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MARGINAL ACCURACY AND FRACTURE RESISTANCE OF CAD/CAM VERSUS MAD/MAM ENDOCROWNS

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ABSTRACT

Background/purpose: The purpose of this in vitro study was to compare marginal accuracy (before and after cementation), fracture resistance of CEREC endo-crowns with the manually milled endocrowns. Materials and methods: Twenty extracted intact mandibular premolars were randomly divided into two groups .The crown portion of the specimens was removed to 1.5 mm above the cement-enamel junction (CEJ). All specimens were endodontically treated with a rotary system and obturated with gutta-percha by a vertical compaction technique. Computer milling machine prepared the tooth with a 1.0-mm wide circumferential shoulder margin at the CEJ and a 2-mm ferrule. In group I: (n = 10), teeth were restored with CEREC endocrowns, in group II: (n = 10), teeth were restored with MAD/MAM endocrowns; all crowns were bonded to the preparations with an adhesive composite resin cement. Marginal accuracy was measured before and after cementation using stereomicroscopes then all specimens were loaded in a universal testing machine with a cross-head speed of 0.5 mm/s until fracture occurred. Results: Data were statistically analyzed using with a student-t test, The mean marginal discrepancy ± standard deviation was recorded as follows: 15.2 ± 1.7 microns for group I and 18.94 ± 4.8 for group II before cementation while The mean marginal accuracy ± standard deviation was recorded as follows: 20.65 ± 3.7 microns for group I and 24.25 ± 4.01 for group II. The mean fracture resistance ± standard deviation was recorded as follows: 785.30 ± 24.15 N for group I and 743.68 ± 20.34 N for group II. A non-significant difference was found between groups with respect to fracture resistance ($P < 0.05$).Conclusion: Endo-crowns exhibited adequate marginal accuracy as well as adequate fracture resistance , marginal discrepancy in MAD/MAM endocrowns were higher than CEREC endocrowns while fracture resistance of CEREC endocrowns were higher than MAD/MAM endocrowns.

KEYWORDS: Endocrowns, CEREC, MAD/MAM, Ceremic crowns.

INTRODUCTION

The classical approach for restoring endodontically treated teeth is to build up the tooth with a post and core, which have physical properties close to those of natural dentin, utilizing adhesive procedures and placement of full-coverage crowns with a sufficient ferrule [1–3] .

With recent developments of adhesive techniques and ceramic materials and techniques, the advantage of adhesive restorations is that a macroretentive

design is no longer a prerequisite if there are sufficient tooth surfaces for bonding. With the adhesive technique, creating a ferrule is a drawback because of loss of the natural tooth structure and enamel. Minimally invasive preparations to preserve a maximum amount of tooth structure are considered the gold standard for restoring teeth [4] .

Innovative machinable ceramic technology introduced new systems for dental restorations in particular computer aided designs computer aided manufacturers CAD/CAM and manually aided design and manually aided manufacturers MAD/MAM endo-crowns. These are ceramic restorations with an integrated, apically protruding retention part. The underside and retention part of the bulk endo-crown are designed and machined to fit an "endo-preparation" in teeth which show complete loss of their coronal hard tissues. Also, it may assemble the endo-canalar post, the core and the crown in one component. The endo-crown preparation consists of a circular equigingival butt margin and a central retention cavity of the entire pulp chamber that in turn is adhesively placed [5].

Bindl & Mörmann, in 1999[6], evaluated the survival rate and the clinical quality of CAD/CAM endo-crowns after two years. Nineteen Cerec endo-crowns (4 premolars and 15 molars) were examined after an average time of 26 months. They found that the service time of the nineteen endo-crowns was 14 to 35.5 months. One molar endo-crown failed after 28 months because of caries recurrence. They concluded that the overall clinical quality of the Cerec endo-crowns was very good, and so far the clinical concept appears feasible.

Otto, in 2004[7], investigated the clinical performance of: (1) adhesively placed Cerec crowns with reduced stump preparations and (2) Cerec endo crowns. The crowns were examined in 20 patients with 10 Cerec crowns with reduced stump preparations and 10 Cerec endo crowns. All crowns had been produced chairside with the Cerec 3 CAD/CAM method using the function mode. The crowns were machined from Vita Mark II feldspathic ceramic blocks, polished manually and placed with dual-curing composite luting agent using a functional adhesive. After one year fractures or loss of retention were not observed. They concluded that the method of producing and placing all-ceramic crowns with reduced stump preparations and endo-crowns chair side in one appointment can be implemented successfully.

