Original Research Paper

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A Comparative Evaluation of Wear of Enamel to Various Restorative Materials of Different Surface Finishes : An in Vitro Study

Abstract:

Aim: The aim of this study is to evaluate the effect of different surface finish of various restorative materials on the wear of opposing enamel.

Objectives of the study: 1.To compare the amount of enamel loss in experimental groups of various restorative materials at different intervals of masticatory cycles. 2.To compare and evaluate the most compatible finished or polished surface of the restorative material causing least enamel wear.

Materials and Methods: A total of 90 samples were prepared for this study - 75 in disc form and 15 enamel antagonist and divided into 6 groups. Group 1 - Enamel vs Enamel antagonist, Group 2 - Enamel vs Fiber Reinforced Composite disc, Group 3 Enamel vs Autoglazed metal ceramic disc , Group 4 - Enamel vs Overglazed metal ceramic disc, Group 5 - Enamel vs Polished metal ceramic disc by polishing kit, and Group 6 - Enamel vs PEEK disc were fabricated. 105 extracted premolars were collected and randomly divided into six groups of 15 each and 15 for enamel antagonist. Each tooth sample was weighed before wear testing using 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 Tukey's post hoc tests was used.

Results: The values obtained for overall mean percentage weight loss after 10000 rotations in increasing order is observed: Group 1 (Enamel Vs Enamel 0.0043 ± 0.00) < Group 6 (Enamel Vs PEEK disc 00.0131 ± 0.01) < Group 2 (Enamel Vs Fiber reinforced composite 0.0258 ± 0.01) < Group 5 (Enamel Vs Polished metal ceramic disc 0.0294 ± 0.00) < Group 3 (Enamel Vs Autoglazed metal ceramic disc 0.0318 ± 0.01) < Group 4 (Enamel Vs Overglazed ceramic disc 0.0451 ± 0.01).

Conclusion: PEEK showed the least amount of enamel wear followed by Fiber reinforced composite. Fiber reinforced composite may cause less wear than dental ceramics. Enamel wear produced by polished metal ceramic disc is substantially less than autoglazed and over glazed metal ceramic disc. This study indicates that any potential damage to ceramic can directly affect enamel and suggests that porcelain should be polished instead of over glazed.

Key-words: Fiber reinforced composite, Autoglazed, Overglazed, Polished surface, Wear, PEEK.

Introduction:

A large number of dental restorative materials are available today for prosthetic purposes. The ideal restorative material should resemble as close as possible to the tooth hard tissues that are to be replaced. Among material properties, wear behavior seems to be of crucial importance, as over time either a reduced wear resistance or an exaggerated abrasiveness may severely jeopardize the esthetic and functional outcome of occlusal rehabilitations.[1] Accurate gauging of the wear rate of human enamel is also essential for wear criteria for restorative

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materials to be defined. Seghi [2] stated that the wear rate of a restorative material should be equal to that of enamel. Several studies have analyzed the in vitro wear resistance of restorative materials opposing either human enamel antagonists or dedicated artificial abraders.[3-7]

A number of manufacturers have developed fiber reinforced composite resins that claimed to be solution for conventional composite for restoring cavities and building core foundations in stress bearing areas has increased rapidly in recent years.[8] Moreover, innovative and enhanced resin composites have been recently introduced, showing promising in vitro wear resistance values, statistically similar to those of human enamel and gold-based alloys.[1] Recent years have shown a paradigm shift, with greater emphasis being laid on superior esthetics with ceramic becoming the current panacea.[9] In a direct comparison between properties, such as flexural strength, hardness, or optical behavior, ceramic/glass ceramic materials are generally superior to dental composites.[10] Dental Ceramic materials are wear resistant, but they may damage the opposing enamel.[11], Dental porcelain has been used increasingly during this century as a crown material. Surface characteristics such as smoothness or glaze influence the wear resistance of porcelain and affect its abrasive potential.[12] Ceramics can either be polished or glazed to achieve a good finish. Differences in surface finish of ceramic may be responsible for variations in the amount of enamel wear. A new polymeric material in this field of dental research is polyetheretherketone (PEEK)-a polymer from the main group PAEK (polyaryletherketone).[13] As PEEK is quite novice material in dentistry comparing to composite, ceramics or zirconia. Clinical tests are essential for characterizing the complex oral wear situation but are also expensive and time consuming. They also do not allow control of variables such as individual mastication forces or oral conditions.[14] Thus, in vitro mastication still appears as a practical solution for ranking the wear performance of emerging new materials.

Thus this invitro study comparatively evaluates the human enamel wear and the surface finish of various restorative materials which substantially cause less wear of natural human enamel.

Methodology :

Total 90 samples were prepared for this study - 75 in disc form and 15 enamel antagonist and divided into 6 groups. Group 1 - Enamel vs Enamel antagonist, Group 2 - Enamel vs Fiber Reinforced Composite disc, Group 3 Enamel vs Autoglazed metal ceramic disc , Group 4 - Enamel vs Overglazed metal ceramic disc, Group 5 - Enamel vs Polished metal ceramic disc by polishing kit, and Group 6 - Enamel vs PEEK disc were fabricated. 105 extracted premolars were collected and randomly divided into 6 groups of 15 each and 15 for enamel antagonist (Group I).

