ORIGINAL RESEARCH PAPER

Dental Science

"COMPARATIVE EVALUATION OF NATURAL TOOTH ENAMEL WEAR OPPOSED BY POLISHED MONOLITHIC ZIRCONIA, POLISHED LAYERED ZIRCONIA AND GLAZED LAYERED ZIRCONIA - AN IN VITRO STUDY"

KEY WORDS:

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ABSTRACT

Statement of Problem: Surface of porcelain restoration is a matter of clinical concern because of its abrasive action on the opposing enamel.

Purpose: This study comparatively evaluated wear of enamel when opposed by three different surface finishes of zirconia.

Materials and Methods: A total of 10 monolithic zirconia, 20 layered zirconia discs (10 mm × 2 mm) with different surface finishes were fabricated. They were divided into three groups of polished monolithic zirconia, polished layered zirconia and glazed layered zirconia. Each group comprised of 10 discs. Thirty human teeth samples were prepared from freshly extracted, unrestored, caries free, nonattrited maxillary first premolars. Each tooth sample was weighed before wear testing using AT200 Mettler Toledo electronic analytical balance of 0.0001 g accuracy. Occlusal surfaces of these teeth were then abraded against the substrates in a wear machine for a total of 10,000 cycles. Each tooth sample was weighed after 5000 cycles and after the total of 10,000 cycles, respectively, using the same balance. Differences in weight of tooth samples before and after wear testing were evaluated statistically using one-way analysis of variance and Bonferroni's correction for multiple group comparisons.

Results: The values obtained for percentage weight loss after 10,000 cycles for glazed ceramic surface were marginally higher than values obtained for polished surface. It was observed that values obtained for percentage weight loss by polished ceramic after 10,000 cycles were statistically less as compared to the values obtained with glazed surface($P < 0.001$).

Conclusion: Enamel wear produced by polished monolithic zirconia is substantially less than polished layered and glazed zirconia. This study indicates the potential damage porcelain can inflict upon enamel and suggests that porcelain should be polished instead of glazed.

INTRODUCTION

Wear is a fact of restorative dentistry.[1] Wear of tooth structure is a natural unavoidable process which occurs when tooth to tooth, or tooth to restoration are in contact. However, the natural process may be accelerated by the introduction of restorations whose properties of wear differ from those of the tooth structure that they slide against.[2] The mechanism of tooth wear lies in the interplay of various factors such as the mechanical load due to compression, flexion and tension, friction and chemical influence. Rarely these factors operate separately, so the term multifactorial nature of dental tissues wear is mostly used.[3]

Physiologic tooth wear results in a slow, progressive loss of tooth substance. Initially, this process manifests as a flattening of the occlusal cusp tips and incisal edge mammelons[1]. The proximal surfaces also flatten and increase in area. Continued wear leads to the exposure of softer dentin and potentially an acceleration of the wear rate. Excessive wear on the occlusal surface can cause an abnormal load and result in periodontal diseases, and can also cause temporomandibular disorders due to the vertical dimension, loss of centric occlusion, diagonal teeth, functional route change during chewing, or masticatory muscle fatigue.[4]

Continuous wear of teeth leads to clinical significance which may have both systemic and biologic consequences.[5] Therefore, wear that occurs between the enamel of teeth and restorations is a very important factor that should be considered in the selection of restorative materials in clinical practice.

Recent years have shown the paradigm shift, with greater emphasis being laid on superior esthetics with ceramics becoming the current trend. The demand for esthetics in dental restorative materials has contributed to the dramatic increase in porcelain occlusal surfaces. This can have serious consequences if the porcelain restoration opposes an enamel surface because in vitro studies have shown the excessive wear of enamel opposing porcelain.[7]

Studies have shown that the wear rate of enamel depends on the surface texture and surface finish of opposing restorative material. Ceramics can either be polished or glazed to achieve a good finish Many studies were performed to identify finishing and polishing techniques that would create surfaces as smooth as or smoother than glazed porcelain . But the results were inconsistent. Differences in surface finish of ceramic may be responsible for variations in the amount of enamel wear.[6] Some authors recommended that glaze must be avoided because glaze surface is harder than underlying porcelain and is be more abrasive. However, some studies showed inconsistent relationship between hardness and abrasiveness of a restoration.[8]

Clinical tests are essential for characterizing the complex oral wear situations but they are expensive and time consuming. They also do not allow control of variables such as individual masticatory forces and oral conditions. Thus in vitro mastication still appears to be a practical solution for evaluating the wear performance of new materials. Therefore, the aim of this in vitro study was to investigate natural tooth enamel wear opposing Polished Monolithic zirconia, Polished layered zirconia and Glazed layered zirconia.

