ORIGINAL RESEARCH PAPER

Volume-8 | Issue-4 | April-2019 | PRINT ISSN No 2277 - 8179

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

COMPARING THE MARGINAL DISCREPANCY AND FRACTURE RESISTANCE OF DIFFERENT CERAMIC VENEER PREPARATION DESIGNS AND ASSESMENT OF MICROTENSILE BOND STRENGTH BETWEEN NORMAL AND FLUOROSED TEETH – AN IN VITRO STUDY.

Dental Science

Dr. R. Himabindu MDS, Professor , Dept Of Prosthodontics, Gitam Dental College, Visakapatnam, A. P

Dr. B. Prasad* MDS, Gitam Dental College, Visakapatnam, A. P. *Corresponding Author

ABSTRACT

PURPOSE OF THE STUDY: To compare the marginal discrepancy and fracture resistance of porcelain laminate veneers fabricated with three different tooth preparation designs and assessment of micro tensile bond strength of veneers prepared on normal and fluorosed teeth with the same preparation design.

MATERIALS AND METHODOLOGY: 50 extracted maxillary teeth were collected, 40 normal and 10 fluorosed teeth. Three different preparation designs were chosen for 30 normal tooth samples. Group I (n=10) is with Window preparation design, Group II (n=10) with Butt joint preparation and Group III (n=10) with Incisal overlap design. Remaining 20 samples are to be tested for Micro Tensile Bond Strength between Group A (n=10, normal teeth) and Group B (n=10, fluorosed teeth) with only Incisal overlap design . Veneers were fabricated with IPS Empress Esthetic Ingots. The first 30 samples are tested with Stereomicroscope for assessment of marginal discrepancy followed by measurement of fracture resistance with Universal Testing Machine at an angle of 45^{0}. Micro Tensile Bond Strength is evaluated in between Normal and Fluorosed teeth with Universal Testing Machine.

RESULTS: Highest marginal discrepancy value of ceramic veneers was found in the Incisal overlap preparation (Group 3) at both incisal and cervical areas and least found with Butt joint preparation (Group 2). Fracture resistance was least in Window preparation (Group 1) and highest in Incisal overlap preparation (Group 3). There is statistically significant difference found between all the three groups. Values from Micro Tensile Bond Strength test between veneers on normal (group A) and fluorosed teeth (Group B) did not result in any statistical significant values .

CONCLUSION: Marginal discrepancy was minimal in Butt joint preparation. Fracture resistance was significant with Incisal overlap design though it had higher marginal discrepancy. Presence of fluorosis did not influence the bond strength values between normal and fluorosed teeth.

KEYWORDS

Porcelain or ceramic laminate veneers, Marginal discrepancy, Fracture resistance and Micro tensile bond strength .

INTRODUCTION

A porcelain laminate veneer is an thin shell of porcelain applied directly to the tooth surface.[1] In esthetic dentistry, laminates are used to restore the original color of the tooth, whereas veneers are used to change the original color of the tooth to make it look more natural.[2] The superior esthetics, good mechanical properties, and biocompatibility made porcelain a better material for fabrication of veneers.[3] Charles Pincus in 1938 introduced thin veneers with air-fired porcelain and attached them with denture adhesive powder.[4] The first commercial porcelain used as a veneer material in the year of 1983 by Horn.[5]

The main factors, which play a key role in the success of veneers, are the case selection, preparation design, type of material and manufacturing technique used, materials for adhesion of prosthesis and occlusal considerations.[6]

Indications for ceramic veneers are extreme discolorations, dental fluorosis, surface defects like attrition, abrasion and abfraction, midline diastema, hypodontia, incisal fractures, agenesis of lateral incisor, recently in cases of anterior guide rehabilitation [7].

