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EVALUATION OF THE FRACTURE RESISTANCE OF MACHINABLE VERSUS COPY MILLING ZIRCONIA RESTORATION AFTER CYCLIC LOADING

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ABSTRACT

Purpose: To evaluate the influence of, layering and mechanical fatigue on the Fracture resistance of Zirconia crown produced using CAD/CAM and copy milling systems. **Materials and Methods:** One metallic die was fabricated to simulate prepared upper premolar tooth (Tooth 24: with anatomic occlusal reduction,). Using universal milling machine Twenty crowns were fabricated using Prettau zirconia blank with a luting space settings of 60 µm. The fabricated crowns were grouped according to fabrication system in to CAD CAM and copy milling (N=20) as well as each group were divided again in to monolithic and by layered (n=10) Crowns were cemented using Panavia resin cement, then the fracture resistance were measured for half of samples using a instron device,. The other half of samples were subjected to cyclic loading (50 N load, 3700 cycles) and fracture resistance. Data were submitted to three-way ANOVA, and statistical significance was set at $p < 0.05$. **Results:** In monolithic groups (MO, CO), the highest fracture resistance was recorded with the CAD/CAM non-loaded samples, (1200.48±41.98N), while the lowest fracture resistance was recorded with the copy milled cyclic loaded samples, (1043±28.04N). In veneered groups (MV, CV), the highest fracture resistance was recorded with the CAD/CAM non-loaded samples, (800±41.57N), while the lowest fracture resistance was recorded with the copy milled cyclic loaded samples, (711±122.89N). **Conclusion:** CAD/CAM groups recorded statistically significant higher fracture resistance than copy milling groups. Monolithic groups recorded statistically significant higher fracture resistance than veneered groups. The cyclic loading (at 37,000 cycles) has no effects on the fracture resistance in all groups.

INTRODUCTION

The fracture resistance , esthetics and accuracy of fit is one of the most important criteria for the long-term success of all-ceramic crowns and bridges, because inadequate fit is potentially damaging to both abutment and periodontal tissues(1). Copy milling is based on pantographic principle that is used to duplicate keys at hardware shops.

Using exact mechanical-tactile model surveying and analogous milling it is considered to be highly precise(2). First, a coping or framework is manually fabricated in wax or composite, and then the pattern is placed into the pantographic machine.

The copying arm of the machine traces the wax pattern while the cutting arm, which has a carbide cutter, mills a selected presintered zirconia block. The final shape is 20% to 25% larger to account for shrinkage during the sintering step. The zirconia block has a density barcode label, so the copy mill machine can be adjusted properly to allow for shrinkage during the sintering phase(3).

The introduction of computer-aided-design and computer-aided-manufacturing (CAD/CAM) technology allows high strength ceramic materials such as alumina and zirconia to be used (4). Most recently, high strength milled alumina and zirconia have been developed for use as a core material in posterior ceramic crowns (5).

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Zirconia, specifically yttrium-stabilized tetragonal zirconia polycrystal (YTZP) was chosen as core material to support ceramic restoration and prevent its bulk fracture[6]. An important property of zirconia is its transformation toughening and ability to slow crack propagation and improve fracture resistance. Zirconia has a flexural strength of 900-1200 MPa and a fracture toughness of 9-10MPa/m[7,8], with its superior mechanical properties, zirconia has been used for multiunit and complete arch frameworks, implant abutments, and complex implant superstructures for fixed and removable prostheses[9].

Since zirconia's opacity, milky color and excessive wear of opposing teeth may be the limiting factors for its clinical application, highly translucent zirconia blocks (Prettau, ZirkonZahn, Italy) are recently introduced into the market.

Prettau Zirconia, which is used in conjunction with a specialized coloring technique, eliminates the use of veneer ceramics entirely. In this way aesthetically pleasing full-zirconia restorations are feasible. Biomaterials in dentistry must fulfill several requirements that include biocompatibility, strength, wear behavior related to intended purpose and esthetics. Fracture resistance is one of the most important factors that can influence the rate of survival. Fracture resistance is not only affected by the material type but also by the cement type and long term usage inside oral cavity.

With the proper use of this system, the procedure for fabricating restorations can be substantially simplified. The hypothesis of this study was that, the mechanical fatigue and layering influence the accuracy of fit of the zirconia crown fabricated using a CAD/CAM system and Copy milling system[10].

MATERIALS AND METHODS

Prepared upper premolar tooth according to manufacturer's recommendations for prettau zirconia posterior crowns (1mm chamfer margin with 12 degrees total occlusal convergence and an approximate height of 5 mm), was simulated by metallic die by aids of universal milling Machin.

