Original Article

The Effect of Preparation Design on the Fracture Resistance of Zirconia Crown Copings (Computer Associated Design/Computer Associated Machine, CAD/CAM System)

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Abstract:

Objective: One of the major problems of all ceramic restorations is their probable fracture against the occlusal force. The aim of the present in-vitro study is was to compare the effect of two marginal designs (chamfer & shoulder) on the fracture resistance of zirconia copings, CERCON (CAD/CAM).

MATERIALS AND METHODS: This in vitro study was done with single blind experimental technique. One stainless steel dye with 50' chamfer finish line design (0.8 mm depth) was prepared using milling machine. Ten epoxy resin dyes were made, The same dye was retrieved and 50' chamfer was converted into shoulder (1 mm).again ten epoxy resin dyes were made from shoulder dyes. Zirconia cores with 0.4 mm thickness and 35 µm cement Space fabricated on the20 epoxy resin dyes (10 samples chamfer and 10 samples shoulder) in a dental laboratory. Then the zirconia cores were cemented on the epoxy resin dyes and underwent a fracture test with a universal testing machine (GOTECH AI-700LAC, Arson, USA) and samples were investigated from the point of view of the origin of the failure.

RESULT: The mean value of fracture resistance for shoulder margins were 788.90±99.56 N and for the chamfer margins were 991.75±112.00 N. The student's T-test revealed a statistically significant difference between groups (P=0.001).

CONCLUSION: The result of this study indicates that marginal design of the zirconia cores effects on their fracture resistance. A chamfer margin could improve the biomechanical performance of posterior single zirconia crown restorations. This may be because of strong unity and round internal angle in chamfer margin.

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INTRODUCTION

One of the major problems of the all ceramic restorations is their probable fracture against the occlusal and lateral force [1]. The common restorations contain metal which leads to toxic, chemical and allergic effects [1] .The difference between their color and natural tooth is another problem [1] Most of the people prefer tooth colored crowns [1] .The major benefits of all ceramic crowns is their esthetic and biocompatible effects [2]. Some crown fractures due to the relatively low mechanical resistance