Contraindications are limited crown structure, parafunctional habits, class III malocclusion conditions, young permanent teeth, crowded teeth, periodontally compromised conditions, and occlusal modifications.[7]

AIM : This study was done to evaluate the Marginal discrepancy and Fracture resistance of ceramic veneers with three different veneer preparation designs and also to assess the Microtensile bond strength of laminate veneers between normal and fluorosed teeth.

OBJECTIVES:

1. Comparison of Marginal discrepancy of ceramic veneers with 3 different preparation designs.
2. Comparison of Fracture resistance of ceramic veneers with 3 different preparation designs.
3. Comparison of Micro Tensile bond strength of ceramic veneers between normal teeth and fluorosed teeth with the same preparation design.

METHODOLOGY OF THE STUDY

50 extracted maxillary central incisors are selected, without any caries, defects , restorations or cracks. Out of 50 samples, 40 are normal teeth and 10 were fluorosed teeth. All the specimens have approximately similar crown length and fluorosed teeth are selected with moderate fluorosis. Exclusion criteria for the teeth collected were with decay; fracture, wear due to abrasion or erosion and restorations. After the selection of samples, they were cleaned with 3% Hydrogen Peroxide for a week to free tooth surfaces from stains and debris and stored in distilled water until testing.

Mounting of Specimens: All the 50 specimens were mounted individually in a PVC tube with standardized dimensions of 1× 1 inch with and soft cold cure acrylic resin (DPI) and long axis of all the specimens are coinciding at the center of the ring with the help of Dental Surveyor (Marathon) with the help of analyzing rod . (FIG 1)

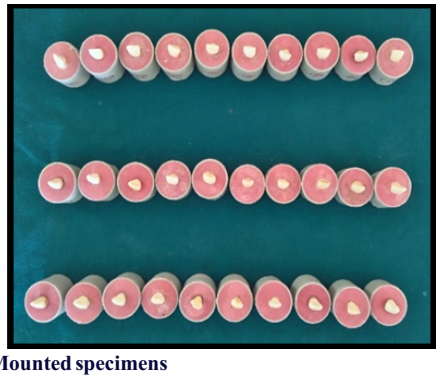


FIG 1: Mounted specimens

Tooth preparation : Silicone putty (Aquasil) impressions were made for every specimen before the tooth preparation, which helps in estimating amount of reduction during tooth preparation and also for fabrication of veneer with uniform thickness. Sectioning the silicone putty vertically helpful in assessment of amount of tooth reduction.

PREPARING THE TOOTH

Labial & Proximal reduction

Depth guiding burs (DW-11 for 0.3mm depth and DW-12 for 0.5mm depth) used for placement of horizontal depth cuts on the labial surface, 0.3 mm of reduction done at the cervical third region and 0.5mm at the middle and incisal thirds. Round end tapered diamond bur **(0835)** is used to join the grooves and the reduction was extended onto the proximal surface upto the contact area. Tooth preparation was

restricted to enamel only without any sharp line angles. A long chamfer finish line is placed at the level of cemento - enamel junction. Reduction is assessed with silicone index.

Incisal Reduction :

- For the **Window technique**, the labial surface reduction terminated at the incisal edge. There is no involvement of incisal edge or lingual preparation.
- For **Butt joint design**, incisal surface is reduced to 2mm with depth orientation grooves with round end tapered diamond (0835), bur is placed parallel to the incisal surface, and remaining tooth structure in between the groves is removed. Clearance is checked with silicone index.
- For **Incisal overlap design** also 2mm of incisal reduction is done with the placement of depth orientation groves. Clearance is checked with silicone index.

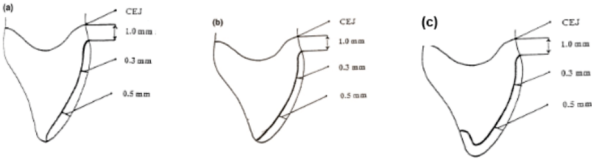


FIG -2 Schematic represenatation of window(a), Butt joint(b) and Incisal overlap preparation©

Lingual Reduction

This is done only for the Group **III**, Group **A** and **B** specimens **(Incisal overlap design)**. Lingual finish line is placed with a round end tapered diamond (0835), bur is held parallel to long axis of the lingual surface and reduce to a depth of 0.5mm. The final reduction was checked with silicone index.

