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COMPARISON OF FRACTURE RESISTANCE OF CAD/CAM INTERIM BRIDGE AND CONVENTIONAL INTERIM RESIN BRIDGE

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ABSTRACT

Background: Interim fixed restorations are important to protect pulp, protect abutment after preparation, assess the parallelism, preventing migration of abutments and improve esthetic appearance in anterior region. Moreover interim prostheses could assist in periodontal therapy, orthodontic therapy, occlusal treatment and implant therapy. Essentially, it should have good resistance to fracture, especially when used for extended treatment periods. **Objective:** evaluate and compare the fracture resistance between Cad/ Cam interim bridges and conventional interim bridges. **Material and Method:** Ideal model of full dental arch was used as a pattern to simulate three Units Bridge with (maxillary first molar and maxillary first premolar) as abutments. This model was then duplicated and resulted cast sectioned by cutting disk to produce a small cast that limited to the prepared bridge area only. This cast was then duplicated and poured by molten wax to produce wax pattern that was modified before casting with the use of radial shoulder finishing line design instead of chamfer finishing line that came with the original ideal model. From this wax pattern, metal master model was produced by lost wax technique. Thirty two impressions for master model with two stage putty- wash impression technique were taken and poured with die stone to produce thirty two stone models. The stone models then divided into four groups with eight models per group, according to the material and fabrication technique used to produce interim bridge and as follow: **Group 1:** Ivoclar CAD CAM (Telio CAD); **Group 2:** Ivoclar conventional (Telio Lab); **Group 3:** Vita CAD CAM(Vita CAD-Temp) and **Group**

4: Vita conventional (Vita VM CC). In fracture resistance test, each interim bridge was seated over master model then subjected to three points bending test using universal testing machine at cross head speed of (1mm/min.) till fracture occurred. **Results:** The results showed that the highest mean value of fracture resistance was recorded by Group 1 (735.9N) followed by Group 3 (585N), Group 2 (508.8N) and Group4 (460.8N) respectively. Concerning fracture mode, the connector area showed the weakest and most frequent area of fracture. **Conclusion:** CAD CAM groups had better fracture resistance values than conventional groups with Ivoclar Telio CAD material showing the highest fracture resistance means value. The most frequent failure mode was within the connectors of interim bridges. CAD CAM fabricated interim bridges are recommended to be used for long term and long span interim treatment.

KEYWORDS: CAD CAM Interim Bridge, conventional, Fracture Resistance.

INTRODUCTION

Interim fixed dental prostheses (FDPs) are important to protect tooth from physical, biological and mechanical effects until the final prosthesis can be cemented. These restorations could be short-term (until the final prostheses has been fabricated) or long-term (in case of a patient requires a longer treatment period, as in full mouth prosthodontic therapy, orthodontic or endodontic treatments, or in oral surgery).[1]

Long-term interim FDPs needs materials with stable color and mechanical properties that guarantee enough fracture strength and adequate dimensional and marginal accuracy.[2-5] Numerous interim materials are used for dental treatment. "Polymethyl-methacrylate (PMMA), a synthetic polymer of methylmethacrylate", was the most common material due to its high strength[6], stability of color, and easy repair. On the other hand, PMMA produced significant heat during polymerization, which may lead to polymerization shrinkage and pulpal discomfort.[7,8]

Using computer-aided design/ computer-aided manufacturing (CAD/CAM) to produce interim restoration is of interest for the reason that CAD/CAM interim therapy uses optical impression which eliminates patient's discomfort. In addition to that, CAD/CAM interim materials are prefabricated with the use of blocks that are industrially polymerized, that prevent polymerization generated shrinkage and heat.[9-11]

Interim crowns and bridges are important components of fixed Prosthodontics treatment. Interim restorations should have sufficient mechanical property to support functional and removable forces, that maintain tooth position and exhibit marginal integrity and biological properties conductive to periodontal health.[12]

The fracture toughness of a material represents its ability to resist crack propagation. This parameter is important in assessing the mechanical strength and long term clinical performance.[13]

MATERIALS AND METHODS

Ideal model of full dental arch made from plastic material (figure 1) was used in this study and prepared to act as pattern that simulate three – unit bridge, the maxillary first molar and maxillary first premolar as abutments and the maxillary second premolar is missed.

