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Comparing and Evaluating the Effect of Different Thickness of Two Metal-Free Restoration on Fracture Resistance in Molar Implant Prosthesis

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Abstract

Aim: The objectives of this article was to determine the minimum thickness of two monolithic materials for a posterior implant prosthesis. Materials and methods sixty monolithic IPS E.MAX CAD and zirconia crowns with different occlusal thicknesses were made with the use of a computer-aided design/computer-aided manufacturing technique was divided into 3 experimental groups: group (1) 0.5 mm group (2) 0.7mm group (3)1mm. A universal testing machine was used to determine the fracture load value. The restoration was loaded until fracture; the fracture resistance was registered. Two-way ANOVA has been used to examine the data., followed by the least significant difference LSD test. One-way ANOVA variance analysis was used to examine the differences in fracture load of monolithic zirconia or IPS E.MAX CAD at various thicknesses ($p=0.05$). Results vertical load test revealed that the fracture resistance of monolithic zirconia higher than the lithium disilicate crown (E.MAX CAD). The results showed that the highest mean value of fracture load test was obtained in the ice zirconia translucent with 1mm thickness group (1880N), while the lowest mean value was in the E.MAX CAD with thickness 0.5mm Group (223N). Conclusions: The fracture resistance of CAD-CAM monolithic crowns is influenced by the occlusal thickness. zirconia prosthesis with occlusal thickness 0.7mm,1mm had a high fracture resistance when compared with E.MAX CAD.

Introduction:

As a matter of choice, dental crowns are utilized to restore natural teeth for many causes, such as tooth loss, discoloration, severe dental caries, damage teeth, and tooth restoration [3]. Various materials are utilized in reestablished teeth, partitioned into metal, ceramic fused with metal, or all-ceramic crowns. monolithic crowns made of different ceramic materials (such as zirconia or lithium disilicate ceramics) have been presented. When compared to traditional veneered frames, monolithic ceramics have a substantially lower chance of cohesive failure [(4)]. lithium disilicate with greater translucency and minimum mechanical strength than Zirconia [(5)]. The mechanical qualities of restorative materials, such as fatigue failure, magnitude and kind of occlusal loads, and crown thickness, limit their long-term effectiveness and survival rate [(6)]. Monolithic Zirconia has excellent mechanical performance, reduced enamel antagonist wear, and no metallic color. They Additionally decrease those major clinical difficulties that consequence from those fracturing of veneering porcelain and zirconia frameworks, especially in an implant prosthesis [(7)]. Although zirconia has a higher elastic modulus (215 GPa) and high flexure strength (1000 MPa) than many metal alloys (7) flexural strength of lithium disilicate ceramic [e.max computer-aided design (CAD)] (360–400 MPa) [(8)]. The occlusal force in the posterior area is one of the significant problems to use metal free restorations is in this region. This is in general due to the concentration of the biting forces on the premolar and molar teeth and to the nature brittleness of ceramics [(9)]. The framework design is an essential factor that may have a great effect on the mechanical performance of restorations [(10)]. The framework design could have a significant effect on mechanical stresses that occurs during mastication [(11)]. According to Jang [(12)]The occlusal thickness of the crown affected fracture strength. Monolithic lithium disilicate crowns showed greater fracture loads over multilayer restorations, according to previous in vitro studies [(1, 13)]. Furthermore, As compared between monolithic Zirconia crowns and monolithic lithium disilicate at the 0.5 mm crown thickness, Monolithic Zirconia crowns appear enough strength to be used in the posterior teeth rather than lithium disilicate [(8, 14, 15)]. The objectives of this study were to establish the minimum thickness of two monolithic materials for a posterior implant prosthesis. The study's null hypothesis Monolithic zirconia crowns would have greater fracture resistance than lithium-disilicate glass-ceramic crowns of the identical thickness.

Materials and Methods

Two different materials suggested for processing specimens, IPS E-max cad (ivoclar vivadent) and pre-sintered zirconia blanks (Steger, Ahrntal, Italy) with different thicknesses (0.5mm,0.7mm,1mm).

Specimen preparation for monolithic zirconia

Thirty ZirkonZahn (Steger, Ahrntal, Italy) A milling technique using pre-sintered zirconia blanks was used to fabricate samples on the mandibular molar area show in Fig (1). Implant abutment was secured in the holding plate of the scanning unit Scanning of the abutment was accomplished by rotational scan to avoid reflection during the scanning procedure the implant abutment was coated with dental scan spray, and a pre-sintered zirconia blank was mounted in the holding plate of the milling unit of the system. The zirconia specimens were sintered at 1500ºC. The groups restorations 1, 2, and 3 given with an occlusal thickness of 0.5, 0.7, and 1mm respectively.

