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Fracture resistance of Zirconia Laminate Veneer Restorations for Mandibular incisor with Butt Joint and Overlapped Incisal Preparation Designs

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ABSTRACT:

Statement of problem: laminate veneer in lower anterior teeth is limited with littlethickness of enamel, little available surface areaand small thickness of final ceramic restorationwhich is subjected to occlusal force.The purpose of this in vitro study was to evaluate the effect of using different incisal preparation designs on fracture resistance of monolithic zirconialaminate veneer restorations on lower incisors.

KEYWORDS: Mandibular anterior teeth, Lower incisors, Laminate veneer, Ceramics, Resin Cement, Fracture resistance test

I. INTRODUCTION

Ceramic laminateveneers are one of conservative procedures for restoration of anterior teeth as it provides excellent aesthetic and restore the function with minimal tooth reduction, the first indications for laminate restoration were amelogenesis imperfecta, intrinsic staining and anatomically malformed teeth, while the contraindications were teeth in an edge-to-edge or cross-bite relationship, severely discoloured teeth, and lack of enamel remaining to support the restoration.

Laminate veneers in lower anterior teeth areachallenging situation because of its important role in anterior guidance as they are subjected to significant occlusal force during function. In addition, there is less enamel thickness available for bonding. Changing the vertical dimension of the lower anterior teeth after restoration with laminate veneer will affect pronunciation of the patient and may lead to speech problems. The surface area which is needed for bonding is much less than that of upper anterior teeth. Also, shrinkage during sintering may have adverse effect on incisal adaptation which may not fit properly. Thus, limitations are in materials of choice.

Zirconia ceramics have excellent biocompatibility and superior mechanical properties which make them a material of choice in prosthetic dentistry nevertheless they have not been used for laminate veneers because of the opaqueness and low translucency. However, recently highly translucent zirconia ceramics have been developed by altering the microstructure and composition of the material.

Fracture resistance is defined as the ultimate stress necessary to cause fracture or plastic deformation and is strongly affected by the size of flaws and defects present on the surface of the tested materials. several factors affect fracture resistance of all ceramic restorations such as material type, preparation design, thickness, cement, luting technique, substrates and tooth type.

II. MATERIALS AND METHOD

Simulation of periodontal ligament of natural teeth by dipping the root of tooth 2 mm away from the cementoenamel junction located by using a calliper (Digital Vernier calliper, Generic, China) into molten wax at a temperature of 110˚C and left until hardened. This resulted in the formation of an approximately 0.2-0.3 mm layer of wax.[1]

Construction of acrylic resin blocks by using a specially designed centralizing device which was obtained from Fixed Prosthodontics Department, Faculty of Dentistry, Mansoura-University to confirm accurate centralization of teeth in acrylic resin blocks. Tooth was fixed in the vertical rod by orthodontic Relief wax (Ortho organizers, Lindenberg, Germany). Acrylic resin (Acrostone cold cure, Cairo, Egypt)was prepared by mixing of powder and liquid according to manufacturer's instructions, then slowly poured into the mold in the centralization device till the same level of the wax. The acrylic resin block was left until complete hardening and then the block was removed from the device.

Before tooth preparation, Addition silicon impression material (Presigum light body fast set President Dental, Germany) was used to make an index as template to evaluate the amount of tooth reduction at incisal surface, finish line and labial surface. The uniform mix was inserted by its injecting tip within the special device and the tooth was put in the center of the mix of impression material vertically until complete setting, then the index was cut in labiolingual direction by a scalpel blade no. 11 into two equal halves

Study grouping

Specimens (n=16) were randomly divided into two main groups(n=8) according to the design of the incisal preparation

Group ZB: Butt joint with zirconia

Group ZO: Incisal Overlap reduction with zirconia

Incisal preparation

The teeth were grouped into two groups according to incisal preparation:

1) Butt joint incisal preparation 90^o angulation was done by dental survey. By using water proof marker (DOUBLE-MARKER, M&G, Beijing, China) make a line in depth of 1.5mm from incisal edge. Prepare horizontally along the line with double sided cutting diamond dental lap disc fixed vertically in the surveyor with the

2) Incisal overlap preparation design with chamfer finish line was done by dental survey. By using water proof marker (DOUBLE-MARKER, M&G, Beijing, China) make a line in depth of 1.5mm from incisal edge. Prepare along the line with double sided cutting diamond dental lap disc fixed in the surveyor vertically with the straight hand piece Then two depth groove 0.5 mm reduction on the lingual surface were down from the incisal preparation line then prepared with safe end stone. Check the preparation design with its own index. Axial preparation was 0.5mm reduction depth was done for the remaining surfaces

Hot water was used to remove the wax from the roots and acrylic resin blocks after the abutment teeth were removed from the acrylic resin blocks. Drying the abutment and the block. A thin layer of adhesive (identium, adhesive, Kettenbach GmbH, Germany) was applied to both the root and the inside of the acrylic resin block and allowed to cure for 5 minutes.