A customized acrylic resin template with standardized moulds of dimensions of disc (10mm diameterx3mm thickness) was fabricated by 3-D printing machine (Figure. 1).

15 Disc of Group II Fiber Reinforced Composite (Gc solare composite with fibers of Everstick C & B)disc were fabricated from the customized acrylic resin template and verified by veriner calliper(10mm diameter x 3mm thickness) (Figure. 2).

The preparation of 45 metal disc was done by conventional casting procedure with wax pattern. Total 45 wax pattern were fabricated (Figure. 3).

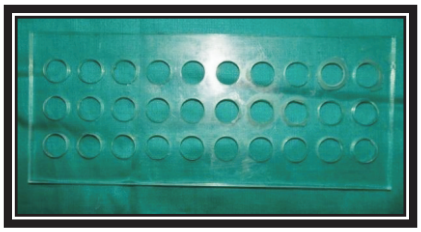


Fig. 1: Customized acrylic resin template

Fig. 2: 15 Fiber Reinforced Composite Disc

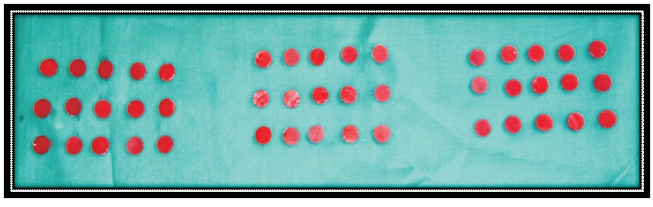


Fig. 3: 45 wax pattern metal ceramic disc

15 wax pattern for each group III, IV and V. ***Another*** customized acrylic template was made by 3-D printing machine of standardized mould dimension of 10mm x 1mm

(diameter x thickness) from which wax pattern have dimension of 10mm diameter x 1mm thickness for group III, group IV, group V. Spruing of 45 prepared wax pattern for metal disc were casted in three sets of group of 15 (Figure. 4). After spruing the were attached to the crucible former base made of rubber. The crucible former was removed once the investment sets. The phosphate bonded investment material was used for investing of patterns in casting ring with debubblizer to increase the wettability of the patterns. After investing ,the investment was left for bench set of one hour and was placed in a Muffle furnance heated around 200 ºC - 400 ºC for 30 minutes. To burn out the remaining traces of wax, the investment was heated further to final burnout temperature (650 ºC).The casting was done in induction casting machine. The temperature of the casting machine was 990 ºC. The metal used for casting was nickel–chromium alloy meant for metal-ceramics.The alloy was placed in the crucible and heated and molten alloys was allowed to flow in invested mould. After casting procedure Deinvest was done, the casting with visible casting defects was rejected then finishing and polishing procedure was done in customary manner. The metal disc were finished of dimension 10mm diameter x 1mm thickness which was latter on verified by digital vernier calliper (Figure. 5,6).

Another custom milled stainless steel template with 24 individual standardized moulds was fabricated by CAD/CAM. Each inner mould of this second template was of diameter 10mm and depth 3mm. (Figure. 7) . Stainless Steel template was duplicated in reversible hydrocolloid material that is, agar with help of duplicating machine (Figure. 8). It was then poured with phosphate bonded investment material and refractory casts was obtained (Figure. 9). The finished metal discs were sandblasted. All the discs were secured in refractory casts within each mould Vita Vacumat, 40 Furnace was used for ceramic built up.Two layers of opaque porcelain were applied, and discs were fired and these Discs were layered with feldspathic leucite ceramic layering material by Ivovlar Vivadent, IPS D. Sign. Condensing of dentin and enamel porcelain was done using the standard protocol for all the discs to achieve the overall thickness of 3.0 mm. Thickness of the dentin porcelain was 1.0 mm, enamel porcelain was 1.0 mm and metal disc thickness was 1.0mm.It was measured using a digital vernier calliper. All the discs were autoglazed progressively by increasing the furnace temperature to 975 ºC. After cooling, discs were retrieved from the refractory casts & 45 metal ceramic disc samples were prepared (Figure. 10)

Fig. 4: Attachment of crucible former

Fig. 5 & 6: 1 X 10 mm thickness of ceramo metal disc verified by digital vernier calliper