MATERIALS AND ,METHODS

Thirty non carious unrestored human maxillary premolars with complete root formation are selected for this study. The teeth were disinfected in thymol and cleaned with an ultrasonic scaler and stored in saline solution to prevent dehydration.

A metal die of length 10mm and width 10×10mm was fabricated. A putty index of this metal die was made. The teeth were embedded in the centre of the putty index with self-cure acrylic resin such that the roots were embedded in the acrylic and the occlusal surface was at least 5mm above the level of the resin. The roots were mounted perpendicular to the base of the mould. The cusp tips were reduced with a super fine grit diamond polishing bur. Then, Monolithic zirconia and layered zirconia were fabricated and subjecting to polishing and glazing procedures.

TEST PROCEDURE

Each mounted tooth sample was weighed before testing, using AT200 Mettler Toledo electronic analytical balance of 0.0001 g accuracy (Figure 2). Wear tests were conducted on a Pin on disc wear testing machine (Figure 3). The mounted discs and extracted human premolars were placed onto holders on a testing machine which provided contact between the specimens The enamel specimens were inserted into the upper specimen holder. The enamel specimen was projected at least 3mm from the opening of the holder. The lower member has a disc which rotates at the selected speed.

Wear tests were performed with a load of 1.5 kg at 30 cycles per minute for 10000 cycles. The specimens were tested in artificial saliva to reduce the friction during testing. The loss of weight of all the enamel specimens after 1st 5000 cycles, 2nd 5000 cycles and after total 10000 cycles was noted by using AT100 Mettler Toledo Analytical Balance and obtained results were subjected to relavant statistical analysis.

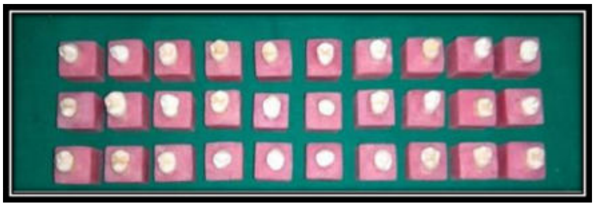

Figure 1 : Mounted premolar teeth

Figure 2 : mettler Toledo analytical balance

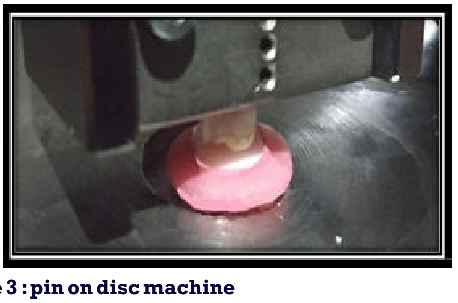

Figure 3 : pin on disc machine

RESULTS

Table 1: Mean and Standard deviation of enamel wear of samples after 1st 5000 cycles between Group I (Polished Monolithic zirconia), Group II (Polished Layered Zirconia) and Group III (Glazed layered zirconia) using ANOVA test

Study Groups	N	Mean	Std. Deviation	ANOVA	
				F	p-value
Polished Monolithic Zirconia	10	0.073	0.007	135.36	<0.001*
Layered Polished Zirconia	10	0.096	0.006		
Layered Glazed Zirconia	10	0.118	0.006		

*p<0.05 Statistically Significant, p>0.05 Non Significant, NS

Table 2: Mean and Standard deviation of enamel wear of samples after 2nd 5000 cycles between Group I (Polished Monolithic zirconia), Group II (Polished Layered Zirconia) and Group III (Glazed layered zirconia) using ANOVA test