MATERIALS AND METHODS

Twenty intact, non-carious, human mandibular premolars without cracks, extracted for orthodontic reasons, were cleaned and stored at 18ºC in normal saline and randomly assigned to two groups of 10 teeth each. Teeth of similar size and shape were selected by root length and crown dimensions after measuring the buccolingual and mesiodistal widths at the cementoenamel junction (CEJ) in millimeters, and allowing a maximum deviation of 10% from the mean [8] .

The crown portion of all premolars was removed to within 1.5 mm above the CEJ and endodontically treated with ProTaper nickel-titanium (Ni-Ti) rotary files, a 16:1 contra angle handpiece, and ATR Tecnika Vision Motor (Dentsply Maillefer, Ballaigues, Switzerland) according to the manufacturer's instructions, and was obturated with gutta-percha by a vertical compaction technique.

Specimens were restored with classic CEREC all ceramic crowns in group A, while teeth were restored with with zirconia crowns using in groupB

Samples were divided into 2 groups (10 samples each) according to the type of restoration :Group I: In which teeth will be restored by computer aided design ,computer aided manufacturer (CAD/CAM) CEREC 3 (Sirona Gmbh,Germany) to obtain ceramic endocrowns.

Group II: In which teeth will be restored by copy milling manually aided design manually

aided manufacturer (MAD/MAM) Zirkonzahn machine(Zirkonzahn manually milling,Italy) to obtain ceramic enodocrowns.

All endodontically treated premolars were prepared using a preparation Computerized Numerical Control machine (C.N.C) (C.N.C.Premium 4820, i-mes, Germany) to standardize the extra-coronal preparation dimensions (Fig. 1) where a 1.0-mm wide circumferential shoulder margin at the CEJ and a 2-mm ferrule were prepared.

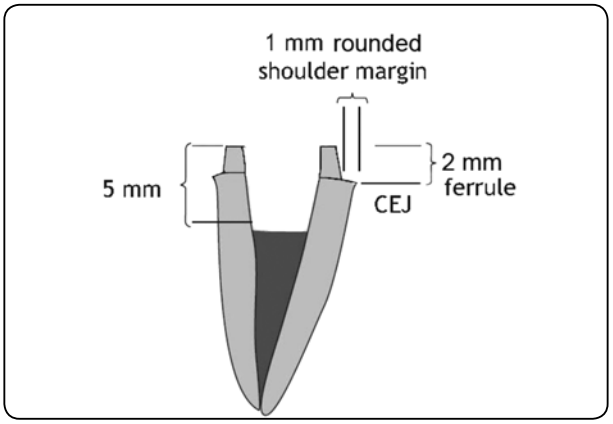

Fig. (1) Illustrated Diagram Showing Prepared Tooth for Endocrown

Fabrication of CREREC endocrown:

The teeth were sprayed with Cerec spray to be prepared for optical impression followed by scanning procedures using optical camera. Followed by designing of the restoration where margins of the restoration was done by moving the cursor along the preparation margins. The restoration framework was calculated and then displayed on the screen The Scale, Position and Rotate tools allowed adjustment of the restoration dimensions according to the manufacturer's recommendations.When the Next icon was clicked the finished restoration was displayed in the milling simulation the milling procedure the type of block was selected from the Select box by clicking 3M Paradigm Z100 block (3M,USA), the block type and size "14" was selected and confirmed followed by milling of the restoration (Fig. 2,3)

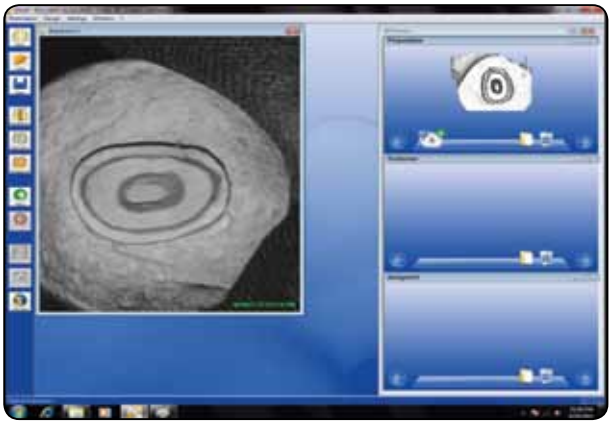

Fig. (2) Scanned Image for Tooth to be Restored with Endocrown (Group I)