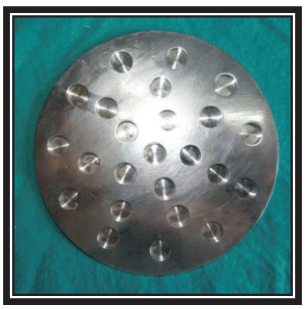


Fig. 7: Custom milled steel template with standardized moulds

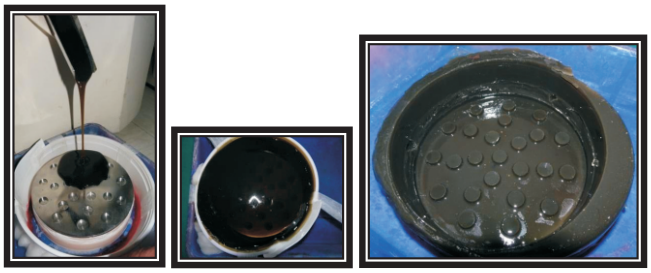


Fig. 8: Steel template was duplicated in reversible hydrocolloid material

Fig. 9: Refractory Casts

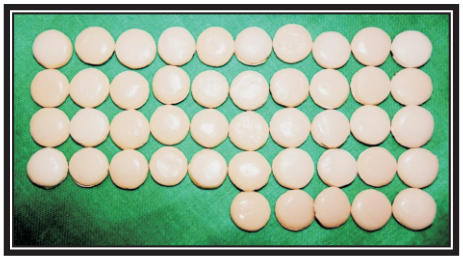


Fig. 10: 45 metal ceramic disc

15 discs were randomly selected and kept aside as a Group III - Autoglazed metal ceramic disc. ***and for*** Group IV Glaze liquid was applied evenly to 15 discs of this group with sable brush. Discs were fired at the temperature of 915 ºC for glaze firing (Group IV - Over glazed ceramic surface) **(Figure. 11).**

Fig. 11: 15 *Group* IV – Overglazed metal ceramic disc

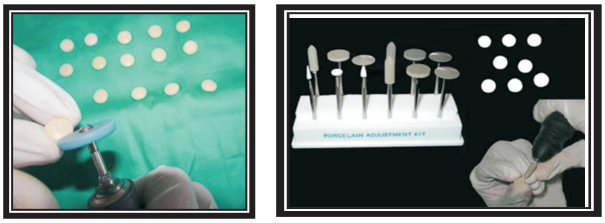


Fig. 12: 15 Polished metal ceramic disc polished by Shofu Ceramic Polishing Kit *Group* V

For 15 samples of Group V were polished by Shofu polishing kit**.** Polishing Wheels with green ring for fine surface was used for polishing at the speed of 10,000 rpm using gentle and even pressure for all the samples. Only one operator polished all the samples. One polishing wheel was used only for five samples. Samples were then cleaned in an ultrasonic cleaner for 10 min **(Figure. 12).**

15 Wax pattern of standard dimension was fabricated of standard dimension of disc 10mm diameter x 3mm thickness by customized acrylic template. Initially the wax pattern which was invested in mould with an investment material especially developed for this Bio HPP system and was heated between 630 ºC and 850 ºC in pre-heating oven, the wax gets melt away and then cooled at 400 ºC.At this temperature, Bio HPP is brought to the melting range of this investment material mould and melted down.

The press plunger helps to insert Bio HPP into the mould was transferred in 2 press system **(Figure. 13).** After raising the lift in the system, the pressure procedure was triggered automatically which takes place in a vacuum, the mould was cooled down to room temperature within 35 minutes & pressure was maintained by whilst and was deinvested as usual. After devesting it was polished by a dry cotton buff maintaining the standard dimension of 10mm diameter x 3mm thickness **(Figure. 14) .** In such way 15 disc of PEEK (Bio-HPP) was fabricated in Shree Sai Dental Lab, Pune, India**(Figure. 15).**

Total 105 freshly extracted human unrestored, caries free, nonattrited maxillary first premolars of young adolescent patients undergoing orthodontic extractions was collected. They were disinfected in formalin and preserved in saline. Only those teeth having sharp cusps and proper anatomy were selected **(Figure. 16).**

Fig. 13: PEEK material (Bredent) *for 2 press* system

Fig. 14: Finishing of PEEK Disc

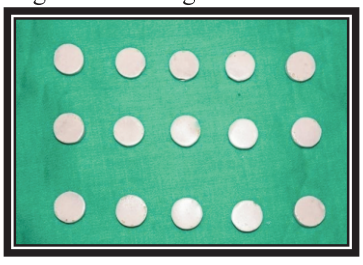


Fig. 15: *Fabrication of Group VI - 15* PEEK (BIO-HPP) Dise

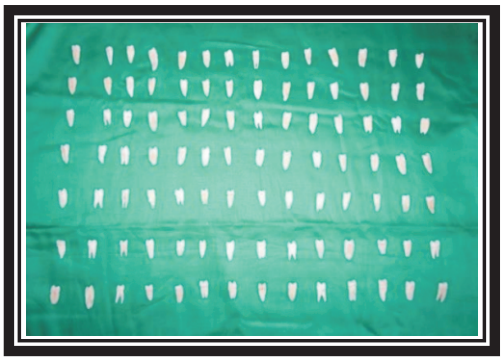


Fig. 16: 105 freshly extracted first premolars teeth

Teeth were sectioned transversely at the cement–enamel junction to separate crowns from the roots. All the crowns of premolars were mounted in self–cured acrylic resin except Fifteen crown sections for Group I. ***90*** mounted extracted premolars was then randomly divided into Six groups of 15 each**.** Each mounted tooth sample was weighed before testing, using 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 (**Figure. 17).**

Each mounted specimen was cleaned and dried with absorbent paper before weighing. 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 mounted discs and extracted human premolar were placed onto holders on a wear machine TR-20-M61 Tribometer (Wear and Friction Monitor) manufactured by Ducom ***which provide contact between the specimens*** **(Figure. 18).** Its consist of horizontal load arm with the holder for mounting the enamel antagonist and Advanced rotating wheel over which ***different restorative material disc and sectioned crown of premolar (Group I) Disc samples was secured.*** The cusp tips and various restorative discs were positioned under a constant load of 1.5 kg and sprayed with artificial saliva (Biomed, MP Sai) for the entire duration of the experiment. This setting was controlled by the software named as Winducom 2010. The specimens were made to rub against one another in a sliding motion to simulate the oral wear cycle **(Figure. 19).**