Finishing the Preparation

All sharp angles were rounded off and finished using the fine grit diamonds burs (**RE1 and FL**). The finished preparation was then polished using polishing cup (**Ceramiste Ultra CA –1**) in the veneer preparation kit (**Shofu**). Burs are replaced after every three specimen preparations.

IMPRESSION MAKING

Impressions are made with a custom tray using dual technique with putty and light body material **(Aquasil) and** casts were poured with type IV Die stone **(GC Fujirock)**.

FABRICATION OF VENEERS

Ceramic veneers are fabricated with Leucite reinforced heat pressed ceramic (**IPS Empress**) following the manufacturer instructions. The dies were coated with two sealer (**Kerr**) layers 1mm short of the preparation margin. Then wax patterns (**Bego**) were prepared. 2.5mm of prefabricated sprue (**Surana**) placed at an angle of 45-60^{0}.

Investing

The IPS silicone ring was carefully positioned on the investment ring base without damaging the wax patterns and filled with investment material (powder to liquid ratio is 4:1) up to the marking. The investment material was allowed to set for a period of 30 minutes. The temperature of the preheating furnace was maintained at 850 °C (1562 °F). The **EP 600 furnace** was calibrated with the Automatic Temperature Checking Set 1.

Pressing: Before the preheating cycle for the investment ring ended the appropriate press program for IPS Empress and the respective investment ring size (**EP 600/EP 600 Combi**) was selected. The press temperature of the IPS Empress ingots was 1075 °C. (FIG- 3)

Divesting

Rough divestment was carried out with glass polishing beads at 4 bar (60 psi) pressure. Later for fine divestment, only 2 bar (30 psi) pressure is applied.

Finishing the Veneers

A fine diamond disk was used to cut the sprues at low speed using light pressure and sufficient irrigation. Then wash firing was done using the IPS Empress **Esthetic Veneer Wash paste**. The wash pastes were applied thinly to cover the entire restoration. The veneers were etched with **9% Hydrofluoric acid gel** (Ultradent) for 1 minute. The veneers were washed thoroughly with air/water spray for 30 seconds. Prior to the cementation procedure, the veneers were silanated . **Silanating agent** was applied for 60 seconds **(Ultradent)** and dried with air. (FIG-4)

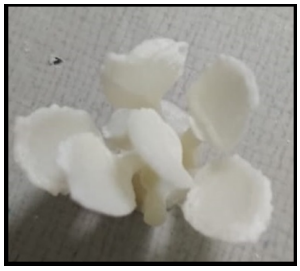


FIG 3: Ceramic veneers after pressing

FIG 4: Ceramic veneers after polishing and glazing

Cementation:

The bonding surface of the tooth was etched with 37% Phosphoric acid (Kerr) for 15 secs. After that it was thoroughly rinsed off with water spray and then the tooth was dried by blotting with moist cotton pellet. Silanating agent was applied on the intaglio surface of the etched veneer and uniformly dried by using a clean, dry stream of air. Then the bonding agent was applied on to the etched tooth surface and dried by using a clean, dry stream of air for 1-3 seconds. The bonding agent was also applied on to the intaglio surface of the etched and silanated veneer. A thin layer of composite resin cement was applied to the center of the intaglio surface of the veneer. Light finger pressure was exerted on the restoration until the cement polymerized. The excess composite resin luting agent was carefully removed. Light polymerization was performed according to the instructions of the manufacturer for 40 seconds on both the palatal and facial surfaces, using a light-emitting diode **(LED)** polymerizing unit **(Ivoclar Vivadent)**. The veneers were polished using rubber points polishing cups, pumice paste, and diamond polishing paste. Until testing, the specimens were stored in distilled water.