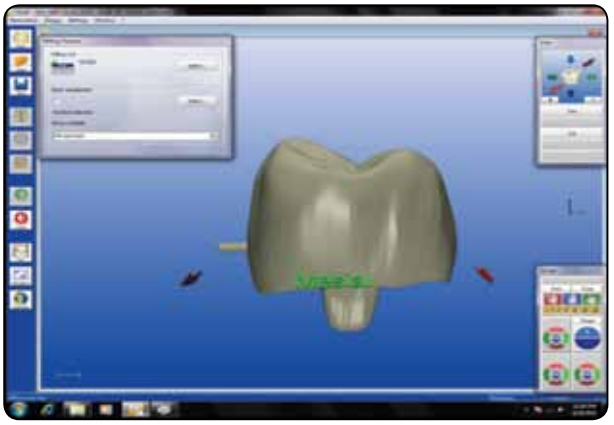

Fig. (3) Finished Endocrown Restoration (Group I)

Fabrication of crowns using manually milling technique by MAD/MAM

Light cured composite moke ups was constructed over prepared teeth followed by milling of translucent prattau zirconia blocks using Zirkonzahn manually milling system) (Fig. 4) . then prattau color liquid A2 was used to color zirconia. zirconia was dried under infrared lamb(Zirconlamb 250), finally crowns were sintered in Zirrkonzahn sintering furnace followed by glazing.

Fitting surface of all crowns were sandblasted with 120 μ alumina. All crowns were adhesively luted with Variolink II composite resin cement (Ivoclar Vivadent co., Leischtentin). The base and catalyst were mixed at a 1:1 ratio and coated onto

Fig. (4) Milling of zirconia prattau (Group II)

the inner surface of the crowns. Crowns were seated in cementing devise under constant 3 Kg. static load and excess luting material was removed. The light-polymerizing unit (Bluephase; Ivoclar Vivadent, Leischtentin) was held on the buccal, mesial, lingual, distal and occlusal surfaces for 1 minute. The curing power was 1200 mW/cm2. The curing mode was initiated with a soft start for 30 seconds, followed by high-power mode for 30 seconds.

Measurement of marginal gap and fracture resistance

Marginal gap was measured using high resolution digital microscope (Dino-lite digital microscope –Taiwan) with a fixed magnification of 40X, measurements were performed at 8 equidistant landmarks along the cervical circumference for each crown before cementation, then re-measurement of marginal gaps at the same points were carried after cementation. Each sample in the two tested groups was individually and vertically mounted in the lower fixed compartment of a computer controlled materials testing machine (Lloyd Instruments Ltd. Model LRX-plus, Fareham, UK.) with a load cell of 5 kN and data were recorded using computer software (Nexygen-MT; Lloyd Instruments) The samples underwent pre-loading in a cyclic manner. Each sample underwent 20,000 cycles at loads between a minimum 10 N (to prevent lateral dislocation of load applicator and to help in stabilizing the specimen during test) and a maximum 100 N with a load profile in the form of a sine wave at frequency of 1 Hz [9] . (Fig. 5).

Fig. (5) Universal Testing Machine

RESULTS

Data analysis was performed using Aasisat 7.6 statistics software for windows(Campina Grande. Paraiba state, Brazil). Student t- test was carried out to detect significance between two groups, p-values ≤ 0.05are considered to be statistically significant. Regarding the effect of processing technique on vertical marginal gap values, it was found that CAD/CAM recorded statistically non significant values P> 0.05 lower vertical marginal gap mean values than MAD/MAM but it was statistically significant after cementation (Table1, Figure 6).

TABLE (1) **Mean and standard deviation (SD) and results of students t test for comparison of marginal gap -before and after cementation- between two groups(μm.).**