Figure. (1): Ideal model from plastic material.

This model then duplicated and poured by die stone to make a cast that then sectioned using cutting disk to produce a small cast that limited to required work only and as shown in figure (2).

Figure. (2): The resulted cast.

This cast then duplicated to form a mold that poured with molten wax to obtain a wax pattern that modified in its design to make the margins more prominent and shaping from chamfer to radial shoulder finishing line that proved to give more accurate margins. This wax pattern then sprued, invested and casted to obtain the final master model (figure 3).

Figure. (3): Master model from metal.

Thirty two impressions for master model with two stage putty- wash impression technique were taken and poured with die stone to produce thirty two stone models, then divided into four groups with eight models per group, according to the material and fabrication technique used to produce interim bridge and as follow:

Group 1: Ivoclar CAD CAM (Telio CAD).

Group 2: Ivoclar conventional (Telio Lab).

Group 3: Vita CAD CAM (Vita CAD-Temp).

Group 4: Vita conventional (Vita VM CC).

Interim bridges fabrication by conventional technique

Group 2 and group 4 samples were fabricated by this technique using Telio lab PMMA and Vita VM CC materials. First waxing up for full anatomy dental interim bridge was done on every model, and then silicone key formed on it that registered the fine details of the waxing up. After set, silicone key removed and remaining wax cleaned off and block out for any undercuts was done, then separating fluid was applied using fine brush. Mixing powder and liquid in silicone bowel as manufacturer's instruction was utilized with standard ratio and after reaching dough stage, the silicone key filled with material and seated back on model and placed in polymerizer for about 15 minutes with a pressure of 2 bar and temperature of 40-50c. After polymerization, finishing and polishing for every interim bridge was made.

Interim bridges fabrication by CAD/CAM technique: Group 1 and group 3 samples were fabricated by this technique using Telio CAD and Vita CAD Temp materials. First the models were covered with a scan spray and fixed on the dental scanner (Imes-Icore) and bridge design was by exocad software and the same design was for both types of materials with cement space of 100um with wall thickness in occlusal of 1.5mm and 0.8 mm circumferentially and connector dimensions was set for 12mm for both milled materials that used in the current study. The bridges were then milled using CORITEC 250i machine.

Before fracture resistance testing and for the metal model to be easily fixed between the jaws of testing machine holder and to prevent any movement from master model during testing, metal model was embedded in auto polymerizing acrylic block (base) that prepared by mixing cold cure acrylic resin in a rectangular shaped split mold that specially designed for it with a dimensions of (3cm x5cm) and height of (3cm). The samples were tested for fracture resistance by the use of three point bending test with a "universal testing machine" (Layree, China). Each sample was positioned with a slight pressure on the metal model and gripped on the testing machine. Steel ball with a diameter of 5mm was used to apply load on samples and this ball is positioned on machine arm that loaded in the pontic (in central fossa area) (figure 4) with a speed of (1mm/min.) for the crosshead that applied load until sample fracturing taken place**.** In order to distribute the applied force over a larger area and to avoid loading stress peaks on the pontic surface, i.e., homogenous stress distribution, rubber piece with 1 mm thickness was positioned between the sample and load tip.

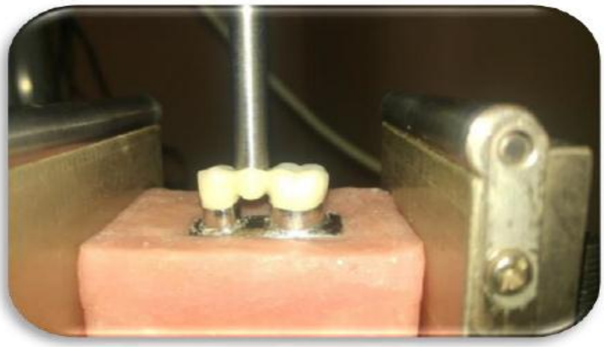

Figure. (4): Bridge sample under load from steel ball of loading cell.