MEASURING MARGINAL DISCREPANCY

The obtained veneer samples were tested for marginal discrepancy. By using **Stereomicroscope** (LABOMED) equipped with a camera (Progress C3) with an image analysis software (PROGRESS 14 PLUS). This was done at four different points along the margins (mesiocervical, distocervical, mesioincisal and distoincisal margins). Marginal discrepancy was measured at all the four regions are examined under stereomicroscope for marginal discrepancy. On each area the maximum marginal opening was considered and the mean of marginal discrepancies at the cervical and incisal margins were obtained and it was termed to be the marginal discrepancy of each specimen(FIG-5). The obtained results were tabulated and statistical analysis is done.

MEASURING FRACTURE RESISTANCE

The specimens tested for marginal discrepancy were then subjected to Fracture resistance test. Compressive pressure has been applied at a crosshead rate of 0.5mm/min using a ball-ended plunger touching the palatal surface of tooth at an angle of 45^{0}(FIG-6). Testing for fracture resistance was done using Universal Testing Machine (Instron 8801). The results obtained were tabulated and statistical analysis is done.

MEASUREMENT OF MICROTENSILE BOND STRENGTH

MTBS is measured for 10 samples of ceramic veneers, each on normal and fluorosed teeth. Composite material is bonded onto the labial surface of the veneer and a metal ceramic bracket is adhered on top of it. All the samples are tested using Universal Testing Machine (Instron 8801) until debonded (FIG-7). The results obtained were tabulated and statistical analysis was done.

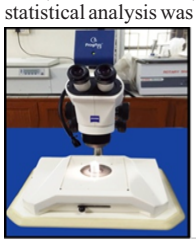
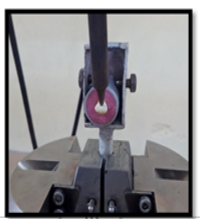
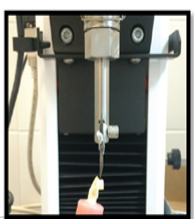
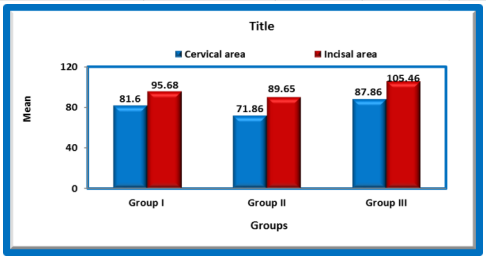




FIG-5: Specimen placed in Stereomicroscope
FIG-6 : Sample placed at an angle of 45^{0} in UTM
FIG-7: Assessment of Micro Tensile Bond Strength

Table 1& Graph 1: Comparison of Marginal discrepancy between **Group I** (n=10) (window preparation), **Group II** (n=10) (Butt joint preparation) and **Group III** n=10) (Incisal overlap preparation) at **Incisal Margin and Cervical margin.**

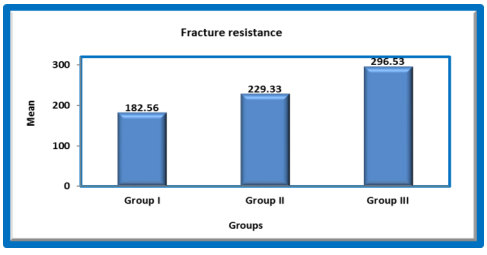
Groups		Mean	SD	P-value
Window preparation	Cervical area	81.60	8.09	<0.01*
	Incisal area	95.68	6.77	
Butt joint preparation	Cervical area	71.86	7.41	<0.01*
	Incisal area	89.65	6.33	
Incisal overlap preparation	Cervical area	87.86	6.25	<0.01*
	Incisal area	105.46	8.62	



The above table and graph shows that the mean values of samples in group I, II and III by ANOVA test. A significant difference (p< 0.01%) is observed in between Group I, Group II and Group III at the incisal and cervical region. Highest marginal discrepancy was seen in group III and least in Group II design. The decreasing order of marginal discrepancy is Group III > I>II.