The test was run for a total of 10,000 cycles on the wear machine, for each pair of samples. Each mounted tooth sample was weighed before testing and after first 5000 cycles

Fig. 17: Electronic analytical balance of 0.0001 g accuracy

Fig. 18: TRIBOMETER TR-20-M61 (Wear and Friction Monitor)

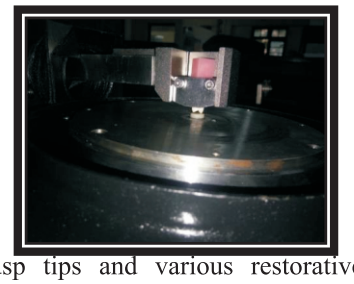


Fig.19 : Cusp tips and various restorative discs were positioned under a constant loa

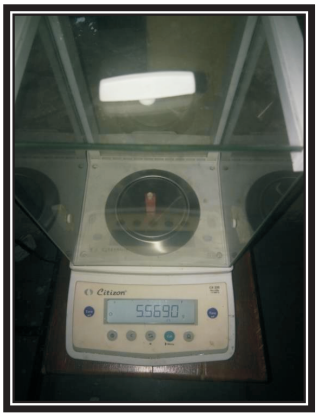


Fig. 20 : Each tooth sample was also weighed before & after 5000 &10000 cycles respectively

This was done in order to determine if wear rate varied with duration of testing. Each mounted tooth sample was weighed after 10,000 cycles. **(Figure. 20).** The same protocol used for measuring baseline weight was repeated. The weight from Electronic Analytical Balance was made at 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.

Observations and Results:

Results :

The data on percentage weight change is shown as median with minimum and maximum for each group. For this study, median was used as it does not get affected by the wide variations in values.

Relative percentage change in weight was calculated using the following formula: 100 × (baseline weight – weight during different cycles)/(baseline weight). The statistical comparison of average levels of percentage change in weight between various groups was done using one–way ANOVA analysis of variance technique with Post hoc Turkey test for multiple group comparisons as appropriate with necessary transformations to satisfy underlying normality assumption. Within the group, comparison was done by Paired analysis using Post hoc Turkey test , a nonparametric test procedure. After analyzing statistically according to the formula mentioned above, following results were obtained:

Table 1: Comparison of mean weight of enamel at baseline for 6 groups.

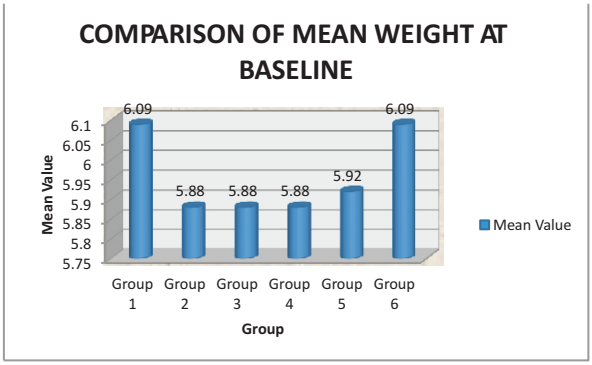
Group	N	Mean ± SD	F value	P value
Group 1 Enamel Vs Enamel	15	6.09 ± 0.24	1.85	0.113, NS
Group 2 Enamel Vs FRC disc	15	5.88 ± 0.31		
Group 3 Enamel Vs Autoglaze metal ceramic disc	15	5.88 ± 0.36		
Group 4 Enamel Vs Overglaze metal ceramic disc	15	5.88 ± 0.29		
Group 5 Enamel Vs Polish metal ceramic disc	15	5.92 ± 0.33		
Group 6 Enamel Vs PEEK disc	15	6.09 ± 0.25		

One-way ANOVA test applied. P value = 0.113, Not significant

The table 1 shows the comparison of mean weight at baseline in the six groups.

In Group 1 (Enamel Vs Enamel) the weight at baseline was 6.09 ± 0.24 gm, in Group 2 (Enamel Vs FRC) it was 5.88 ± 0.31 gm, in Group 3 (Enamel Vs Autoglazed metal ceramic disc) it was 5.88 ± 0.36 gm, in Group 4 (Enamel Vs Overglazed metal ceramic disc) it was 5.88 ± 0.29 gm, in Group 5 (Enamel Vs Polished metal ceramic disc) it was 5.92 ± 0.33 gm and in Group 6 (Enamel Vs PEEK disc) it was 6.09 ± 0.25 gm. The comparison of mean weight between the six groups was done using one-Way ANOVA which was found to be statistically not significant (P>0.05), showing that the mean weight at baseline was comparable between all the six groups at baseline. There was no statistically significant difference seen in the mean weight at baseline between any of the pairs (P>0.05), showing a comparable mean weight between each pair.