Specimen preparation for IPS EMAX CAD

IPS EMAX CAD (ivoclar vivadent, Germany) specimens on the mandibular molar area were produced by In Lab 4.2 software (Sirona Dental Systems GmbH, Bensheim , Germany). As earlier described, implant abutment was scanned and digitized and 30 IPS E.MAX CAD were fabricate employing a dedicated CAD software (Exocad Dental CAD, Exocad GmbH, Darmstadt, Germany). The groups restorations 1, 2, and 3 given with an occlusal thickness of 0.5, 0.7, and 1mm respectively show in Fig (2).

Load to fracture test

Before beginning the test, a holder must be made to hold the implant with the specimen during test procedure FIG (2.3).

In the occlusal fossa, a 4.0 mm stainless steel hemispherical tip was placed Fig (3). The experimental load was given to the tooth using a Universal Testing Machine at a crosshead speed of 0.5 mm/min in a direction parallel to the longitudinal axis of the tooth until failure, and the maximum breaking loads were registered in Newtons (N) using a computer coupled to the loading machine.

Statistical analysis

IBM SPSS statistical program Version 24 used for doing the statistical analysis of the current study. The usual statistical methods were utilized in order to evaluate and analyze the results; these consist of: Descriptive statistics (mean, standard deviation, Minimum, Maximum) And Inferential statistics (Student test (t-test).

Results:

The mean fracture applied load for EMAX crowns varied from 223 to 675 N as thickness increased from 0.5 to 1 mm, and from 427 to 1880 N for zirconia crowns. The influence of the ceramic materials and crown thickness on the fracture load values of monolithic restorations were investigated applying two-way ANOVA. The thickness factor had a significant impact on the results of the fracture load values was a highly significant difference P<0. 001. The fracture load values of zirconia and EMAX crowns of the same thickness were compared, a high significant difference was found (P<0.001) Table (1), actually suggesting that zirconia ceramic has a better resistance to fracture. The findings of a one-way ANOVA on the fracture load values of lithium disilicate ceramic crowns suggested that there were large significant differences in fracture load values as the thickness of the crowns varied in both zirconia and EMAX crowns P<0.001 Table (2 and 3). The fracture load values for the 0.5 mm crowns were the lowest. For both zirconia and EMAX, an increase in fracture load values was seen with statistical high significance as the crown thickness increased.

Discussion:

The condition of loading, the elastic modulus of the supporting die, material type, occlusal thickness, and processing processes all influence the all-ceramic sample's resistance to fracture. One of the most major disadvantages of using all-ceramic restorations in the posterior location is the risk of fracture related to occlusal and lateral forces. The amount of the biting forces exercised to the premolar and molar teeth, as well as the nature brittleness of ceramics, are the significant cause behind this (16). The elastic modulus of the supporting die structure is a major point influencing on the fracture resistance of all-ceramic crowns, according to the study Yucel et al (17) study the elastic modulus of the supporting die structure is a critical factor in defining the fracture resistance of all-ceramic crowns. As a result, earlier research evaluating the fracture strength of all-ceramic monolithic crowns revealed that only the monolithic design played better than the veneered one (18-21). Monolithic (full-contour) restorations having recently been created to address issues with the chipping of porcelain layers applied over zirconia (20). in spite of the fact that the manufacturer recommended a Crowns must have a lesser layer thickness, it was indefinite if the layer thickness could be reduced to maintain a more natural tooth structure, which would be beneficial(22). The fracture test scenario was collected the data without the use of any aging processes like thermo-cycling or cyclic loading. The fracture resistance of monolithic zirconia crowns examined was higher than that of E.MAX CAD, confirming the hypothesis. Tim f zesewitz etal.(23) In their experiment, they used a single monolithic zirconia crown (MZC), monolithic lithium disilicate, and monolithic feldspar ceramic to come up with comparable results. Under axial loading, monolithic zirconia demonstrated the higher fracture resistance of all the samples tested. Considering the variance in structure and properties of these two materials, this outcome was expected. With their unique ability for the phase change to prevent crack propagation, E.MAX CAD materials do not have the same fracture toughness as zirconia materials. The current study's findings revealed that, as predicted, the strength of all groups increased as crown thickness increase. The analysis of research objective is to evaluate the correlation between monolithic crown strength and variations in thickness, as well as to compare the two featured materials that are believed to be acceptable for crowns within the same area of indications. According to the outcomes of an ANOVA test, occlusal thickness has a major effect on fracture resistance. One of the essential aspects determining fracture resistance is the occlusal thickness of all-ceramic crowns. The sample crowns had the same occlusal thickness as those employed in earlier in vitro experiments(8, 22, 24). The fracture means values for zirconia crowns ranged from 427-1880 N and 223-675 N for E.MAX CAD crowns as the thickness changed from 0.5 mm to 1 mm in this investigation. The fracture loads of the crowns should be related to the observed biting force to accurately describe the findings of this study. In first mandibular molar occlusal bite force for Males had a 633 N, whereas females had a 527 N occlusal bite force. Other studies have found that the average high biting force in the posterior area is 597 N for females and 847 N for males, with a maximum of around 900 N (25). Masticatory force in the molars can range from 780 N to 1120 N in people who have parafunction (26). As an outcome, in a Table(1), the results of the zirconia fracture test except 0.5 mm group (427 ±93.81424 N), the other thickness groups seemed to an achieved sufficient fracture loads in a molar area similar findings have been reported by(20). Clinicians and technicians could utilize the suitable zirconia thickness of 0.5 mm. According to this investigation, 0.5 mm is unsatisfactory for posterior implant occlusion, but then at least 0.7 mm can be considered acceptable in molar implant restorations. Nakamura et al. and Weigl et al (27, 28)showed that monolithic zirconia crowns could sustain occlusal loads in the molar areas with an occlusal thickness of 0.5 mm. While the results of the E.MAX CAD fracture test in a Table (1) only 1MM group 675± 37.29894 achieved sufficient fracture loads in the molar area and others group show result that's lower than the reported occlusal bite force value it did not suggest to used. At 450 N, Maeder et al (29). observed cracking in lithium disilicate glass-ceramic with a thickness of 0.5 mm. This might mean that such a thin restoration isn't suited for people who have heavy loading forces. Sorrentino et al(8) CAD-CAM monolithic lithium disilicate crowns must have enough fracture resistance to be used in molar areas, but not in an ultrathin design (0.5 mm).

