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Ceramic Restorations Worn Against Different Occlusal Antagonist (In Vitro Study)

*Yasser Othman [1],Cherif Mohsen,[2]Omaima El-mahallawi[3]
[1]*Doctorate student of Fixed Prosthodontics, Faculty of Dentistry, Minia University.*
[2]*Professor of Fixed Prosthodontics, Head of Fixed Prosthodontic Department, Faculty of Dentistry, Minia University.*
[3]*Professor of Fixed Prosthodontics, Faculty of Oral and Dental Medicine, Cairo University.*
*Corresponding author: *Yasser Othman*

Abstract:
Objectives: *Wear assessment of different ceramic restorations placed against different occlusal antagonists.*
Materials and methods: *Sixty ceramic sample discs (13mm in diameter and 2mm in thickness) were divided into two groups; full contour zirconia (Zr) and lithium disilicate press on zirconia substrate (E.max) discs. Sixty antagonists were constructed and subdivided into three subgroups: (1)Discs wearing against extracted teeth. (2) Discs wearing against Porcelain fused to metal crowns (PFMc). (3)Discs wearing against full contour zirconia crowns (Zrc).Sample discs and antagonists were dynamically three-body loaded in dual axis chewing simulator with 49 N for 75000 loading cycles. Wear measurement for sample discs and antagonist were calculated using height, weight loss,and surface roughness. Data were statistically analyzed with a 2-way analysis, followed by a Tukey test when showed significantly. Student t-test was done between main groups.*
Results: *E.max showed statistically significant higher wear rate than the Zr group. Teeth showed higher wear rate more than ceramic antagonist but the difference was statistically non-significant. The surface roughnesses for groups and subgroups were changed but the differences were statistically non-significant.*
Conclusion: *Zr vs. E.max has more wear than Zr vs. Zr. No difference in wear value of teeth, PFMc and Zrc opposing to ceramic restoration but teeth were slightly more wear than others. Zr and E.max exhibit acceptable wearing compatibility with the opposing PFMc and Zrc.*
Keyword: *Full contour zirconia, Lithium disilicate ceramic, Wear.*

I. Introduction

Dental prosthetic materials should have good mechanical properties that will enable them to withstand a repetitive masticatory pressure for a long time in the oral environment.Despite dental ceramic has a biocompatibility and aesthetic advantage. It is inherently fragile in tension and haslimitations in clinical use due to their susceptibility to fracture.(1)Full contour zirconia restoration was recently released. it has advantages in that no chipping porcelain is fractured due to the absence of veneering porcelain, and more strength can be obtained evenin conservative preparation for tooth structure, compared to previous all-ceramic preparationtaking into account the rigidity and elastic modulus of zirconia that is much higher than enamel,a great worry has been brought in clinic would natural teeth be damaged by excessive wear and stress concentration caused by mechanical mismatching between zirconia and natural enamel. (2, 3)Dental wear is a natural and unavoidablephysiological process, resulting from the fact that dental materials are submitted to the forces associated with mastication and to the chemical and thermal aggressive environment of the oral cavity. (4) Ideally, dental ceramics should possess both high wear resistance and minimal abrasiveness. The wear rate of ceramics should preferably match that of posterior tooth enamel. The ceramic against ceramic restoration has become more common clinically due to theincreased demand for ceramic restoration. (15)In this context, the overall goal of the present work is contributed to understanding the wear behavior of ceramics worn against different antagonists.The null hypotheses for this study were as follows: (1)-Ceramic restoration cause great wear of opposing human enamel than other restorative material. (2)-No difference would be found between full contour zirconia and lithium disilicate restoration wear depth opposing to human enamel or different restoration.

II. Materials And Methods

2.1. Samples and Antagonists preparation. Disc with 13mm in diameter and 2mm in thickness were designed and constructed by CAD/CAM system (Laserdentium GmbH & Co. Germany) using full contour zirconia block (Prettau, Zirkonzahn GmbH, Bruneck, Italy) andlithium disilicate glass ceramicingot (Ivoclar Vivadent, Liechtenstein) Press on full contour zirconia core.Samples were finishing and polishing using finishing bur(Komet Dental,Gebr. Brasseler GmbH, Germany)NTI green, blue, yellow polishing kit (Patterson Dental,