Graph 1: Bar diagram showing comparison of mean weight of enamel between the six groups at baseline: Group 1



Enamel Vs Enamel

Group 2 - Enamel Vs FRC disc

Group 3 - Enamel Vs Autoglazed metal ceramic disc

Group 4 - Enamel Vs Overglazed metal ceramic disc

Group 5 - Enamel Vs Polished metal ceramic disc

Group 6 - Enamel Vs PEEK disc

Table 2: Comparison of mean weight loss of enamel after 5000 rotations in the six groups

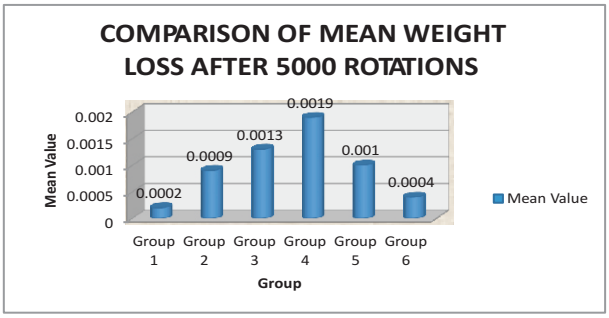
Group	N	Mean ± SD	F value	P value
Group 1 Enamel Vs Enamel	15	0.0002 ± 0.00	40.31	0.000*
Group 2 Enamel Vs FRC disc	15	0.0009 ± 0.00		
Group 3 Enamel Vs Autoglaze metal ceramic disc	15	0.0013 ± 0.00		
Group 4 Enamel Vs Overglaze metal ceramic disc	15	0.0019 ± 0.00		
Group 5 Enamel Vs Polish metal ceramic disc	15	0.0010 ± 0.00		
Group 6 Enamel Vs PEEK disc	15	0.0004 ± 0.00		

One-way ANOVA test applied. P value = 0.000, Significant

The table 2 shows the comparison of mean weight after 5000 rotations in the six groups.

In Group 1 the weight after 5000 rotations was 0.0002 ± 0.00gm, in Group 2 it was 0.0009 ± 0.00 gm, in Group 3 it was 0.0013 ± 0.00 gm, in Group 4 it was 0.0019 ± 0.00 gm, in Group 5 it was 0.0010 ± 0.00 gm and in Group 6 it was 0.0004 ± 0.00 gm. The comparison of mean weight between the six groups was done using one-Way ANOVA which was found to be statistically significant (P<0.05), showing that the mean weight after 5000 rotations was varying between all the six groups at baseline. This means wear of enamel increased consistently with an increase in number of cycles. Overall the weight loss after 5000 rotations in increasing order is shown below:

Group 1 < Group 6 < Group 2 < Group 5 < Group 3 < Group 4



Graph 2: Bar diagram showing comparison of mean weight loss of enamel between the six groups after 5000 rotations :

Group 1 - Enamel Vs Enamel

Group 2 - Enamel Vs FRC disc

Group 3 - Enamel Vs Autoglazed metal ceramic disc

Group 4 - Enamel Vs Overglazed metal ceramic disc

Group 5 - Enamel Vs Polished metal ceramic disc

Group 6 - Enamel Vs PEEK disc

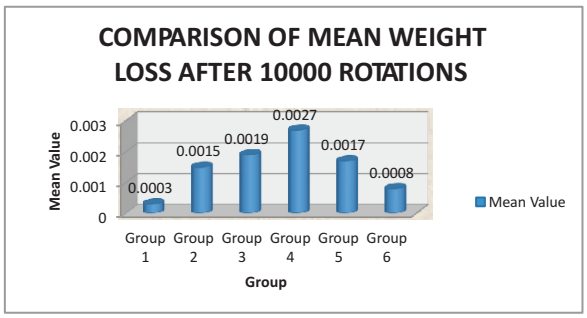
Table 3: Comparison of mean weight loss of enamel after 10000 rotations in the six groups

Group	N	Mean ± SD	F value	P value
Group 1 Enamel Vs Enamel	15	0.0003 ± 0.00	48.21	0.000*
Group 2 Enamel Vs FRC disc	15	0.0015 ± 0.00		
Group 3 Enamel Vs Autoglaze metal ceramic disc	15	0.0019 ± 0.00		
Group 4 Enamel Vs Overglaze metal ceramic disc	15	0.0027 ± 0.00		
Group 5 Enamel Vs Polish metal ceramic disc	15	0.0017 ± 0.00		
Group 6 Enamel Vs PEEK disc	15	0.0008 ± 0.00		

One-way ANOVA test applied. P value = 0.000, Significant

The above table shows the comparison of mean weight after 10000 rotations in the six groups. In Group 1 the weight after 10000 rotations was 0.0003 ± 0.00 gm, in Group 2 it was 0.0015 ± 0.00 gm, in Group 3 it was 0.0019 ± 0.00 gm, in Group 4 it was 0.0027 ± 0.00 gm, in Group 5 it was 0.0017 ± 0.00 gm and in Group 6 it was 0.0008 ± 0.00 gm. The comparison of mean weight between the six groups was done using one-Way ANOVA which was found to be statistically significant (P<0.05), showing that the mean weight after 10000 rotations was varying between all the six groups at baseline.Overall the weight loss after 10000 rotations in increasing order is shown below:

Group 1 < Group 6 < Group 2 < Group 5 < Group 3 < Group 4



Graph 3: Bar diagram showing comparison of mean weight loss of enamel between the six groups after 10000 rotations:

Group 1 - Enamel Vs Enamel

Group 2 - Enamel Vs FRC disc

Group 3 - Enamel Vs Autoglazed metal ceramic disc

Group 4 - Enamel Vs Overglazed metal ceramic disc

Group 5 - Enamel Vs Polished metal ceramic disc

Group 6 - Enamel Vs PEEK disc

Table 4: Comparison of mean percentage weight loss of enamel after 5000 rotations in the six groups

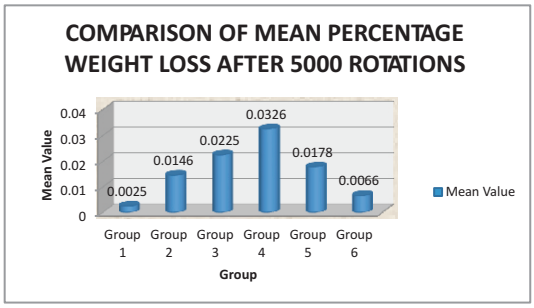
Group	N	Mean ± SD	F value	P value
Group 1 Enamel Vs Enamel	15	0.0025 ± 0.00	41.15	0.000*
Group 2 Enamel Vs FRC disc	15	0.0146 ± 0.00		
Group 3 Enamel Vs Autoglaze metal ceramic disc	15	0.0225 ± 0.01		
Group 4 Enamel Vs Overglaze metal ceramic disc	15	0.0326 ± 0.01		
Group 5 Enamel Vs Polish metal ceramic disc	15	0.0178 ± 0.00		
Group 6 Enamel Vs PEEK disc	15	0.0066 ± 0.00		

One-way ANOVA test applied. P value = 0.000, Significant

The above table shows the comparison of mean percentage loss after 5000 rotations in the six groups. In Group 1 the mean percentage weight loss after 5000 rotations was 0.0025 ± 0.00%, in Group 2 it was 0.0146 ± 0.00%, in Group 3 it was 0.0225 ± 0.01%, in Group 4 it was 0.0326 ± 0.01%, in Group 5 it was 0.0178 ± 0.00% and in Group 6 it was 0.0066 ± 0.00%. The comparison of mean percentage weight loss between the six groups was done using one-Way ANOVA which was found to be statistically significant (P<0.05), showing that the mean percentage weight loss after 5000 rotations was varying between all the six groups at baseline.

Overall the mean percentage weight loss after 5000 rotations in increasing order is shown below:

Group 1 < Group 6 < Group 2 < Group 5 < Group 3 < Group 4



Graph 4: Bar diagram showing comparison of mean percentage weight loss of enamel between the six groups after 5000 rotations : Group 1 - Enamel Vs Enamel

Group 2 - Enamel Vs FRC disc

Group 3 - Enamel Vs Autoglazed metal ceramic disc

Group 4 - Enamel Vs Overglazed metal ceramic disc

Group 5 - Enamel Vs Polished metal ceramic disc

Group 6 - Enamel Vs PEEK disc

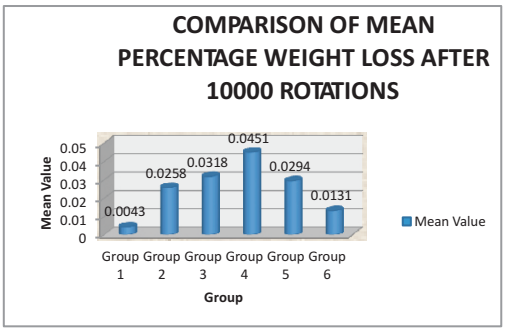
Table 5: Comparison of mean percentage weight loss of enamel after 10000 rotations in the six groups

Group	N	Mean ± SD	F value	P value
Group 1 Enamel Vs Enamel	15	0.0043 ± 0.00	47.78	0.000*
Group 2 Enamel Vs FRC disc	15	0.0258 ± 0.01		
Group 3 Enamel Vs Autoglaze metal ceramic disc	15	0.0318 ± 0.01		
Group 4 Enamel Vs Overglaze metal ceramic disc	15	0.0451 ± 0.01		
Group 5 Enamel Vs Polish metal ceramic disc	15	0.0294 ± 0.00		
Group 6 Enamel Vs PEEK disc	15	0.0131 ± 0.01		

One-way ANOVA test applied. P value = 0.000, Significant

The above table shows the comparison of mean percentage weight loss after 10000 rotations in the six groups. In Group 1 the mean percentage weight loss after 10000 rotations was 0.0043 ± 0.00%, in Group 2 it was 0.0258 ± 0.01%, in Group 3 it was 0.0318 ± 0.01%, in Group 4 it was 0.0451 ± 0.01%, in Group 5 it was 0.0294 ± 0.00% and in Group 6 it was 0.0131 ± 0.01. The comparison of mean weight between the six groups was done using one-Way ANOVA which was found to be statistically significant (P<0.05), showing that the mean percentage weight loss after 10000 rotations was varying between all the six groups at baseline. Overall the mean percentage weight loss after 10000 rotations in increasing order is shown below:

Group 1 < Group 6 < Group 2 < Group 5 < Group 3 < Group 4



Graph 5: Bar diagram showing comparison of mean percentage weight loss of enamel between the six groups after 10000 rotations :

Group 1 - Enamel Vs Enamel

Group 2 - Enamel Vs FRC disc

Group 3 - Enamel Vs Autoglazed metal ceramic disc

Group 4 - Enamel Vs Overglazed metal ceramic disc

Group 5 - Enamel Vs Polished metal ceramic disc

Group 6 - Enamel Vs PEEK disc

Discussion :

The aim of this study is to evaluate the effect of different surface finish of various restorative materials on the wear of opposing enamel. A large number of dental restorative materials are available today for prosthetic/restorative purposes. In selecting an appropriate restorative material, its wear behavior in the oral cavity should be considered."Wear" is defined as the loss of a substance due to continual use. Wear in dentistry occurs when two articulating surfaces undergo slipping and sliding movements against one another when a load is applied.[3] Several studies concluded that mismatch of wear rate can result in either excessive wear of the restorative material or the opposing dentition and may subsequently result in occlusal destabilization, tooth

sensitivity, or loss of esthetics.[8,9,11,12] There are various types of tooth coloured restorative material used in dental restoration i.e. Self cure acrylic resin, Composite resin, Giomers, Feldspathic porcelain, Compomers, Ceromers, Cention, Feldspathic porcelain, All ceramic, Zirconia, Fiber reinforced composite, Zirconia, PEEK, etc.

One of the material tested is PEEK. As PEEK is quite novice material in dentistry comparing to composite and ceramics. Unfortunately, there is no clinical research made to prove PEEK's superiority over other materials. Therefore, there is a need to investigate potential effectiveness of wear of PEEK on enamel. Thus this study investigates the wear properties of restorative materials (i.e. Fiber reinforced composite, Feldspathic porcelain including PEEK) and their potential abrasive effects on the opposing natural teeth.

The complex nature of tooth wear leads to difficulties in conducting wear studies. Although, Clinical tests are essential for characterizing the complex oral wear situation but are also expensive and time consuming.[15] and the results scatter widely due to patient and dentist related factors.[16] On the other hand, the present in-vitro wear study allows to simulate artificial oral environment which precisely control the variables such as individual mastication forces for oral conditions. Thus this in-vitro mastication appears as a practical solution for ranking the wear performance of emerging new restorative materials when opposed to natural enamel.

In the present study, occlusal enamel surface was tested to evaluate wear. Phillips 1982 [39] stated that enamel varies in its properties depending on the position of the enamel on 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 Hence in this study, freshly extracted non attrited maxillary first premolars of young adolescent patients undergoing orthodontic extractions was used. Since this study observed the wear behavior of enamel only the cuspal tips of the extracted premolar were held in contact with the various restorative material discs.

The wear mechanism was carried out by Tribometer TR-20-M61 (Wear and Friction Monitor by Ducom. The wear machine used provided a combined action of the impact, followed by sliding that matches the inherent action of closure during mastication of the mandibular teeth onto the maxillary teeth. The regime for wear testing was based on previous reports from the literature by Jagger et al 1994 [17] and Elmaria et al 2006.[18] The cusp tips and various restorative discs were positioned under a constant load of 1.5 kg and sprayed with artificial saliva. For each sample, abrasive test was run for a total of 10000 cycles on the wear machine.[19]

Loads applied in previous wear studies have been reported in either grams, kilograms or Newtons, and ranged broadly from as small as 180g or 1.8 N to 100 N (Shabanian and Richards 2002[20] , Elmaria et al. 2006 [18] ; Ranjitkar et al 2008 [21]; Mulay et al 2015 [19]). Artificial saliva, Biomed, was used in this study to simulate oral environment. Li and Zhou 2002 [22] investigated the influence lubrication on the wear behavior of human enamel, using a reciprocating wear test apparatus. It was found that the depth and severity of the wear scars were much smaller with artificial saliva lubrication than in dry conditions and therefore, concluded that saliva plays an important lubricant effect during the wear process of enamel in the oral environment.

To pursue the aim of this study total 90 samples were prepared 75 in disc form and 15 for enamel antagonist and divided into 6 groups i.e. Group 1-Enamel vs Enamel antagonist, Group 2-Enamel vs Fiber Reinforced Composite disc, Group 3-Enamel vs Autoglazed metal ceramic disc, Group 4- Enamel vs Overglazed metal ceramic disc, Group 5- Enamel vs Polished metal ceramic disc by shofu polishing kit, and Group 6- Enamel vs PEEK disc were fabricated.

As per previous review of literature Gauri M et al 2015[19] weighed each mounted tooth sample before and after 1st and 2nd 5000 cycles testing using electronic analytical balance of 0.0001 g accuracy. The weight from Electronic Analytical Balance was made at readings, baseline, intermediate and final that is, before testing, after 5000 cycles and after 10,000 cycles of wear for each tooth sample, statistical analysis was done to obtain the tooth substance loss at each interval. Similarly Slack et al 1949[23] reported a preliminary method for testing abrasion in which weight loss was calculated to determine loss during abrasion. Cornell et al 1957.[24] Also conducted a wear study of natural teeth. Teeth samples were tested in an apparatus that produced impact and sliding forces similar to those of mastication. Weight loss was calculated after each cycle in order to compare the relative wear of natural teeth.