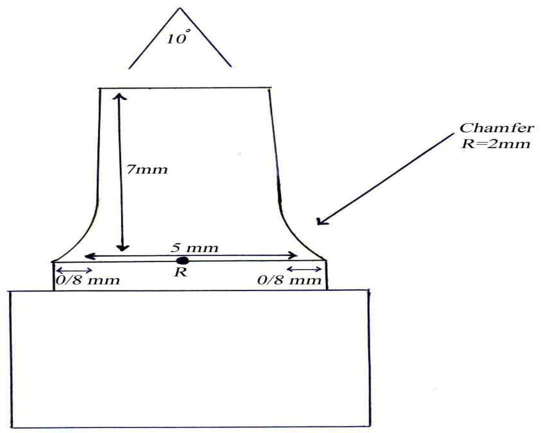


Fig (a1):Diagram of chamfer

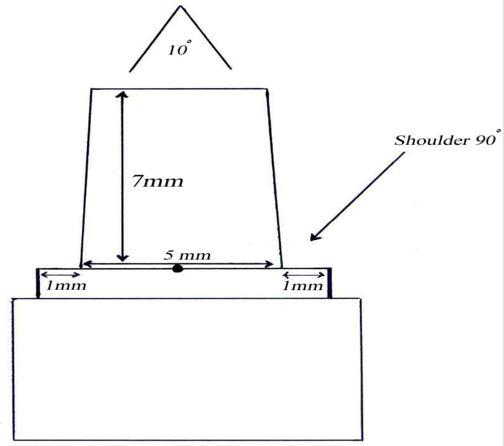


Fig (a2): Shoulder preparation

of ceramic crowns have become more apparent [1]. This is mainly due to the magnitude of the biting forces applied on the premolar and molar teeth and to the inherent brittleness of ceramics [3,4]. Ceramic materials are sensitive to the tensile stresses, and superficial flaws and internal voids effect on their fracture resistance [1]. Such defects may represent the sites of crack initiation. This phenomenon may be influenced by different factors such as marginal design and thickness of the restoration, residual processing stress, magnitude and direction and frequency of the applied load, elastic modulus of the restoration components, restoration-cement interfacial defects and oral environmental effects [5]. In one research, the camparison of stress distribution during mastication between maxillary second premolars restored with metal-ceramic crowns and non-restored teeth was done by finite element analysis method (FEA). They registered high stresses at the cervical line of the restored teeth within the dentin-metal interface and within the ceramic-metal interface [6]. Florian Beuer suggested that shoulder margin has a greater fracture resistance than chamfer margin [7]. Sadan et al proposed that both of these types of finishing lines are considered to be adequate for the tooth [8]. Di Iorio et al suggested that the shoulder margin could improve the biomechanical performance of single crown alumina restorations [9]. De Jager et al discovered that for long lasting restorations in posterior region it is advisable to make a chamfer with collar preparation [10]. Cho L et al suggested that chamfer margins with 0.9 and 1.2 mm depths have greater fracture resistance than shoulder and rounded shoulder margins with 1.2 mm depths. [11]. Potiket et al suggested that a 1mm deep shoulder finishing line with a rounded internal line angle has good fracture strength for the natural teeth restored with all ceramic crowns [12]. Rammersberg et al discovered that a minimally invasive 0.5 mm axial chamfer tooth preparation has the greatest stability for posterior metal free crowns [13]. The aim of the present in vitro study is to compare the resistance to fracture under static compressive load (not cyclic) applied to zirconia cores with chamfer and shoulder margins. The hypothesis of the present study is the effect of marginal design of crowns on an improved mechanical performance of cercon crowns, from a clinical point of view. Such a condition can be achieved preparing a chamfer margin in crowns instead of a shoulder margin.

MATERIALS AND METHODS

This in vitro study was done by using one machined standard stainless steel dye with 7 mm height and 5 mm diameter. The axial walls were 10° convergent [14].The marginal area of