Table 2 and Graph 2: Comparison of Fracture resistance between Group I (Window preparation), Group II (Butt joint preparation) and Group III (Incisal overlap preparation).

Groups	N	Minimum	Maximum	Mean	SD	P-value
Window preparation	10	26.10	329.02	182.56	97.23	0.04*
Butt joint preparation	10	83.26	411.75	229.33	109.20	
Incisal overlap preparation	10	139.57	392.57	296.53	86.18	

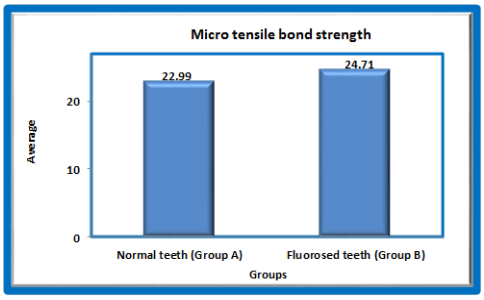


A significant difference (p=0.04) is observed in between Group I, Group II and Group III.

- Highest fracture resistance was seen in Group III and least in Group I design.
- The increasing order of fracture resistance is Group I>Group II>Group III.

Table 3 and Graph 3: Comparison of Micro Tensile Bond Strength between Normal and Fluorosed teeth.

Groups	Micro Tensile Bond Strength		P-value
	Mean	Standard Deviation	
Normal teeth (Group A)	22.99	2.59	0.19
Fluorosed teeth (Group B)	24.71	3.04	



There is no statistical significance present between the two groups, but relatively higher values of MTBS are present in fluorosed teeth(Group B) than normal teeth(Group A) after **independent t test .**

RESULTS

The mean value of marginal discrepancy at incisal area

1. For Group I (Window preparation) – 81.60
2. For Group II (Butt joint preparation) – 71.86
3. For Group III (Incisal overlap preparation) – 87.86

The mean value of marginal discrepancy at cervical area

1. For Group I (Window preparation) – 95.68
2. For Group II (Butt joint preparation) – 89.65
3. For Group III (Incisal overlap preparation) – 105.46

Highest fracture resistance was seen in Group III and least in Group I design

No statistical significance present between the two groups, but relatively higher values of MTBS are present in fluorosed teeth(Group B) than normal teeth(Group A) after independent t test .

DISCUSSION-

Ceramic veneers are thin bonded prosthesis prepared on labial and proximal surface of anterior teeth with a minimal reduction.[8] Evolution of new ceramic materials, advanced techniques, adhesives and armamentarium available for tooth preparation made ceramic veneers, a better option for a minimally invasive approach to enhance esthetic appearance.[9] Ceramic veneers are considered as the best treatment plan for an esthetic procedure not only because of the conservative nature of preparation but also they leave the intact enamel.[10]

Veneers have a good survival rate of approximately 93% observed in a time period of 15 years [11] The most common complications with Porcelain Laminate Veneers observed in the clinical practice are **fracture of veneers marginal discrepancy and debonding**[12]. The present study is to compare the marginal discrepancy and fracture resistance of ceramic veneers with three different preparation designs and to assess the variation in micro-tensile bond strength of ceramic veneers between normal and fluorosed teeth.

MARGINAL DISCREPANCY - Diedrich and Erpenstein defined the marginal gap as the space between the restoration margin and external preparation margin.[13]Marginal discrepancy results in severe sensitivity because of the exposed dentinal tubules . It can also lead to plaque accumulation and food debris at the restoration margins leading to periodontal breakdown around the exposed restorative margins of the abutment teeth.[14]Marginal discrepancy is measured at the cervical and incisal regions for all the preparation designs. Precise marginal adaptation is always important because it plays a key role in the successful treatment.