Study Groups	N	Mean	Std. Deviation	ANOVA	
				F	p-value
Polished Monolithic Zirconia	10	0.074	0.006	58.82	<0.001*
Polished layered Zirconia	10	0.090	0.007		
Glazed layered Zirconia	10	0.107	0.008		

*p<0.05 Statistically Significant, p>0.05 Non Significant, NS

Table 3: Mean and standard deviation of enamel wear between Group 1 (Polished Monolithic zirconia), Group II (Polished Layered zirconia) and Glazed layered zirconia

Study Groups	N	Mean	Std. Deviation	ANOVA	
				F	p-value
Polished Monolithic Zirconia	10	0.147	0.008	132.47	<0.001*
Layered Polished Zirconia	10	0.186	0.010		
Layered Glazed Zirconia	10	0.225	0.014		

*p<0.05 Statistically Significant, p>0.05 Non Significant, NS

Table 4: Inter-comparison of enamel wear between Group I and other groups Group II and III after 10000 cycles using Tukey Post Hoc test

(I) Group	(J) Group	Mean Differen c e (I-J)	Std. Error	p-value	95% Confidence Interval	
					Lower Bound	Upper Bound
Group I	Group II	-0.039	0.005	<0.001*	-0.051	-0.027
	Group III	-0.078	0.005	<0.001*	-0.090	-0.066
Group II	Group III	-0.039	0.005	<0.001*	-0.051	-0.027

The results of present study showed a mean loss of 0.073gm (Table 1) after 1st 5000 cycles and 0.074gm (Table 2) after 2nd 5000 cycles for Polished Monolithic zirconia, 0.096gm (Table 1) after 1st 5000 cycles and 0.090gm after 2nd 5000 cycles (Table 2) for Polished Layered zirconia and 0.118gm after 1st 5000 cycles(Table 1) and 0.107gm after 2nd 5000 cycles (Table 2) for Glazed Layered zirconia.

DISCUSSION

Monolithic zirconia has been used in posterior region, especially for single crowns, in order to eliminate the veneer cracking. Because of its high fracture resistance and ability to withstand high force with only 0.5 mm occlusal thickness, Monolithic zirconia has been suggested for use in patients with limited inter occlusal space.[9] Since all-ceramic crowns are not burdened with the task of masking a dark metal substructure, a greater portion of their thickness can be composed of comparatively more translucent porcelain. And due to this fact, they tend to create a more lifelike look.[10]

The surface treatment of all ceramic crowns may be responsible for changing in the rate of enamel wear. Glazing of ceramic restorations produces a smooth, aesthetic and hygienic surface and is considered as a step which reduces the amount of wear of opposing teeth and restorations, but this layer of glaze can be removed shortly after being in function or by a required occlusal adjustment that may lead to more abrasive wear of the opposing teeth because of the insufficiently polished exposed surface of the crown.

In this study all the material discs were fabricated with the dimensions of 10mm diameter × 2mm thickness which is in accordance with study conducted by Gauri mulay et al who fabricated ceramic discs of dimensions 10mm diameter × 2mm thickness.[6] The reason for using this dimension was to ensure that the cusp tips are in contact with only test specimen and not any other surface at any point of testing during rotation.

This study measured two-bodied wear as Flanagan et al stated that the teeth come in contact more number of times in between meals (394 swallowing cycles) than during eating (146 swallowing cycles).[11] Artificial saliva was used as a medium to simulate oral environment and to flush off the worn particles and to prevent clogging.

Clinical testing is the ideal method for estimating the complex wear performance of restorative materials. However, these in vivo studies have often been time consuming and costly. Even great variation among subjects is unavoidable.[12]

In contrast, laboratory tests of wear behaviour with chewing simulators, which allow for the achievement of comparable results with different materials under standardized conditions, seem to constitute effective methods for the pre-clinical evaluation of material behavior.[5]

Pin on disc is the most common and simplest method of wear testing used. The base of the method is the use of two-component wear. The mounted discs and extracted human premolars were placed onto holders on a two-body wear machine, which provided contact between the specimens. Tooth sample was attached to the upper member, and the disc was attached to the lower member. The test samples were positioned in holders and additionally secured to the machine with the autopolymersing resin. This test is very simple, standardized and inexpensive.