A total of 40 prettau zirconia crowns were used in this study and randomly • divided into two main groups according to the technique of fabrication of ceramic crowns, (M) group and (C) group. Group (M). CAD CAM system were used for fabrication of Zirconia crowns (n=20), Group (C). Copy milling system were used for fabrication of Zirconia crowns (n=20). Each (M) and (C) groups were subdivided into two subgroups according to layering (10 for each) Monolithic (O) and Veneered (V).

Group M fabricated by exocad system according to default parameter and 60 micron pacer thickness. Group C fabricated with Mad Mam system

All groups cemented with Panavia resin cement and the fracture resistance was evaluated by instron device for half of all samples

The other half were subjected to mechanical fatigue (cyclic loading) for 37000 cycles, 50 N and range of frequency 1-1.6 Hz which resemble 3 months under function by custom mad chewing simulator device which fabricated in Al-Azhar University by postgraduate students and the marginal gap were evaluated again after cyclic loading by the same parameters.

RESULTS

Quantitative data were described using range minimum (Min) and maximum (Max), Mean and Standard Deviation (±SD). Significance of the obtained results was judged at the 5% level.

• By Easy Randomizer Software.

Three ways (ANOVA) was assessed to showing the effect of each factor and the interaction between the groups. Post Hoc test (Tukey) for pair-wise comparisons between the groups.

The Max, Min, mean and standard deviation values of the fracture resistance (n) according to the type of used material, type of cement and cyclic loading are summarized in (Table 1).

TABLE (1) Comparison between the measurements of the studied groups represented by (Min, Max, mean and Standard deviation) according to material used, veneering and cyclic loading.

Variables		Veneering			
		Monolithic		Veneered	
		Non-aged	Aged	Non-aged	Aged
Ceramic groups	Cad cam	1200.48 ±41.98	1193.37 ±32.43	800 ±41.57	790 ±71.10
	Copy milling	1090.26 ±23.76	1043 ±28.04	720 ±68.17	711 ±122.89

Fracture resistance results (Mean ±SD) showing the interaction between fabrication technique, veneering and cyclic loading are summarized in (Table 6).The difference between the material types was statistically highly significant ($p \le 0.05$) but no statistical significant difference ($P > 0.05$) be found according to the cyclic loading (Table 2).

TABLE (2) Three Way ANOVA Test for Comparison of marginal gap results

Source	Mean Square	F	P
Fabrication technique	1278.030	44.42	.002
Veneering	33.856	1.207	.080
Cyclic loading application	4.389	.086	.795

Regarding the fabrication technique: In all groups there was statistical significant difference ($p \le 0.05$) between machinable zirconia crowns recording higher fracture resistance mean value (995± 192.13) than copy milled zirconia crowns (891 ± 188.50)

Regarding to veneering: There was statistical significant difference ($P<0.05$) between monolithic groups (1131±39.96) and layered groups (755±58.76)

Regarding the effect of cyclic loading: there was no statistical significant difference ($P > 0.05$) between Aged groups and non-aged groups

DISCUSSION

The prepared tooth was using milled metallic die as it have several important advantages including strength, abrasion resistance, and detail reproduction[11].

In the present study, the marginal fit was evaluated for each crown specimen at 12 specific locations, 3 locations at the middle of the four axial walls, mid-buccal, mesial, distal, and lingual[12]. The mean of all readings was calculated from the mean values of cervical circumferential measuring locations. In order to avoid statistical variance as much as possible, all the measurements were performed by the same operator [13].

The cyclic loading process was done by custom made dual axis chewing simulator prototype which fabricated by postgraduates students in Alazhar university under supervision of Robota mechatronics company.

The vertical load of 50 N was used which considered an average value for physiological masticatory forces in the teeth of non-bruxism patients[14]. Number of cycles performed 37000 cycles which resemble 3 months' under normal function [15].

The hypothesis of this study was accepted partially as there is statistically significant deference between materials used in this study where, the mean fracture resistance value of Copy Milled and veneered samples higher than CAD CAM and monolithic samples. And there is no significant difference related to mechanical fatigue.

The results of this study regardless to the fabrication technique totally it was found that M groups recorded statistically significant ($P<0.05$) higher fracture resistance mean value than C groups

The lower value of copy milled zirconia can be explained due to 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 flm thickness between internal surface of coping and external surface of die which in turn lead to uneven load distribution. Discussion 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 irregularity at the margins which has bad effect in the fracture resistance[16].

However, from a clinical viewpoint, the statistically significant difference between the two systems is not relevant, since both systems still exhibit a clinically acceptable fracture resistance [17].

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