	CAD/CAM		MAD/MAM		P-value
	Mean	SD	Mean	SD	
Before cementation	15.2	1.7	18.94	4.8	> 0.05*
after cementation	20.65	3,7	24.25	4.01	< 0.005*

significant at P≤ 0.05

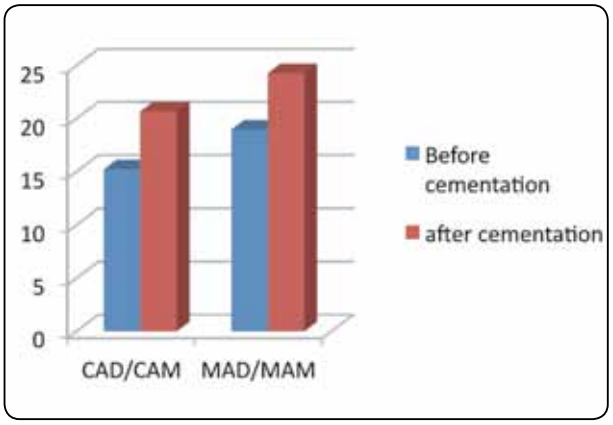

Fig. (6) Histogram representing mean and marginal gap of two groups (microns) before and after cementation

Mean and standard deviation values after cyclic loading with CAD/CAM were 785.30±24.15N while the values were 743.68.± 20.34N with MAD/MAM,t here was a statistically significant difference between the two groups P value < 0.001 where CAM/CAM showed statistically significant higher mean fracture resistance than MAD/MAM.

TABLE (2) **Mean and standard deviation (SD) and results of students t test for comparison of fracture resistance between two groups**

CAD/CAM		MAD/MAM		P-value
Mean	SD	Mean	SD	< 0.001*
785.30	24.15	743.68	20.34	

**** significant at P≤ 0.05***

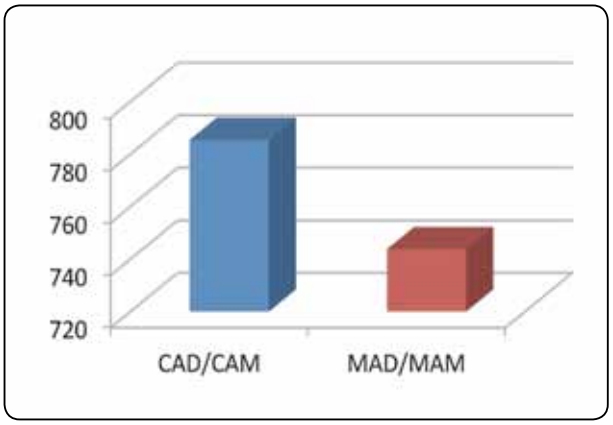

Fig. (7) Histogram representing mean and fracture resistance (N) of two groups

DISCUSSION

Endocrowns were tried as a new alternative approach to conventional post and core for restoration of endodontically treated teeth. Human teeth were used as abutment which are more closely approximates clinical situation with respect tooth architecture and morphology [4]. McLean and Von Fraunholes considered restorations successful when they had marginal discrepancy less than 120 μ[10]. Adaptation of zirconia restorations may be affected by preparation design ,milling process,size of milling burs and material cementation during milling process [11] .MAD/MAM specimens recorded higher total marginal gap alue than CAD/CAM with no significant differences ,this may be due to the accurate laser scanner built insit CEREC unit recognized sufficient data points when laser stone die was scanned from several directions resulted in accurate digital model as well as the high precession milling unit and instruments with 4 milling motors and virtual 5th axis. Before each restoration was ground ,automated calibration of the instruments was carried out with CEREC system, this resulted in the improved grinding precession and accuracy of fit of the restoration as reported by Mormann et al[12] .Regarding MAD/MAM technique ,manual skills and experience had a decisive influence on the size of marginal gap[13] ,the polymerization shrinkage of the composite moke up[14] and the accuracy of their tracing by styli might present other causes for this result, also the carbide burs used and the pressure exerted by the operator during milling resulted in copings with irregular fitting surfaces and margins. Physiological maximal occlusal forces may vary up to 500N. depending on fascial morphology and age [15] results of several studies reported that mean loading forces ranged from 50-250 N. while parafunctional behavior such as clinching and bruxism produces load between 500-800 N. [16] the obtained results of showed that fracture resistance of endocrowns are within accepted limits as single unit restoration such as endocrowns reduces bonded

