1] unconventional preparation (100.6 $\pm$ 7.956) fracture load in slot preparation (107.4 $\pm$ 6.804) https://eprints.ugd.edu.mk/id/eprint/16325. The sample size was 16 per group, but now it has increased to 30 per group for strong study results and non-responders, etc. Non-probability sampling technique was applied for the selection of patients. A total number of 60 anterior teeth extraction patients attending the Oral and Maxillofacial Surgery Department of Dr. Ishrat Ul Ebad Khan Institute of Oral Health Science, fulfilling inclusion criteria were included in this study Written informed consent was taken from all the patients included in this study. Demographic details like name, age, gender, and address were noted. Extracted teeth were placed in a normal saline solution at room temperature until use. Teeth were randomly divided into two groups (n=30) with different veneer preparation designs. Conventional preparation and novel preparation (modified form of feather edge preparation by adding 2 slots 2x2 in diameter at the mesial and distal side of the tooth) Impression of prepared veneer was taken with light body and heavy body (hydrophilic vinyl poly-siloxane material, ISO 4823 TYPE 0) impression material and models made. Composite (light cure, radiopaque Nano-hybrid, IvoclarvivadentAG9494 Schaan) material was used for preparing veneer designs for restoration, according to the instructions of manufacturers. The polymerization of material was taken by curing unit (light emitting diode LED) in the wavelength range 400-500nm for 30 sec. Resin-based luting cements were used for bonding of veneer to prepare tooth structure. Thereafter, all specimens were arranged vertically. The fracture strength test was carried out at a constant speed of 5mm/min. Force was applied at the 45° angle to the long axis of the tooth. Fracture strength of all the teeth was noted at the given fracture load and data were statistically analyzed.The collected data were analyzed in the statistical program SPSS version 26. Mean ± standard deviation was evaluated for quantitative variables like the age of the patient. Frequency and percentage were calculated for qualitative variables like the patient's gender and the success of the veneers in terms of fracture. The independent sample T-test was applied to compare the fracture resistance between the two procedures.A

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surgical instrument was used to analyze the tooth. a) Novel veneer preparation (black arrows show slots on mesial & distal walls). b) the Depth of the slot is 2mm (using the Williams probe), c) the Depth of the prepared tooth is 0.5 mm (using the Williams probe) and d) Direct composite veneer preparation and cementation (Figure 1).

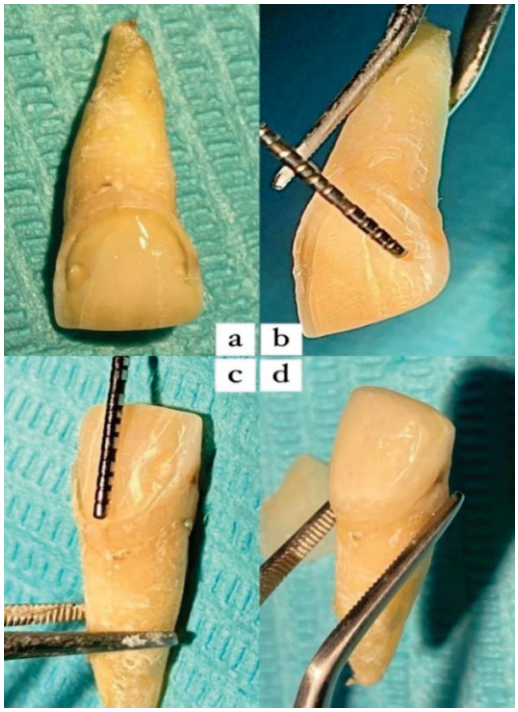

Figure 1: Analysis of Tooth

A fracture load was applied (cyclic/stress path triaxial system) in a testing machine (universal testing machine Instron 4301)(Figure 2).