Phillips RW stated that enamel varies in its properties depending on its position in the tooth and its histological structure. Cuspal enamel is stronger and can withstand forces in a direction parallel to the enamel rods than perpendicular to the rods because the enamel crystals in the head of the enamel rod are oriented parallel to the long axis of the rod.[13] In conformity with the above study, recently extracted non attrited, non-carious premolars were used. Since this study was to observe the wear behaviour of enamel in a clinical environment, only the cuspal tips of the enamel specimens were held in contact with the specimens.

The load chosen in this study was a weight of 1.5kg, which is comparable to 49N chewing force exerted which vary from individual to individual. It is generally found that males can bite with more force (118-142 lbs) than can females (79-99lbs).[14] Length and time of contact were a result of the mechanical design of the wear machine. Theoretically, all teeth specimens were in constant contact with the zirconia specimen, equally distributing the load throughout the simulation phase. Maxillary premolar teeth were selected for the study because they are one of the posterior teeth that bear occlusal loads and sharp cusps of maxillary premolars enables us to measure the amount of wear.

Weight loss is selected in this study because of its ease of measurement and clinical relevance regarding the vertical dimension of occlusion. Specimen wear was determined as weight loss between before and after weighing. The mounted specimens were cleaned and dried before they were weighed. Each mounted tooth sample was weighed using AT200 Mettler Toledo electronic analytical balance of 0.0001 g accuracy. As this electronic machine had a fully automated calibration technology and a micro weighing scale, values of all the mounted premolars were accurately measured. To ensure accuracy, the balance was kept on a free-standing table at all times, away from vibrations, and weighed the specimens with the glass doors of the balance closed to avoid the effect of air currents. The readings, baseline, intermediate and final that is, before testing, after 5000 cycles and after 10,000 cycles of wear for each tooth sample, were statistically analyzed to obtain the tooth substance loss at each interval.

The null hypothesis is that there is no difference between enamel wear opposed by Polished Monolithic Zirconia, Polished Layered zirconia and Glazed layered Zirconia. The results of this study indicated significant differences in the teeth wear caused by monolithic and layered zirconia with different surface finishes. Therefore, the null hypothesis was rejected.

In the present study there was statistically significant difference seen between groups with relation to their mean loss of weight values. In the present study, Polished monolithic zirconia showed least enamel wear followed by Polished layered zirconia and the highest tooth wear was shown by Glazed layered zirconia Rafat Amer et al investigated the 3-body wear of enamel opposing dense sintered yttrium-stabilized zirconia, Monolithic zirconia and Layered Zirconia. Their results showed a mean loss of 1.82mm for smooth layered zirconia, mean loss of 1.39mm for smooth Monolithic zirconia and mean loss of 3.29mm for glazed Monolithic zirconia. The results of the present study are in agreement to Rafer Amer et al. where in Monolithic Zirconia showed less wear than Layered zirconia. Moreover, the smooth surfaces of Monolithic zirconia showed less wear than the glazed group. Layered zirconia has larger grain size (2-4μm), which are weakly held to the amorphous matrix and are affected more by enamel wear, causing the surface of the ceramic to become rougher and potentially causing more wear on the opposing enamel.[15]

Mundhe K et al evaluated the wear of zirconia and metal ceramic crowns in vivo conditions.[16] They concluded that metal ceramic crown caused more wear than zirconia. The reason for less abrasive wear by zirconia is attributed to its polymorphic structure and relative thermal and dimensional stability. They also prevent crack propagation by volumetric expansion. It occurs as the result of transformation toughening mechanism that takes place during the transformation of tetragonal to monoclinic phase. As a result, zirconia has higher strength than feldspathic dental porcelains.

According to many authors after subjecting different specimens for the same duration of wear testing, glazed ceramic specimens exhibit much more enamel wear than those which were mechanically polished. In the studies conducted by Preis et al[17] and Sabrah et al[18] glazed surfaces caused more enamel wear than polished surfaces.