surfaces as well as increase stress zones and increase fracture or debonding resistance .Favorable results may be explained with adhesive cementing which compensates for the reduced length of the root part due to the reduced than usual fulcrum line. Mean fracture resistance of CAD/CAM specimens are higher than that of MAD/MAM.MAD/MAM is copy milling process subjected to human errors in fabrication steps, resin pattern fabrication and milling process.Resin coping is a polymeric material, it might have some surface resiliency when being traced with stylus tracer leading to uneven thicknesses of the coping in some points which in turn exhibit irregular film thickness between internal surface of coping and external surface of die which in turn lead to uneven load distribution. Also manually tracing of pantographic arm of the copy mill system is affected by pressure, speed exerted by operator which may vary from operator to another and vary according to cutting efficiency of milling burs. As applying aggressive forces and using dull burs will produce heat generation induces internal stresses and cracks in the coping which lead to catastrophic failure of the coping.The satisfactory results of endocrowns restorations in the current were in agreement with reports by Bindle and Mormann in 1999 [6] and Lander and Dietche in 2008[5] that considered endocrown restorations is a promising and conservative alternative in the treatment of posterior endodontically treated teeth that require long term protection and stability

RECOMMENDATION

According to the present study, CAD/CAM and MAD/MAM endocrowns should be considered a feasible, conservative and esthetic restorative approach, as the adhesive monoblock restorations preserve maximum tooth structure ,reduc the need for macro-retentive geometry and provide more efficient and better esthetics results than conventional approach.

REFERENCES

1- Bitter K, Kielbassa AM. Post-endodontic restorations with adhesively luted fiber-reinforced composite post systems:a review. Am J Dent;20:353–60.2007

2. Dietschi D, Duc O, Krejci I, Sadan A. Biomechanical considerations for the restoration of endodontically treated teeth: a systematic review of the literature, part I: composition and micro- and macrostructure alterations. Quintessence Int; 38:733–43.2007

3. Dietschi D, Duc O, Krejci I, Sadan A. Biomechanical considerations for the restoration of endodontically treated teeth: a systematic review of the literature, part II: evaluation of fatigue behavior, interfaces, and in vivo studies. Quintessence Int.;39:117–29.2008

4- Chang CY, Kuo JS, Lin YS and Chang YH: Fracture resistance and failure modes of CEREC endo-crowns and conventional post and core-supported CEREC crowns. J. Dent. Sci. ; 4:110–117,2009.

5- Lander E and Dietschi D: Endocrowns: A clinical report. Quit. Int.; 39:99-106,2008.

6- Bindl A and Mörmann WH: Clinical evaluation of adhesively placed Cerec endo-crowns after 2 years preliminary results. J. Adhe.s Dent. ; 1:255-265,1999.

7- Otto T: Computer-Aided direct all-ceramic crowns: Preliminary 1-Year results of a prospective clinical study. Int J Periodontics Restorative Dent; 24:446-455,2004.

8- Soares PV, Santos-Filho PC, Martins LR, Soares CJ. Influence of restorative technique on the biomechanical behavior of endodontically treated maxillary premolars, part I: fracture resistance and fracture mode. J Prosthet Dent ; 99:30–7,2008.

9- Chen HY, Hickel R, Setcos JC and Kunzelmann KH: Effects of surface finish and fatigue testing on the fracture strength of CAD-CAM and pressed-ceramic crowns. J. Prosthet. Dent.; 82: 468–75, 1999.

10- Mclean J.W. and Von Fraunhofer G. : The estimation of cement film thichness by an in vitro technique . British Dent. J. ,131:107-110 ,1971

11- Comelekoglu,M. , Dundar, M., Oscan W. and Gunger L.: influence of cervical finish line type on the marginal adaptation of zirconia ceramic crowns . J. Oper. Dent. 34(5),586-92,2009

12- Mormann W.H., Schug J.G. :Grinding precession and accuracy of fit of CEREC 2 CAD/CAM inlay. J.Am.Dent. Ass. 128:47-53,1997.

13- Witkowski S.,Komine F., Gerds T.: Marginal accuracy of titanium coping fabricated by casting and CAD/CAM techniques . J. Prosth. Dent. 6:47-52, 2006.

14- Alfayume A.A. ,Younis J.F.,El-Demellawy M.:The effect of dynamic loading on the marginal fit and fracture resistance of all-ceramic and conventional metal ceramic resin bonded bridges . Master degree thesis ,Faculty of Dentistry, Ain Shams university,2010.

15- Gonzalo,E. Saurez M. and Serrano B. : Marginal fit and fracture resistance of zirconia posterior fixed partial denture Int.J.Prosth. ;21: 398-399.2008

16- Lofstrom, L. and Barakat M. : S.E.M evaluation of clinically cemented cast gold restoration. J. Prosth. Dent.; 61,664-669, 1989.