Conclusions:

Within the limitation of this test, it can be concluded that the thickness and material type of the restoration played a major effect in deciding its fracture resistance. The occlusal force in the molar region can survive the fracture load for posterior zirconia crowns with a wall thickness of 0.7,1mm. Fracture loads for posterior lithium disilicate E.MAX CAD with 0.5,0.7mm thickness were too low, while fracture resistance F≥600N was satisfactory with 1mm thickness.

Fig. (1) Thirty monolithic zirconia specimens

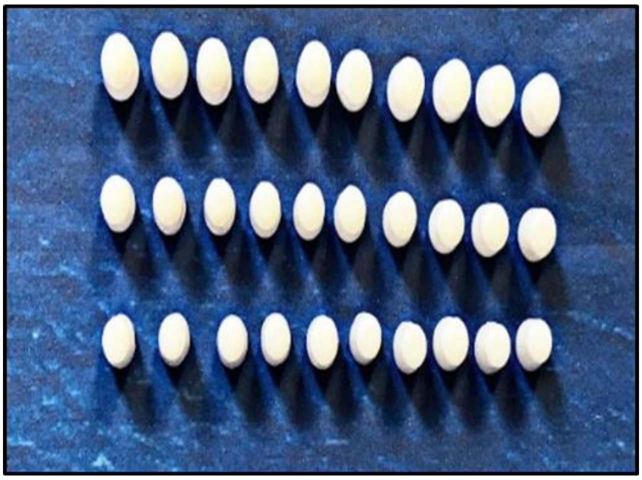

Fig. (2) Thirty IPS EMAX CAD specimens

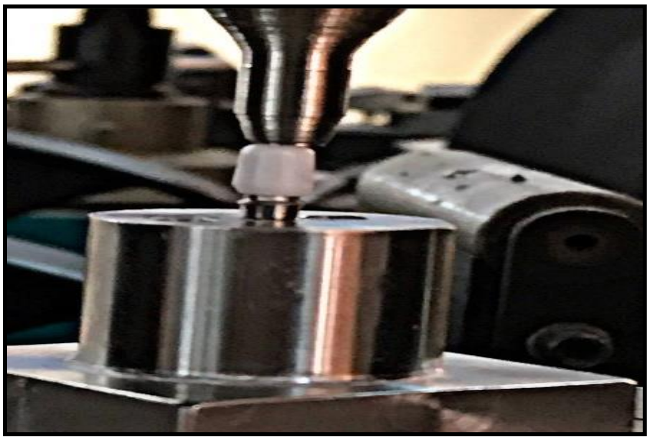

Fig. (3) Axial load direction and application of static load at fracture

Table (1) Mean of fracture load values (N) of two all-ceramic crowns at different thickness

	0.5 mm	0.7 mm	1 mm
zirconia n=30	427±93.81424	669.2000±98.94870	1880±518.11625
E.MAX CAD n=30	223.4000±21.57777	491.7000±47.79365	675.1000±37.29894
T	7.007	6.705	6.437
P	0.000	0.000	0.000

Table (2) One-way ANOVA for fracture load values of zirconia crowns with different thicknesses

	F-test	P-value	Sig
Between groups of zirconia (0.5 mm,0.7mm,1mm)	63.335	0.000 P<0.001	HS

Table (3) One-way ANOVA for fracture load values of E.MAX CAD crowns with different thicknesses

	F-test	P-value	Sig
Between groups of E.MAX CAD (0.5 mm,0.7mm,1mm)	373.33	0.000 P<0.001	HS

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