The results indicate that enamel loss was significantly different depending on the surface condition (polished and glazed, P as shown in Table 1 and Table 2. Significant results were obtained in this study where in Polished Monolithic zirconia and Polished layered zirconia comparatively showed less wear of enamel than Glazed Layered Zirconia. Possible explanation is that the surface hardness of the glazed surface is high. The results of this study are in agreement with Gauri Mulay, who concluded that glazed surface causes more enamel wear compared to polished surface.[6]

Jagger DC, Harrison A stated that amount of enamel wear produced by both glazed and unglazed ceramic was similar and also investigation of the glazed porcelain surface showed that the glaze was removed in less than 2 hours of wear on the machine.[19] However, the present study proved that wear produced by polished zirconia was substantially less compared to glazed zirconia. Hudson J D et al stated that glazed ceramic caused significantly more loss of vertical height and surface area. The reason for higher abrasion by glazed ceramic was attributed to the ceramic underneath the glaze with high asperities, and high hardness and rough surface which tends to abrade the comparatively softer enamel.[8]

Kadokawa et al stated that the wear rate of enamel when opposed to a smooth and polished porcelain surface was significantly lower than when opposed to a rough porcelain surface.[20] This might relate to the clinical situation in which polished restorations are in daily function and then start to develop roughness on the contact surfaces. Moreover, differences in wear rates of mutual opposing teeth and/or restorations might alter an individual's occlusal relationship. Thus, periodically checking the occlusion and maintaining the smoothness of restoration surfaces might be necessary.

Significant correlation was also found between initial and subsequent wear of enamel at different intervals. The enamel wear produced by over the glazed surface was significantly greater initially (up to first 5000 cycles) while the percentage of wear receded during 2nd 5000 cycles.

On comparision of loss of weight of teeth opposed by Glazed layered zirconia is 0.118 (Table 1) after 1st 5000 cycles and 0.107(Table 2) after 2nd 5000 cycles. The rate of wear is more during 1st 5000 cycles than 2nd 5000 cycles. This could be attributed to the fact that the glaze was removed after the short period of time intraorally. Thus after the glaze is removed wear rate reduces comparatively. The possible reason might be that worn out glazed layer exposes underlying well polished smooth surface and hard surface which decreases further wear.

There is no consensus in the literature about the efficiency of different finishing and polishing methods to obtain greater surface smoothness on the ceramics. According to Barghi et al the polishing/finishing systems are considered effective for reducing surface roughness, but they must not substitute the glaze, because they are unable to offer a sufficiently smooth surface after the action of a diamond point.[21]

Most ceramics have comparatively higher hardness values than human enamel, and the hardness of a ceramic has been used as a predictor of its potential to abrade opposing teeth. Moreover, oral wear is a complex process that is influenced by many internal and external factors, including the different kinds of restorative materials, surface treatments, parafunctional habits, neuromuscular forces and properties of saliva.[22] Most of the studies have evaluated the wear behaviour of ceramics in a fixed pattern, comparing different test groups after the same number of predefined wear cycles.[23]

When choosing ceramic crowns for restorations, the wear behaviour should be considered among the most important factor because it is an irreversible and unavoidable process.[24] An appropriate wear resistance or a mild wear regime is able to guarantee the long-term stability of the ceramic restorations, when they are subjected to repetitive masticatory force in the mouth. In contrast, the severe wear of ceramic restoration is regarded as a significant cause, which lead to the failure eventually.[25] As a result, the wear properties of ceramic restorations have a great influence on therapeutic outcome. The limitations of this study includes limited inclusion of physiologic parameters such as temperature, contact time and pH cycling. Regarding the methods of wear testing, the amount and duration of load as well as velocity are some of the factors that influence the amount of enamel wear. Even though control of variables is difficult in clinical studies, In vitro studies such as the present study do not replace them. In future in vivo studies should be conducted and outcomes should be interpreted with caution.

CONCLUSION

Within the limitations of this study, the following conclusions can be drawn:

1. Significant differences were found in the natural teeth enamel wear opposed by Monolithic and layered zirconia specimens with different surface finishes.
2. Polished Monolithic zirconia showed least enamel wear followed by Polished layered zirconia and the highest enamel wear was showed by Glazed layered zirconia.
3. Among polished groups, Polished monolithic zirconia showed less wear.

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