USA.) and Silicon carbide papers (Buehler, GmbH, Germany.) in the sequence 320, 400, 600 and 1200 grite were used until a highly polished flat surface was achieved.Antagonist wascollected and prepared using extracted human upper first premolar teeth for orthodontic reasons,porcelain fused to metal crown constructed by feldspathic Porcelain (Vita Zahnfabrik, Germany) and full contour zirconia crown (Prettau,Zirkonzahn GmbH, Bruneck, Italy). Antagonist crown was cemented to duplicated upper first premolar acryliclike tooth preparation[5] using adhesive resin cement(Preeze, Self-Adhesive Cement, Pentron, USA.) Standardized embedded antagonist in the acrylicresin block 1to 3 mm above cementoenamel junction or margin of the crowns with the prominent buccal cusp in the acrylic resin were done using specially designed custom-made copper holder device.

2.2.A wear test. It was conducted using the chewing simulator ROBOTA (Ach-09075DC-T, AD-Tech Technology Co., Ltd.,Germany) which has four chambers simulating the vertical and horizontal movement. (Fig:1)The parameter of the wearing test was described in (Table:1)with the presence of an intermediatematerial (a mixture ofequal weights of non-plasticized PMMA powders and distilled water) [6]to simulate a food bolus.

Figure (1): Chewing simulator.

Table 1: Parameters of the wearing test.

Vertical movement	2 mm
Cycle frequency	1.6 Hz
Horizontal movement	1 mm
Weight per sample	5 kg

2.3. Wearmeasurement before and after wear. The weight using Electronic weight balance (Sartorius, Biopharmaceutical, and Laboratories, Germany) was used for sample and antagonist. Height using Digimatic micrometer (High-Accuracy Digimatic, Digital Micrometer, USA.) was used for the antagonist. Surface roughness for sample and antagonist were measured using anoptical microscope, and a digital camerain the middle of each sample and antagonist. They were photographed using USB Digital microscope with a built-in camera (Sartorius, Biopharmaceutical, and Laboratories, Germany.) WSxM software was used to calculate the average of heights (Ra) expressed in µm, which can be assumed as reliable indices of surface roughness. Scanning Electron Microscope(SEM)(Philips XL 30 CP, Eindhoven, Netherlands.)

for the sample, evaluated at magnifications of 50×operating at 10 kV. 2-way analysis of variance was performed, followed by a Tukey test when showed significantly. Student t-test was done between main groups.

III. Results

3.1. Wearing testofsamples and antagonists weresummarized in (Fig:2).

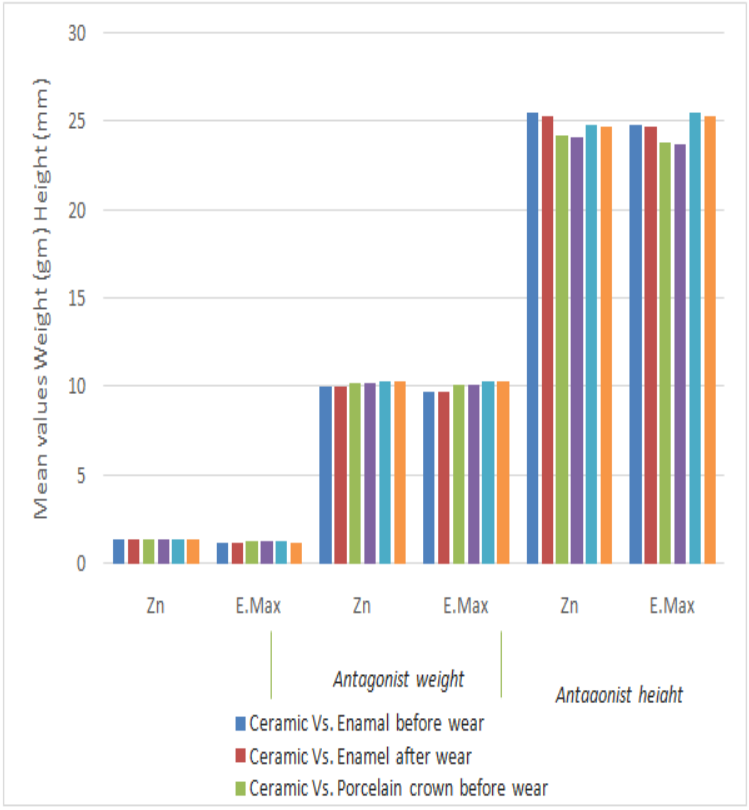


Figure (2): Column chart showing wear mean values for group and subgroup before and after wear simulation.