Injection of additional silicon light body (Silaxil light body base, Enesyl catalyst, Lascoda, Italy) into the acrylic resin block, followed by inserting and pressing the abutments into the acrylic resin block. After final setting, the extra out material was removed with a scalpel

Fabrication of laminate veneer

This CAD/CAM system is made up of two independent parts: a milling unit (Ceramill motion 2, AMANNGIRBACH, Austria) and a scanning (Shining 3D auto scan DS-EX Pro, Micron dental). The following laminate veneer fabrication stages were carried out in accordance with the manufacturer's instructions. Scanning of the abutments and designing of the restorations

The prepared abutment teeth were scanned using an extraoral scanner (Shining 3D auto scan DS-EX Pro, Micron dental, China.) but first an antireflection spray called (Occlutec no.19350000) was applied to aid in the optical impression. Numerous photos were collected from various angles, and all images were calculated together to provide the final image of the specimen. This images ware saved in the catalogue of the software (ExoCAD, GmbH, Darmstadt, Germany) as 3D virtual models

Millig and glazing

Super high translucent zirconia (Zolid fx)zirconia blank was fixed in milling machine holder. The laminate veneers and their sprues were dispensed on the disk. The CAM software was used to mill veneers by the milling machine (Ceramill motion 2, Amanngirbach, Austria). Sprues were separated and finished. The veneers were sintered by zirconia oven (Mihm-Vogt Tabeo, GmbH, Germany) according to the manufacturer's instructions by raising of the temperature to 1450˚C with the rate of 8˚C/min within approximately 3 hours and holding time for 2 hours, and then cooling to room temperature with the rate of -8˚C/min and then glazing was carried out. After finishing of veneers, checking it with caliper at cervical, middle and incisal thirds to verify of 0.5 mm at middle and cervical thirds and 1.5 mm at incisal.

Surface treatment of the restorations was done by air-borne particle abrasion of fitting surface of laminate veneers with Al_2O_3 of 50 µm in diameter at 0.2 MPa of pressure for 10 seconds from a distance of 10 mm perpendicularly by sandblaster (Renfert Gmbh, Untere Giesswiesen 2, Germany). All specimens were cleaned with ultrasonic (Ultrasonic cleaner, Jeken, China) after sandblasting for 5minutes. Zirconia priming agent (Monobond N, Ivoclar Vivadent, Liechtenstein, Germany) was applied in the internal surface by using micro brush and rubbing for 60 seconds then dried gently for 5 seconds

The cemented restorations were subjected to thermocycling (Thermocycler SD Mechatronik, Feldkirchen-Westerham, Germany) to simulate oral conditions. The specimens were subjected to 10,000 cycles in temperature between 5˚C and 55˚C to simulate one year in oral cavity. Each cycle consists of cold-water 5˚C for 30 seconds, then

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Transport time for 10 seconds and then hot-water 55˚C for 30 seconds.

A chewing simulation machine (Chewing simulator, CS4, SD Mechatronik, Feldkirchen-Westerham, Germany) was used to apply cyclic loading fatigue. Specimens were subjected to 120,000 repeated mechanical cycles to simulate 6 months in the oral cavity. The specimens were fixed vertically in the testing chamber. 50N Load was applied with steatite antagonist of 6mm diameter mm. Load was applied vertical to the middle of the incisal edge with ascending speed 60mm/s, descending speed 40mm/s and mouth opening 2mm to simulate clinical condition

Fracture resistance test was performed by Universal testing machine (Model 3345, Instron, USA). The specimens were inserted vertically with long axis of the testing arm. Tin foil was inserted between the tooth and indenter to dispense the load.[2, 3]

The indenter was a chisel blade was placed on the incisal edge of the laminate veneer and load application was carried out at cross head speed of 0.5 mm/min till the fracture of veneer and drop of the reading occurred. Then the data was recorded in newton using software

III. RESULTS

All specimens were survived after thermocycling load aging. It was illustrated that highest mean load value among the monolithic zirconia group was detected for OZ group (840.50 ±162.16 N), then BZ group (595.46 ±124.35 N) . Post Hoc Tukey testshowed that there was no significant difference between the two designs.