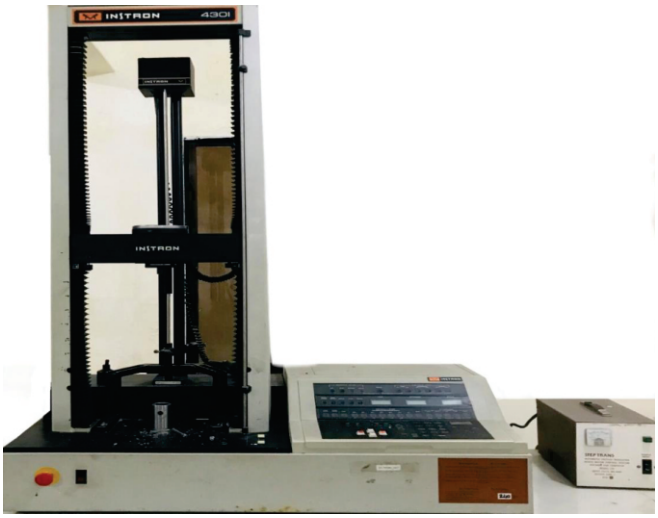

Figure 2: Instron 4301 Universal Testing Machine (Used for Tensile, Compression, Shear, Fatigue, Friction, and Flex Tests)

Novel prepared tooth cemented with indirect composite veneer by placing under Universal Testing Machine (Instron 4301)(Figure 3).

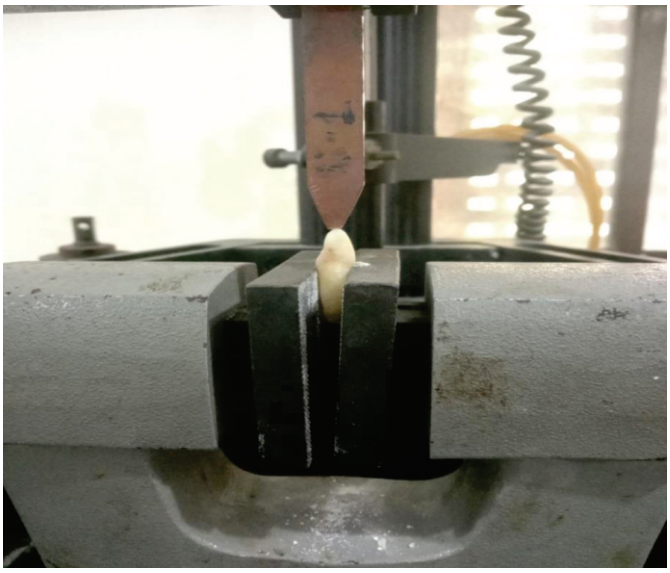

Figure 3: Novel Prepared Tooth Cemented with Indirect Composite Veneer Placed Under Universal Testing Machine (Instron 4301).

RESULTS

Results show the demographic parameters of the study participants. In this study, a total of 60 patients were divided equally between the two groups (n=30 for each). In this study, the demographic characteristics and fracture resistance of composite veneers with different preparation designs were compared between two groups of participants. The average age of participants in the Conventional Veneer group (n=30) was 52.46 ± 15.05 years, while the Novel Veneer group (n=30) had a slightly younger mean age of 46.03 ± 17.9 years. Regarding gender distribution, the Conventional Veneer group consisted of 13 males (43%) and 17 females (57%), whereas the Novel Veneer group included 14 males (46%) and 16 females (54%) as presented in table 1.

Table 1: Demographic Parameters of the Study Participants

Parameters	Conventional Veneer	Novel Veneer
Age	52.46 ± 15.05	46.03 ± 17.9
Gender		
Male	13 (43%)	14 (46%)
Female	17 (57%)	16 (54%)

Results show a comparison of fracture load between the two groups. In terms of fracture load performance, the Conventional Veneer group had an average fracture load of 309.7 ± 126.3 N, compared to 335.5 ± 136.14 N in the Novel Veneer group. Although the Novel Veneer group showed a higher mean fracture load, this difference was statistically significant (P=0.005) as presented in table 2.