In the teeth, antagonist wear against Zr and E.max group samples weight change mean value (0.00087±0.0004 and -0.000016±0.0005 gm). respectively. The difference between groups was statistically **non-significant** as indicated by t-test (t=1.3, p>0.05). In the teeth, antagonist wear against Zr and E.max group antagonists weight change mean value (-0.0051±0.001 and -0.0027±0.0009 gm). respectively. The difference between groups was statistically **non-significant** as indicated by t-test (t=1.4, p>0.05).In the teeth, antagonist wear against Zr and E.max group antagonist'sheight changes mean value (-0.155±0.008 and -0.138±0.02 mm). respectively. The difference between groups was statistically **non-significant** as indicated by t-test (t=0.82, p>0.05)

In the PFMc antagonist wear against Zr and E.max group samples,weight change mean value (-0.000383±0.0009 and -0.013142±0.045 gm). respectively. The difference between groups was statistically **non-significant** as indicated by t-test (t=0.5496, p>0.05). In the PFMc antagonist wear against Zr and E.max group antagonists weight, change mean value (-0.000317±0.0012 and -0.00082±0.00018 gm). respectively. The difference between groups was statistically **non-significant** as indicated by t-test (t=1.1, p>0.05).In the PFMc antagonist wear against Zr and E.max group antagonists,height change mean value (-0.092±0.53 and -0.042±0.091 mm). respectively. The difference between groups was statistically **significant** as indicated by t-test (t=2.97, p<0.05)

In the Zrc antagonist wear against Zr and E.max group samples,weight change mean value (0.00010±0.00005 and -0.04312±0.04 gm). respectively. The difference between groups was statistically **significant** as indicated by t-test (t=2.7, p<0.05).In the Zrc antagonist wear against Zr and E.max group antagonists weight, change mean value (-0.0350±0.03 and -0.0016±0.0008 gm). respectively. The difference between groups was statistically **significant** as indicated by t-test (t=2.4, p<0.05). In the Zrc antagonist wear against Zr and E.max group antagonists,height change mean value (-0.0700±0.2 and -0.0655±0.22 mm). respectively. The difference between groups was statistically **non-significant** as indicated by t-test (t=0.155, p>0.05)

The total effect of samples groups was found that E.max group showed higher wear rate mean value (-0.02423±0.012 gm) than Zr groups mean value (-0.00126±0.0008 gm) and this was statistically *significant* as indicated by ANOVA (P=0.0428<0.05). Total effect of antagonist subgroups was found that teeth showed the highest wear rate followed by PFMc while and Zrc showed the lowest wear rate and this was statistically *non-significant* as indicated by ANOVA (P=0.0597>0.05)