The initial fracture that resulted from the applied load was registered and all the data was statistical analyzed. Master model secured between two jaws of holder positioned on the base of testing machine that connected to computer had data processing software installed (Max Test.exe). On the computer screen the program window displayed and bending test selected. The increasing compression load applied to the sample and the maximum load at the time of fracture recorded and displayed in Newton (N). At the same time the program set and displayed different curves (stress-strain, load- extension) and a sudden load drop was detected on stress strain curve at the time of fracture. Mode of fracture for samples in four groups was evaluated to determine fracture patterns (point of fracture) in dental bridge that could happen at different points (pontic, abutment, mesial connector, distal connector or the both connectors).

RESULT

A total of 32 measurements of fracture resistance from four groups were recorded for two different techniques and two different manufacturers in Newton (N). Table (1) shows the fracture resistance means, standard deviations, minimum and maximum values for the four groups. The fracture resistance results showed that the lowest mean was for Group 4(Vita conventional) (460.8 N) and highest mean (735.9 N) was for Group 1(Ivoclar cad cam).

Table. (1): Descriptive statistics (mean, standard deviation, minimum and maximum) of fracture resistance for the different groups measured in Newton.

Groups	No.	Mean	SD	Min.	Max.
Group 1 (Ivoclar Cad Cam)	8	735.9	47.0	688	810
Group2(Ivoclar Conventional)	8	508.8	29.0	476	557
Group 3 (Vita Cad Cam)	8	585.0	28.5	550	620
Group 4 (Vita Conventional)	8	460.8	31.4	414	501

The highest and lowest fracture resistance means values in Newton of the four groups are shown in Figure (5).

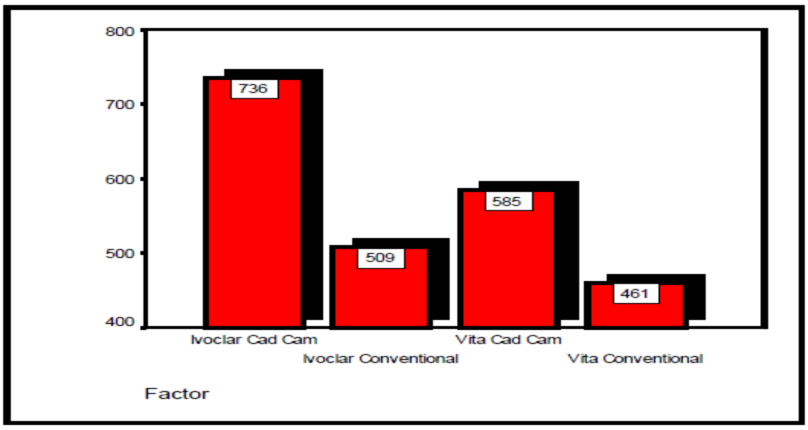

Figure. (5): Plotting chart showing the mean values of fracture resistance of the four groups.

To see whether the difference in the mean value for all groups was statistically significant or not, one way (ANOVA) test was applied in Table (2).

Table. (2): One way ANOVA test among the four groups(Fracture Resistance Test).

ANOVA Test						
Fracture Resistance test						
S.O.V.	Sum of Squares	df	Mean Square	F	Sig.	C.S.
Between Groups	347197.8	3	115732.6	95.641	0.000	HS
Within Groups	33881.9	28.	1210.1			
Total	381079.7	31				

Highly significant difference was founded in fracture resistance among all experimental groups.

LSD test which were applied to know the actual significant levels among all probable pair wised for different groups, as illustrated in table (3).

Table (3): Pair's wise Comparisons by (LSD) test among studied groups (Fracture Resistance Test).