Table 2: Comparison of Fracture Load between Two Groups

Parameters	Conventional Veneer (n=30)	Novel Veneer (n=30)	p-Value
Fracture Load	309.7 ± 126.3	335.5 ± 136.14	0.005

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DISCUSSION

Different research works have examined the effect of preparation design on composite veneers' fracture strength. For example, Huang *et al.*, concluded that a veneer preparation with a chamfered design provided significantly higher fracture resistance than that of a beveled edge design [17]. As well, other researchers have examined the factors influencing the fracture strength of veneered teeth such as the depth of tooth preparation and the design of the veneering margin [18]. A recent study by Nabil *et al.*, highlighted that the new preparation methods including slot and groove can increase the bonding between the composite material and the tooth as the effect was on the fracture resistance [19].They mentioned the mean fracture load was about 100 N for the conventional preparations but the novel slot preparations were 107 N or more.These results indicate that it is possible to alter the mechanical properties of the composite veneer through changes in the preparation design. In another study, Tribst *et al.*, established that other factors that enhance the fracture resistance include; veneer thickness and also the right curing process [20].This is in line with information from other studies, which showed that veneer failure load dependency is determined by the preparation design, the choice of composite material,and bonding techniques. The study contributes to the existing knowledge about the effects of preparation design on the fracture toughness of the composite veneer.This study did not find any difference in the fracture load between the Conventional and Novel Veneer preparation groups, although the resulting trend supports the outcomes of prior studies. For instance, Bommanagoudar *et al.*,concluded from their study published in 2019 that preparation designs which they concluded as novel preparations including slot and groove configurations offered improved fracture resistance than the conventional chamfer preparations [21]. In their study they compare the mean fracture load of conventional designs being 320 N with novel preparations of 345 N, the latter was significantly different from the former at $p<0.05$. This indicated that although integration of new designs may increase fracture resistance, the actual value added cannot be measured easily due to sweeping elements of material, depth of preparation, adhesive methods, etc. Likewise, Zlatanovska *et al.*, compared the role of various preparation geometry on the fracture load of the composite veneer and noted that a chamfer preparation had significantly less fracture resistance of about 295 ± 110 N than that of slot preparation that was 355 ± 120 N ($p<0.05$) [22].The results of these analyses imply that in some cases, new geometries may reduce stress concentrations and distribute forces evenly across the veneer which could likely enhance the material's longevity. However, the present study in terms of mean Fracture load is at conventional preparations=309.7 ± 126.3 N and novel preparations=335.5 ± 136.14 N, in which the difference is statistically significant p-value=0005. Since the data obtained in this study displayed a high standard deviation, it might be the variability inherent to the samples that has affected the significance of the results compared to the specific design used in the study Thus, the effect of this novel design may be less pronounced or specific to certain circumstances than was previously described in other articles. Additional research also shows that the fracture toughness of veneers may be sensitive to bonding methods and curing duration.The study of Nagi *et al.*, revealed that better curing and higher bonding enhanced the fracture resistance with values higher than 360 N in the optimized methodologies irrespective of the preparation modality [23].Their results also suggest that the design of preparation might not always be sufficient to produce enhanced fractural toughness disregarding procedural effects. Further individual specific parameters, like prognosis in tooth shape and biting force, probably may affect the veneer preparation as demonstrated by Juncar *et al.*, [24]. In their work, they stated that design novelty described better patient outcomes inasmuch younger patients and patients with high force generation capacity attained means of 350N of fracture loads instead of 310 N in their counterparts; Old patients and low force generation patients as evidenced by the patient demographics and variability.

CONCLUSIONS

It was concluded that increasing fracture resistance of the prepared materials with new preparation designs trends in the present study, however, the obtained data was statistically significant between two groups (p-value0.005).The study has revealed Novel veneer preparation to be more reliable and consistent the Conventional Veneer.

Authors Contribution

Conceptualization: FURQ
Methodology: RZ, SH, SA, JM
Formal analysis: RZ,
Writing review and editing: FURQ, GR, NK, SA

All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

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