3.2. Surface roughness testof samples and antagonists were summarized in (Fig:3).

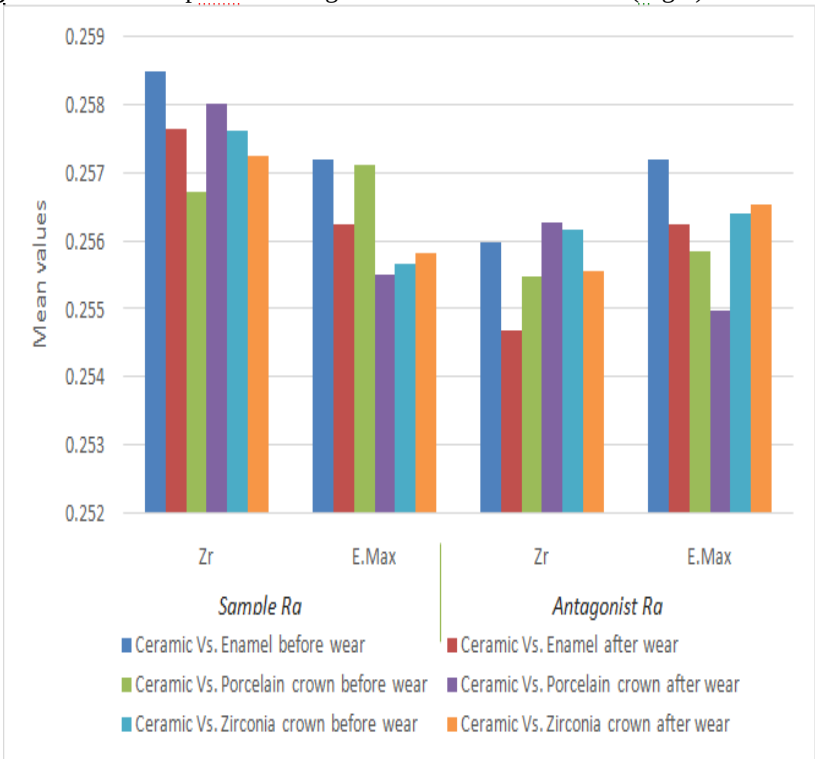


Figure (3): Column chart showing Surface roughness mean values for group and subgroup before and after wear simulation.

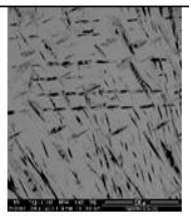
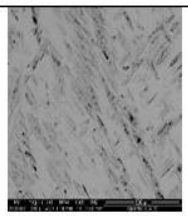
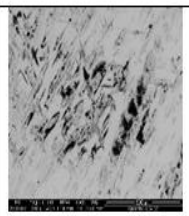
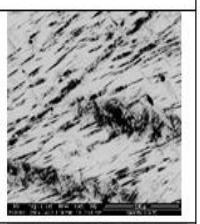
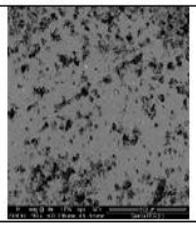
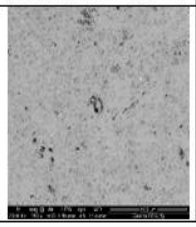
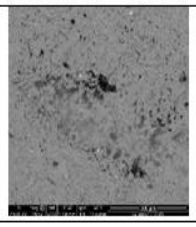
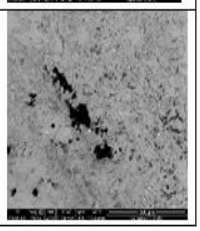
In the teeth, antagonist wear against Zr and E.max group samples roughnesschanges mean value (-0.00085±0.00068 and -0.00035±0.0007µm). respectively. The difference between groups was statistically **non-significant** as indicated by t-test (t=2, p>0.05). In the teeth, antagonist wear against Zr and E.max group antagonistroughnesschanges mean value (-0.0013±0.0006 and -0.00095±0.0008 µm). respectively. The difference between groups was statistically **non-significant** as indicated by t-test (t=0.188, p>0.05).

In the PFMc antagonist wear against Zr and E.max group samples,roughness changes mean value (0.0013±0.0008 and -0.0016±0.0009 µm). respectively. The difference between groups was statistically **significant** as indicated by t-test (t=5.5, p>0.05).In the PFMc antagonist wear against Zr and E.max group, antagonist roughness changes mean value (0.000783±0.0016 and -0.00087±0.0015 µm). respectively. The difference between groups was statistically **non-significant** as indicated by t-test (t=1.7, p>0.05).

In the Zrc antagonist wear against Zr and E.max group samples roughness changes mean value (-0.00037±0.0001 and 0.00017±0.002 µm). respectively. The difference between groups was statistically **non-significant** as indicated by t-test (t=0.707, p>0.05)**.** In the Zrc antagonist wear against Zr and E.max group antagonist roughness changes mean value (-0.00062±0.0003 and 0.00015±0.002 µm). respectively. The difference between groups was statistically **non-significant** as indicated by t-test (t=0.732, p>0.05).

The total effect of groups was found that E.max group showed the higher change in Ra mean value than Zr groups mean value and this was statistically **non-significant**as indicated by ANOVA (P=0.3514>0.05).The total effect of subgroupswas found that enamel antagonist showed the highest change in Ra mean value followed by full contour zirconia antagonist while veneering porcelain antagonist showed the lowest change in Ra mean value and this was statistically **non-significant** as indicated by ANOVA (P=0.0981>0.05). **Sem** for samples before and after wear against different antagonist showed in (Table:4). The porosity, being greater in E.max than Zr. None of the Zr or E.max was showed any wear traces after wear process, while the samples against PFMc and Zrc showed minimal noticeable wear area without remarkable surface features.