(I) Group	(J) Group	Mean Diff. (I-J)	Sig.	C.S.
Group 1 (Ivoclar CAD CAM)	Group 2 (Ivoclar Conventional)	227.130	0.000	HS
	Group 3 (Vita CAD CAM)	150.880	0.000	HS
	Group 4 (Vita conventional)	275.130	0.000	HS
Group 2 (Ivoclar Conventional)	Group 3 (Vita CAD CAM)	-76.250	0.000	HS
	Group 4 (Vita conventional)	48.000	0.000	HS
Group 3 (Vita CAD CAM)	Group 4 (Vita conventional)	124.250	0.000	HS

There was a statistically significant difference in the fracture resistance mean values between the four groups.

Modes of Fracture: The samples were examined under (20x) magnification using light microscope to identify the type of fracture. The frequency of each mode of fracture for all groups was calculated as shown in table (4). The identified modes of fracture were (mesial connector, distal connector, both connectors, pontic or in abutment).This analysis indicated that in group1, five of the samples had fractured through mesial connector and one sample fractured through both connectors and there was fracture in the pontic in two samples. For group 2, seven samples were fractured through mesial connector and one through both mesial and distal connectors, while group3 showed six samples that were fractured through mesial connector and one through distal connector and one through both mesial and distal connector. In group 4, six of the samples were fractured through mesial connector and two samples through distal connector.

Table. (4): Fracture modes & patterns of the four tested groups.

Groups	Mode of Failure					No. of samples
	Fracture Patterns				Abutment Tooth Fracture	
	Mesial connector	Distal Connector	Mesial and Distal Connectors	Pontic		
Group1	**5**	**-**	**1**	**2**	**-**	**8**
Group2	**7**	**-**	**1**	**-**	**-**	**8**
Group3	**6**	**1**	**1**	**-**	**-**	**8**
Group4	**6**	**2**	**-**	**-**	**-**	**8**

DISCUSSION

The improved mechanical properties play an important role when the interim FDPs are expected to function for extended periods of time or when additional therapy is required before completion of definitive treatment like during the prosthetic phase of dental implants and reconstructive procedures, while evaluation of a change in vertical dimension, for orthodontic stabilization, in case of assessing the results of periodontal and endodontic therapies and in cases of bruxism.[14,15] Interim restorations may fracture throughout construction, functioning, trimming or even after removed from patient's mouth.[16,17] This failure often occurs as a result of a crack propagating from a surface flaw[8], inadequate transverse strength, impact strength, or fatigue resistance.[18,19] In long span prostheses, connector region subjected to fracture mostly as a result of some functional or Para-functional movements that led to localization of stresses inside the prosthesis.[20,21] Fracture could also happen as a result of voids during construction of prosthesis.[22]

METHODOLOGY

Master Model: Natural teeth have a large variation due to size, age, shape, anatomy and storing periods after their extraction causing difficulty in getting standardized abutments and for that, metal models were used in this study.[23] The advantages of using metal model includes; easy reproduction, standardized preparation, more resistant to destruction, wear or scratching under testing procedure.[24]

Use of Loading Ball and Rubber Foil: Stainless steel ball with a diameter of 5mm was utilized in this study to representing pontic contact pressure by opposing cusps and those were affected by elastic modulus ratio of the sample to loading ball elastic modulus and radius. Rubber piece was placed between the bridge sample and loading ball to be as stress stopper that simulating cushion activity of food between upper and lower teeth and help in avoid cone cracks.[25-28]

Fracture Resistance Testing method: The interim bridge samples were subjected to three points bending test (the same test used for bars specimens).[29-31] Steel ball loaded in pontic at area of central fossa with a speed of (1mm/min.) for the crosshead until bridge fracture taken place.[32] Initial fracture was registered as a result of the load application.

Test Results: In the current study, group 1 (Ivoclar Cad Cam) showed highest fracture resistance mean value (735.9N) followed by group 3 (Vita Cad Cam) with value of (585N) and group 2 (Ivoclar conventional) with mean value of (508.8N) and finally; group 4 (Vita conventional) with (460.8N) that showed the lowest fracture resistance mean value between all groups.