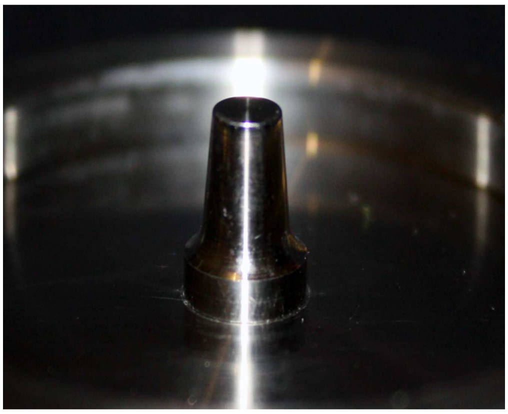


Fig (b1):Standard dies of Chamfer

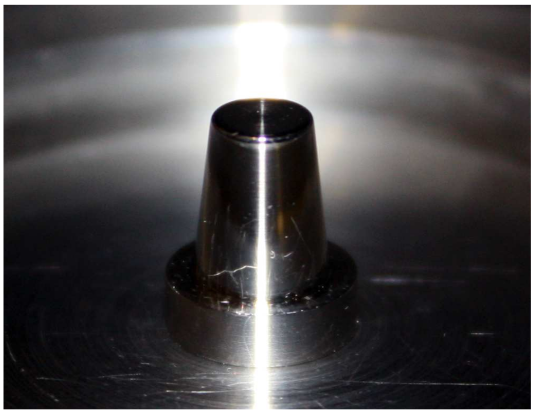


Fig (b2): Shoulder preparation

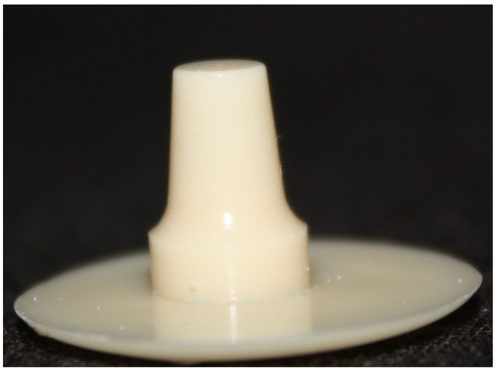


Fig (c1): Epoxy resin dies with chamfer

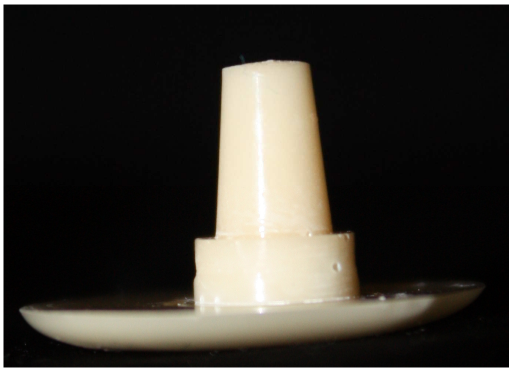


Fig (c2): Shoulder margin

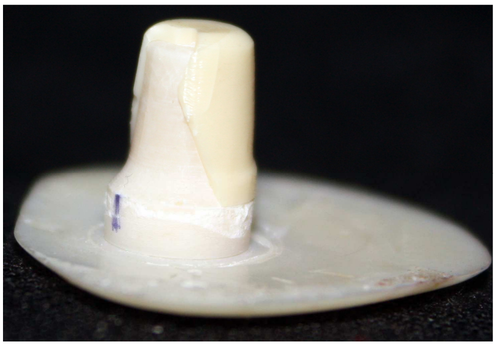


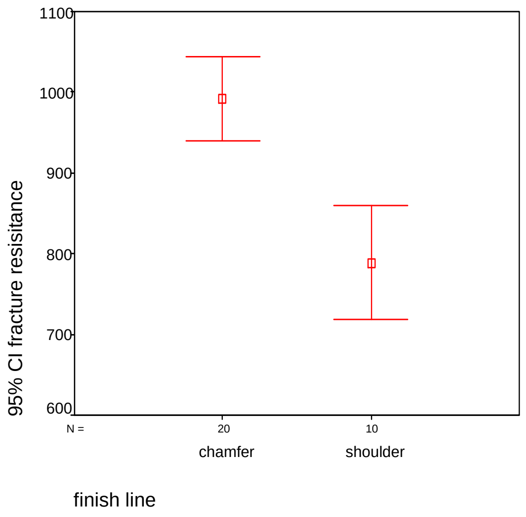
Fig (d1): Fracture area in chamfer

Fig (d2): Shoulder margin

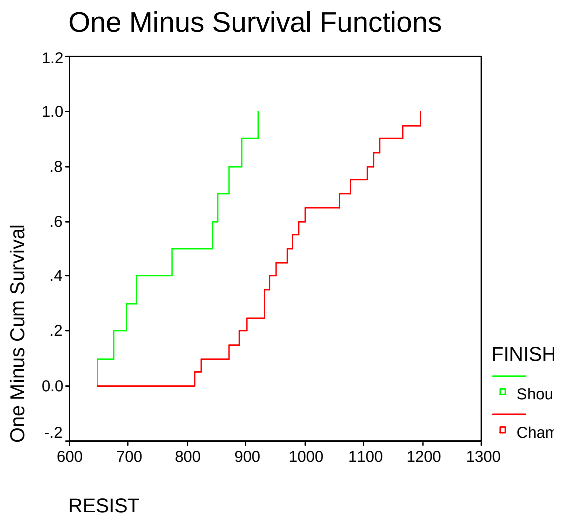
the dye was prepared with 50° chamfer finish line (0.8 mm depth) [15,16].

(figure a1, b1).10 poly vinyl siloxane impressions(PVC, Elite H-D+, Zhermach, Germany) were made and ten epoxy resin dyes (CW2215, Hunstman-Germany) were created from these Impresions (Fig c1).

Afterwards. The standard dye was converted into shoulder with 1 mm depth [15,16]. (Fig a2, b2).



Graph 1. Error-bar graph shows the mean fracture resistanceof shoulder and chamfer margin with 95% confidence interval.



Graph 2. Kaplan-Meir graph shows the cumulative distribution of fracture /load in the chamfer and shoulder finishing lines.

Again 10 PVC impressions were made and ten epoxy resin dyes were created from these impressions (Figure c2) [7,9]. (20 copings were made of a partially sintered ZrO_2 ceramic material by using CAD/CAM technology (Cercon Smart Ceramics, Degu Dent, Hanau, Germany). The copings with 0.4mm thickness and [15,16] 35µm cement space[7]. milled out from the presintered ZrO_2 by cercon milling (Cercon, Brain, Dego Dent, Hanau, Germany) and Cercon Heat (Degu Dent, Hanau, Germany) heated.

them at 1350°C for 6 hours Because the coping determinates the overall resistance to fracture of veneered crown mainly [15,17] porcelain veneering was omitted.