Greater than 0.5mm of tooth reduction can results in dentinal exposure which may lead to risk of losing marginal seal.[15] The amount of reduction is standardized with use of 0.3mm and 0.5mm depth grooves at the cervical and incisal regions respectively. In this study marginal discrepancy is measured with stereomicroscope by direct view at the cervical and incisal margins after cementation . Highest marginal discrepancy was seen in **Group III (incisal overlap)** and least in **Group II** (butt joint).

Other studies which have findings similar with the present study are as follows . Hekimoglu et al.[16] in their study concluded that **Window preparation** showed less amount of micro leakage than the **Incisal overlap preparation** and more amount marginal discrepancy is observed at the cervical region than at the incisal region may be because of deviation in the orientation of enamel prism and the enamel . Based on the survival rates of ceramic restorations 100 to 150 µm of marginal discrepancy was considered as a clinically acceptable value.[17] In this study all also the values of marginal discrepancy are in the range of clinically acceptable value. Stappert et al.[18] showed the highest marginal discrepancy is reported in group III(Incisal overlap preparation) and least in group II (Butt joint preparation) and this is in correlation with this study.

Mirra et al.[19] in their study concluded that microleakage is more of cervical than at the incisal area and high at the palatal margin in incisal

overlap preparation than feather edge and butt joint preparation which correlate with the present study. In contrast Al-Dwairi et al.[20] in their study concluded that cervical margins showed lowest absolute marginal discrepancy than at the incisal margin. Ranganathan et al.[21] also concluded that least marginal discrepancy is observed in cervical area than at the incisal area. These findings are inconsistent with this study.

FRACTURE RESISTANCE - Friedmann reported that 67% of the failures in the ceramic veneers are fractures.[11] Ceramic veneers are more prone to failure when they are subjected to more amount of tensile loads.[22] Different preparation designs resulted in varied stress distribution.[23]For these reasons three commonly used preparation designs are considered in this study to evaluate the fracture resistance of ceramic veneers, which are Window preparation, butt joint preparation and incisal overlap preparation. Incisal overlap showed better fracture resistance than other preparations.

Jankar et al.[22] stated that highest fracture resistance in Palatal overlap preparation may be due to increased surface area for bonding of ceramic veneer and also Palatal overlap preparation prevents the torquing forces in the incisal area of veneer to the below tooth surface. They also stated that preservation of enamel at the peripheral layer of the prepared tooth surface, which helps in counter acting the shear stresses and also allow definitive path of cementation.

De Andrade et al.[24] stated that incisal overlap preparation is thrice effective than feather edge preparation in intake of axial forces. Study done by shetty et al.[25] showed that palatal overlap design have higher fracture resistance and ability to dispense force more effectively than the natural teeth. Study done by Mustafa et al.[26]also showed that ceramic veneers prepared with incisal overlap has highest fracture resistance than window and feather edge preparation. These findings are similar with this study. Similar results are obtained with Mirra et al..[19]. Prasanth et al.[27] concluded that feather edge design has highest fracture resistance than butt joint and overlap preparation as more amount enamel is present which contradicts with this study . But in clinical practice less fracture are reported for incisal overlap. Calamia et al.[28] stated that window preparation shown more fracture resistance than preparation involving the incisal edges.

MICROTENSILE BOND STRENGTH- In this study Micro tensile bond strength test is preferred over shear bond test as it most accepted technique for measuring the bond strength.[29] MTBS is challenging procedure because of the brittleness of the ceramics and also having the low tensile strength.[30]The advantages of the micro tensile bond strength test are that force is applied in a more perpendicular manner, the testing interface is uniformly distributed, which resulted in more accurate estimation of the bond strength.[31]

MTBS mean values for normal teeth with veneer is 22.9 and fluorosed teeth is 24.1 which are similar to studies of Vidolitti etal.[32].The results shows that **no statistical significance was observed between the normal and fluorosed teeth**. But relatively higher values observed for fluorosed samples which may be due to presence of fluro-hydroxyapatite crystals which increases the surface bonding capacity by creating more resin tags.