IV. DISCUSSION

According to the results of our study, the first null hypothesis of this study was incisal preparation designs will have no effect on fracture resistance of ceramic laminate veneers of lower incisors. This null hypothesis is rejected as it showed statistically significant difference between all groups within the monolithic zirconia

In this study mandibular incisor was selected because of its important role in anterior guidance as it is subjected to significant occlusal force during function.[4] In addition, there is less enamel thickness available for bonding. The surface area which is needed for bonding is much less than that of upper anterior teeth. [5] Changing the vertical dimension of the lower anterior teeth after restoration with laminate veneer will affect pronunciation of the patient specially the /s/ sound and speaking movements with incisal overlaps.[6] Restoring mandibular incisors with laminate veneers is an alternative treatment modality proved to be a more conservative and predictable option than full crown option.[7]

Natural teeth were preferred due to their superior strength and bonding abilities, which better simulated clinical situations. [8] Digital caliper was used to make sure that all selected teeth had comparable dimensions to eliminate potential differences. After that, all of the teeth were kept in saline solution to keep them moist until they were needed. This prevented the teeth from drying out and cracking.[9, 10]

Translucent zirconia was introduced as an alternative esthetic solution, as it combines strength and translucency of feldspathic porcelain. Fracture is still the main reason for a failure of ceramic veneers and it is important to use of materials with different mechanical properties, so translucent zirconia was selected in our study.[5, 11, 12]

Several studies were done to propose the best incisal preparation design. [13-23] Researchers proposed that the type of incisal preparation design depends on buccolingual width of incisal edge, occlusion and esthetic requirements.[24] If mandibular incisor tooth is in functional contact , incisal edge should be restored with sufficient thickness for the restoration to withstand continuous occlusal contact with the opposing tooth.[25]

Although, incisal overlap design was less conservative, a cause to change tooth dimension, liable to risk fracture for thin palatal edge, not protecting palatal surface, not necessary in all cases and had limited path of insertion (which has to be seated from bucco-incisal direction only), it was preferred over non-overlap incisal designs because its long-term clinical outcomes and survival rate.[4, 25] Butt joint incisal preparation design was less conservative, lesser in preventive in decreasing the microleakage at the incisal margin, less in tensile stress, a cause to change tooth dimension, not protecting palatal surface, not necessary in all cases and lesser in stress tolerance under functional loading than overlap design, it was preferred over non-overlap incisal designs [4, 24, 26] In vitro studies showed that the butt joint incisal preparation design and the palatal chamfer design were favourable in terms of ceramic fracture and frequency of tooth failure, so they were chosen in our study.[27]Incisal reduction with bevel angulation toward labial or lingual surfaces was investigated in little studies with promoting results compared to non-incisal preparation designs(feather edge and window preparation). This study proposed bevel designs in our study to gain advantages of both overlapped designs and to eliminate disadvantages as possible as we can.[17, 28]

For standardization of teeth preparation, heavy body index and depth grooves were used as a guide during incisal, labial and proximal reduction and a dental surveyor was used to standardize incisal preparation. [29]The CAD/CAM technology was used in construction of laminate veneer as it had the ability to control anatomy and thickness of the restoration.[30]

Adhesive resin cement was selected as it was found that all ceramic restoration cemented using adhesive resin cement had greater fracture resistance than traditionally cemented restorations.[31]Light cure resin cement was used because of increased working time compared with other cure type and its colour stability. [32]Etch and-rinse cement was selected to be used in this study as it consists of separate step of etching of enamel and dentin with phosphoric acid, which produce the highest bond strength to enamel through all resin cements.[33] Variolink aesthetic cement was selected as it showed good mechanical and physical properties.[34]

Surface treatment of fitting surface of the restorations before the bonding was performed to create surface roughness through the micromechanical interlocking which enhance the bonding to the cement. [35]In this study, surface treatment was performed for each material according to manufacturer instructions. Zirconia was treated with 50 µm AL_2O_3 which results in increasing surface roughness and undercuts which result in enhancing the bond strength.[36]

A possible explanation of the decreased fracture resistance of monolithic zirconia might be might be the effect of colour pigments of multi-layered technique. As half or more of the grains are in cubic phase which has large grain size resulting in porosity between crystals and decrease the density**,** so it was not undergone transformation and there was no resistance to crack propagation and so decreased the mechanical properties.**[37]**Another factor that may affect the result is the bond strength of monolithic zirconia is sand blasting of zirconia which result in rough surface only without the porosities that responsible for microretention.[38, 39] That explains why adhesive failure was the most common fracture mode among monolithic zirconia groups

V. CONCLUSION

Within the limitations of this study, the following conclusions could be drawn:

1-Incisal preparation design had no effect on fracture resistance value of monolithic zirconia in mandibular incisors.

2-The fracture resistance for monolithic zirconia was highest incisal overlap followed by butt joint.

Limitations

1- This in vitro study was carried out on mandibular incisors only.

2- Short period simulation of intra oral condition in cyclic loading and thermocycling.

3- The load was evaluated in fracture resistance test with vertical angulation only.

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