Copings were evaluated visually, those with margin damaged and visually unacceptable were rejected and another coping was made instead. Each coping was cemented on its definitive dye with GI (GC Gold Labled, Tokyo, Japan) [13] by an experienced technician and Finger pressure was applied during the setting time [18].

Table 1: Fracture resistance of chamfer and shoulder edge zirconia cores

Margin design	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
chamfer	10	991.7500	112.00088	25.04416	939.3320	1044.1680	813.00	1196.00
shoulder	10	788.9000	99.56399	31.48490	717.6762	860.1238	647.00	921.00

After cementation, excess luting agent was removed and fitness was considered accomplished when two or more investigators determined-by visual inspection-that no marginal gap was visible [7]. Ten samples were stored in a saline solution at room temperature for 24 hours. Mechanical tests were carried out using a universal testing machine (GOTECH AI-700LAC, Arsona, USA). The compressive static load was applied at the center of the occlusal surface along the long axis of dye with a crosshead speed of 0.5 mm/min according to previous studies [7] that starts from 0N and increased until fracture occurred [19]. The fracture load data were automatically recorded using by vista software, which also completed stress-strain diagram and recorded the breaking load. Samples were investigated from the point of view of the origin of the failure (Fig. d1, 2).

RESULTS

The mean ±SD of fracture resistance were 788.90±99.56 N for the shoulder and 991.75±112.00N for chamfer margin (Graph 1). Both of minimum and maximum fracture resistance of the two groups were more than intra oral loads. The student's t-test revealed a statistically significant difference between two groups (p=0.001).This research carried out with 95% confidence, Kaplan Meir graph showed the design of fracture, that chamfer margin bears more cracks till fracture than shoulder margin (Graph 2). Figure d 1,2 showed that the origin of failure of cores with chamfer margin was axial wall and in shoulder margin, the 90° sharp internal angle was the point of failure (Table 1).

DISCUSION

In this study the student's t-test revealed a statistically significant difference between the groups .fracture resistance of chamfer margin was more than shoulder margin. Elastic modulus of the materials that supported core affected on the fracture resistance of the core [20] .Thus, in this study, we use epoxy resin dye that its stiffness is more than brass dye [21]. Another difference between this study and clinical conditions is the unknown nature of the bonding between luting agent and dye material. It is reasonable to suppose the presence of a hybrid layer at the dentin-cement interfaces effects on the biomechanical behavior of the core/supporting dye system. However, both of these factors equally influenced on the two groups in the present study. So, it is possible to make a comparison between the two groups. Fracture resistance of the two groups are more than biting forces [22], so we could use all of these marginal designs in the posterior all ceramic crowns successfully, and it is a very good replacement for PFM crowns. The difference of fracture resistance between the two groups revealed that the chamfer margin has more fracture resistance than shoulder margin (comment D5), because Chamfer margin has a curve and round internal angle which leads to more marginal fitness and spread load better and we don’t have such a condition in a 90° shoulder margin. We use GI for cementation, so we have a strong unity in the margins that make a greater fracture resistance [23,24]. It seems that shoulder margin has the worst marginal fitness in all ceramic materials, so in this condition because of sharp internal angle, we have no strong unity in this marginal design that makes a lower fracture resistance than chamfer margins.

Limitation:

1. We used epoxy resin for casting impressions that was expensive and had long last setting time (about 24-36 hours at room temperature).
2. Cementation was done by figure pressure.
3. Marginal fitness was considered by visual inspection (not SEM) that no marginal gap was visible.
4. CAD/CAM system could not scan 90° sharp internal angle in the shoulder margin

well, so the thickness of cement increased in internal angle and decreased fracture resistance.

CONCLUSION

The results of this study indicate that marginal design effects on fracture resistance. A chamfer margin could improve the mechanical performance of the posterior single crown zirconia restorations. This might be due to the strong unity and round internal angle in the chamfer margin.

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