SUMMARY

Within the limitations of the study, it was evaluated that

1. High value of marginal discrepancy was observed in Incisal overlap preparation followed by window preparation and least in Butt joint preparation. Marginal discrepancy is more at the cervical area than the incisal area in all the preparatory designs.
2. High value of fracture resistance was observed in Incisal overlap preparation followed by Butt joint preparation and least values were observed for Window preparation.
3. Slightly higher values were observed for micro tensile bond strength in ceramic veneers on fluorosed teeth when compared to normal teeth but the difference is statistically insignificant .

CONCLUSION

From this study it can be concluded that Butt joint veneer preparation exhibit higher fracture resistance and less marginal discrepancy so considered to be a better preparation design . Fluorosed teeth exhibit slightly higher micro tensile bond strength than normal teeth.

REFERENCES

1. McLaughlin K, Morrison J E. Porcelain fused to tooth-The state of the art. Restorative Dent 1988; 5: 430-435.
2. Sandesh M Mayekar , Shades of a colour – illusion or reality?. DCNA. January 2001, 45 (1) 155 -173.
3. Highton R, Caputo AA, Mátyás J. A photoelastic study of stresses on porcelain laminate preparations. J Prosthet Dent 1987;58:157-61.
4. Pincus CR. Building mouth personality. Journal of South California Dental Association 1938;14:125-9.
5. Horn H: A new lamination: Porcelain bonded to enamel. NY State Dent J 1983;49:401-403.
6. Arora A, Upadhyaya V, Arora SJ, Jain P, Yadav A. Evaluation of fracture resistance of ceramic veneers with different preparation designs and loading conditions: An in vitro study. J Indian ProsthodontSoc 2017;17:325-31.
7. Dhanda M, Srivastava M, Dobhal A, Sharma N. Ceramic laminate veneers: a conservative approach to esthetics. Ijds 2011;3:20-22.
8. The glossary of Prosthodontics. J Prosthet Dent. 2017;117:E70
9. Radz GM. Minimum thickness anterior porcelain restorations. Dent Clin North Am. 2011; 55(2):353–370.
10. Pini NP, Aguiar FHB, Lima DAN, Lovadino JR, Terada RS, Pascotto RC. Advances in dental veneers: materials, applications and techniques. Clinical, Cosmetic and Investigational Dentistry 2012;4:9-16.
11. Friedman MJ. A 15-year review of porcelain veneer failure: a clinician's observations. Compendium of continuing education in dentistry 1998; 19(6): 625-8.
12. Alghazzawi TF1, Lemons J, Liu PR, Essig ME, Janowski GM. The failure load of CAD/CAM generated zirconia and glass-ceramic laminate veneers with different preparation designs. J Prosthet Dent 2012; 108(6): 386-93.
13. Diedrich P, Erpenstein H. Scanning electron optical analysis of the marginal space of in vivo incorporated shoulder crowns and inlays. Schweiz MonatsschrZahnmed 1985; 95: 575- 586. (In German).
14. Tan PL, Gratton DG, Diaz-Arnold AM, Holmes DC. An in vitro comparison of [3] vertical marginal gaps of CAD/CAM titanium and conventional cast restorations. J Prosthodont. 2008;17(5):378-83.
15. Ferrari M, Patroni S, Balleri P. Measurement of enamel thickness in relation to reduction for etched laminate veneers. Int J Periodontics Restorative Dent 1992; 12:407–13.
16. Hekimoglu, C & Anil, N &Yalçin, E. (2004). A microleakage study of ceramic laminate veneers by autoradiography: Effect of incisal edge preparation. Journal of oral rehabilitation. 31. 265-9.