All fracture resistance test mean values for the interim bridges in the current study were exceed reported maximum biting force in the premolar region (300N).[33] Hagberg in 1987[34] reported that the threshold for withstanding occlusal load in the posterior region should be at least (600N). The current study was in agreement with (Abdullah et al,2016)[25] whom made a comparison of fracture strength and failure modes for CAD/CAM interim crowns (Telio CAD, Vita CAD-Temp and Peek) with that of direct interim crowns (Protemp) and concluded that CAD/CAM crowns showed higher fracture strength than direct one's.

The present study comes in disagreement with a study by (Pentate et al, 2015)[35] whom compared the fracture strength of interim FPD's constructed by direct method and CAD/CAM fabricated interim FPD's (Telio CAD material) and concluded that there was no significant differences between Telio CAD material and fiber reinforced interim restoration concerning compressive strength. The present study was in agreement with (Wimmer et al, 2013)[27] whom evaluated the impact of connector cross-sectional area on the fracture load of 3-unit CAD CAM (Telio CAD, Vita CAD-Temp and art Bloc Temp) FDPs and compared this with conventionally fabricated ones. They conclude that the CAD/CAM resin FDPs revealed significantly higher fracture load values than conventionally fabricated FDPs and showed a significant increase in fracture load with the increase of the cross sectional area.

Effect of fabrication technique on fracture resistance

CAD/CAM resin blocks exhibit high quality concerning its mechanical characteristics and microstructure for the fact that they were industrially fabricated under constant high pressure and heat (polymerization taken place during these fabrication steps only). This permits prosthesis to be fabricated with high fracture strength when compared with traditionally fabricated materials.[9,36]

Commonly, interim restorations were fabricated from self-cured resin material either in shape of paste (resin composite) or powder and liquid system (PMMA). Interims that were fabricated by direct method uses self-cured composites and those that were fabricated by indirect method uses PMMA based acrylic resins that their polymerization takes place in a polymerizer device. Parameters for polymerization of interim FPD's were essential for their mechanical characteristics.[37] When compared with CAD/CAM constructed FPD's, conventional interim FPD's were influenced by polymerizing device, operator, polymerization duration and mixing ratio.[26]

PMMA materials fabricated by conventional technique are uneven in shape, size and have grainer consistency and those were as a results of air bubbles incorporation, the way that material were dispensed in the mold and insufficient mixing of the material which led finally to the lower fracture resistance values.[38] There is important factor that may influencing the conventional technique materials inferior results concerning fracture resistance, which is the incorporated micro cracks and voids that reduce its fracture resistance significantly during mechanical and thermal processes.[39]

Fracture Modes: The most frequent fracture mode in the current study was through connector area. Direction of the propagation was obliquely attaching load point of pontic at occlusal area with gingival embrasure area of the connector. The most area of fracture in all four groups was in mesial connector. This mode has observed clinically and attributed to a cantilever effect as a result of fractured connector in occlusal aspect following the initial fracture from gingival region.[40] Crack propagation line resulted from stress concentration that simulates cracks in way perpendicular to principal tension long axis. When the axial load applied on the pontic, compressive stress were initiated in occlusal embrasure region first, and then followed by tensile stresses at gingival embrasure region.[41,42] Connectors represent the region of least cross section across the bridge, and thus are at high risk for fracture, because of the concentration of stresses in this region during flexure under occlusal loading.[42] According to Tinschert[43], fractures of dental bridges typically occur between the abutment and the pontic. In the study of Fischer et al[44], finite element analysis indicated that the connector between the bridge abutment and the pontic was the critical bridge area.

CONCLUSIONS

1. Cad/ Cam groups showed higher fracture resistance than conventional groups.
2. Group 1 (Ivoclar Cad Cam) showed highest fracture resistance than other groups.
3. The weakest and the most frequent fracture point in all groups is the connector.

Accordingly, for long span and long term interim treatment; Cad/ Cam fabricated interim bridges are recommended.

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