Table (4): SEM for samples before and after wear.

	Before Wear	After Wear		
		Wear against teeth	Wear against PFMc	Wear against Zrc
Full Contour Zirconia				
IPS E.Max Press On Zirconia				

IV. Discussion

At the present study, Zr was selected against PFMc and Zrc because little quantitative and qualitative data exists regarding wearing ceramic against ceramic restoration. [7,1,6,8]E.max was selected because using layering technique have shown more voids on the surfaces compared to pressed technique. [6]Standardization of the occlusal surface of extracted human teeth that used as the antagonist has been a subject of considerable controversy. [9]The present study used polished ceramic because of highly polished ceramic decrease the opposing enamel wear more than the glazed or rough surface. In addition, the polished flat surface was essential to measure the wear accurately. [15,61]Three bodies chewing simulator was used in the present study to stimulate human mastication with abrasive foods. The combination of a vertical application of force and an additional lateral movement of the sample carrier in one masticatory to simulation both abrasive and fatigue wears[10,9,8,6]5 KG bite force which is the mean physiological occlusal force without bruxism based on the intraoral occlusal force reported by previous studies on ceramic wear. [7,1,8]According to **Rosentritt *et al.,*** [11] 750,000 cycles under a load of 49 N represents five clinical years, according to that 75000 cycles with 50 N load were used in present study to stimulate 6 months clinical.Sample groups were wearing against enamel found that the difference between Zr and E.max group with weight change mean value (0.00087) and (-0.000016) respectively, this change was statistically non-significant. This result was agreement with ***Kwon et al.,*** **[8]** zirconia samples found slightly increasing in the weight after wearing against enamel due to the remnant of wearing debris after wear.The present study found non-significant between antagonist and the result was agreement with ***Amer et al.,*** [6] found that the Y-TZP caused slightly less wear on opposing enamel than feldspathic porcelain. Interestingly, lithium disilicate was observed to cause the least amount of wear on opposing teeth when compared to feldspathic porcelain or Y-TZP. Another author ***Preis et al.,*** [12] found porcelain wear is shown to be lower than antagonistic teeth wear.

The veneering porcelain antagonist wore against Zr and the E.max group found a statistically non-significant difference with weight change (-0.000317) and (-0.00082) respectively, while statistically significant difference with height change (-0.092) and (-0.042) respectively. The difference between height and weight result are related to the contact of wearing in the cusp tip shape more than surface area while the weight may be affected by the remnant of wearing debris of the cusp tip. [10]Full contour zirconia antagonist worn against Zr and the E.max group found a statistically significant difference with weight change (0.0350) and (0.0016) respectively. While statistically non-significant difference with height change (-0.070) and (-0.0655) respectively. The explanation of this variation related to the weight loss of antagonist is increasing of opposing zirconia samples after wear and also may be related to the high density of zirconia compared to lithium disilicate restoration.The surface roughness of antagonist value between groups were statistically non-significant. The results of surface roughness antagonist was correlated to the result of antagonist wears. This result was disagreement with ***Ghazal and Kern,*** [13] who showed that the antagonistic surface roughness had a significant effect on the wear of human teeth, and the correlation between the volume loss and antagonistic surface roughness was significant.

According to the null hypothesis for this study that, were as follows: (1)-Ceramic restoration causes great wear of opposing human enamel than other restorative material, was rejected as the study found slightly enamel wear more than another restorative material. (2)-No difference would be found between full contour

zirconia and lithium disilicate restoration wear depth opposing to human enamel or different restoration, was rejected as the study found there is the difference between full contour zirconia and lithium disilicate restoration wear depth opposing to human enamel or different restoration.

V. Conclusion

Within the limits of this study, the following conclusions are drawn:

1- Full contour zirconia vs. lithium disilicate restoration has more wear than full contour zirconia vs. full contour zirconia restoration. The full contour zirconia restoration has more wear resistance than lithium disilicate restoration.

2- No difference in wear value of teeth, feldspathic porcelain and full contour zirconia restoration opposing ceramic restoration but teethwere slightly more than other.

3- Full contour zirconia and lithium disilicate restorations exhibit acceptable wearing compatibility with the opposing feldspathic and full contour zirconia restorations.

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