17. Zaimoglu A, Karaagac¸lioglu L, U c¸tas¸li S. Influence of porcelain materials and composite luting resin on microleakage of porcelain veneers. J Oral Rehabil. 1992;19:319.
18. Stappert, Christian &Ozden, Ummuhan&Att, Wael&Gerds, Thomas &Strub, Joerg. (2007). Marginal accuracy of press-ceramic veneers influenced by preparation design and fatigue. American journal of dentistry. 20. 380-4.
19. Mirra G, El-Mahalawy S. Fracture Strength and Microleakage of Laminate Veneers. Cairo Dent J, 2009; 25:245-254
20. AL-Dwairi, Professor Ziad& M. Alkhatatbeh, Rana & Baba, Nadim&Goodacre, Charles. (2018). A comparison of the marginal and internal fit of porcelain laminate veneers fabricated by pressing and CAD-CAM milling and cemented with 2 different resin cements. The Journal of Prosthetic Dentistry. 10.1016/j.prosdent.2018.04.008.
21. Ranganathan H, Ganapathy DM, Jain AR. Cervical and incisal marginal discrepancy in ceramic laminate veneering materials: A SEM analysis. ContempClin Dent 2017;8:272
22. Jankar AS, Kale Y, Kangane S, Ambekar A, Sinha M, Chaware S. Comparative evaluation of fracture resistance of ceramic veneer with three different incisal design preparations: an in-vitro study. J Int Oral Health. 2014;6(1):48-54.
23. Seymour KG, Cherukara GP, Samarawickrama DY. Stresses within porcelain veneers and the composite lute using different preparation designs. J Prosthodont. 2001 Mar, 10(1):16-21.
24. De Andrade OS, Hirata R, Celestrino M, Seto M, Siqueira S, Jr., Nahas R. Ultimate ceramic veneer: a laboratory-guided preparation technique for minimally invasive laminate veneers. J Calif Dent Assoc 2012;40:489-494.
25. Shetty A, Kaiwar A, Shubhashini N, Ashwini P, Naveen D, Adarsha M, et al. Survival rates of porcelain laminate restoration based on different incisal preparation designs: An analysis. Journal of conservative dentistry : JCD 2011;14:10-15.
26. Mustafa Duzyol, EsraDuzyol, and NilgunSeven, "Fracture Resistance of Laminate Veneers Made with Different Cutting and Preparation Techniques." International Journal of Dental Sciences and Research, vol. 4, no. 3 (2016): 42-48.
27. Prasanth V, Harshkumar K, Lylajam S, Chandrasekharan NK, Sreelal T. Relation between fracture load and tooth preparation of ceramic veneers - An in vitro study. Health Sci 2013;2:1-11.
28. Calamia JR. Materials and technique for etched porcelain facial veneers. The Alpha omegan 1988;81:48-51.
29. Jalali H, Bahrani Z, Zeighami S. Effect of Repeated Firings on Microtensile Bond Strength of Bi-layered Lithium Disilicate Ceramics (e.max CAD and e.max Press). J Contemp Dent Pract 2016;17(7):530-535.
30. Trindade FZ, Amaral M, Melo RM, Bottino MA, Valandro LF. Zirconia-porcelain bonding: effect of multiple firings on microtensile bond strength. J Adhes Dent 2013 Oct;15(5): 467-472
31. Aboushelib, Moustafa&Elmahy, Waleed &Ghazy, Mohamed. (2012). Internal adaptation, marginal accuracy and microleakage of a pressableversus a machinable ceramic laminate veneers. Journal of dentistry. 40. 670-7.
32. Vidotti HA, Garcia RP, Conti PC, Pereira JR, Valle AL. Influence of low concentration acid treatment on lithium disilicate core/veneer ceramic bond strength. J ClinExp Dent 2013 Oct 1;5(4):e157-e162.