In the present study Relative percentage change in weight was calculated using the following formula:

$$100 \times \frac{\text{Baseline weight - weight during different cycles}}{\text{Baseline weight}}$$

The statistical comparison of average levels of percentage change in weight between various groups was done using one−way ANOVA analysis .Within the group, comparison was done by Paired analysis using Post hoc tukey test. The results of one-Way ANOVA which was found to be statistically significant ($P<0.05$), showing that the mean percentage weight loss after 10000 rotations was varying between all the six groups at baseline. Overall mean percentage weight loss after 10000 rotations in increasing order is shown below:

Group 1 (Enamel Vs Enamel 0.0043 ± 0.00) < Group 6 (Enamel Vs PEEK disc 00.0131 ± 0.01) < Group 2 (Enamel Vs FRC disc 0.0258 ± 0.01) < Group 5 (Enamel Vs Polished metal ceramic disc 0.0294 ± 0.00) < Group 3 (Autoglazed metal ceramic disc 0.0318 ± 0.01) < Group 4 (Enamel Vs Overglazed metal ceramic disc 0.0451 ± 0.01) as seen in Table 5 and Graph 5.

Hence Null hypothesis tested in the present study had to be rejected. Statistically significant enamel wear was observed by various restorative materials and their surface finishes when opposing to tooth surface enamel after 10000 cycles.

Hutchings 1992[25] also found that when two materials in contact slide over each other, one or both of the materials will suffer wear on the surface, generally the softer of the two, i.e., tooth enamel Multiple comparisons were done to evaluate the amount of enamel wear when opposed to various restorative material groups at 10,000cycles. The results indicate that mean percentage of enamel loss was significantly different ($P < 0.001$) depending on various restorative material and their surface condition ($P < 0.001$) as indicated in Tables 5 and Graph 5.

In our present study the result shows that statistically significant more enamel loss was associated when enamel was opposed by over glazed metal ceramic disc while PEEK disc showed the least wear of enamel after 10000 cycles. (Table 5 & Graph 5)

One of the material tested was PEEK and recently a study by Wimmer et al 2016[26] evaluated and compare the two-body wear rate of thermoplastic PEEK and investigated all PEEK specimens showed similar significantly lower material wear . The elastic modulus of enamel is 84 GPa [27] which is higher than PEEK is 3.6 GPa [28] , Fiber reinforced composite is 17-21 GPa[27] & Feldspathic porcelain is 69-70 GPa[25] this implies that Enamel is more rigid than PEEK, Fiber reinforced composite & Feldspathic porcelain.

As PEEK when compare to enamel is comparatively softer, flexible and less rigid than enamel. This may attribute to cause least wear of opposing enamel.The Compressive strength of Enamel is highest i.e. 384 MPa[27] and PEEK have the least Compressive strength i.e. 112 MPa[28] which implies that Enamel is more stiffer and brittle than PEEK while PEEK is comparatively softer and Flexible.In our present study in-vitro quantitative wear analysis was done to determine the relative percentage weight loss of enamel. The other perspective i.e. wear of antagonist restorative material was not evaluated because of lack of standardization of experimental restorative disc which was secured by cyanomethylacrylate solution.

Fiber reinforced composite disc statistically cause more enamel loss when compare to PEEK disc but less than overglazed metal ceramic, autoglazed metal ceramic disc & polished metal ceramic disc. (Table 5 & Graph 5). Similary Stawarczyk B et al 2013[29] found composites produce less enamel wear than ceramic-based ones, both in the manually polymerized and in the CAD/CAM versions and also Sripetchdanond et al 2014[30] conducted in vitro study in which resin composite antagonists led to the lowest wear on the opposing enamel, being significantly reduced compared to the enamel wear recorded against ceramic abraders and a recent study by D'Arcangelo et al 2017[1] concluded that recently introduced resin composites showing promising in vitro wear resistance values, statistically similar to those of human enamel. Again this may be because of composites produce wear on their antagonist through hard filler protruding from the abraded resin matrix, and the hardness is thought to be a reliable predictor of their abrasiveness.[31,32]

According to the results of this study when enamel opposed to overglazed and autoglazed metal ceramic disc as both causes significantly higher wear than polished metal ceramic disc. This does not support the work of Monasky and Taylor [34] and Wiley[35]. They all reported that there is no statistically significant difference in the average surface roughness between the final polished surface and the initial autoglazed surface of ceramic.

According to this study, polished surface of ceramic is the least detrimental to opposing enamel. The results of this study indicate that polished ceramics produce less enamel wear than their glazed counterparts. Brewer et al 1990[36] also concluded similar to our study that surface treatment of all ceramic crowns may be responsible for the 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.[36] Krejci et al[37] reported that the polished surface of glass ceramic caused significantly less wear than the glazed surface. In the same study it was also concluded that the wear rate of enamel depends on the hardness, texture, and surface finish of the opposing restoration. Fine polishing has been suggested as an alternative to glazing by several investigators. [32] Furthermore, reglazing or repeated firing of the surface requires additional time and may also lead to devitrification, resulting in increased opacity and loss of vitality.[38] Occlusal adjustment of ceramic restorations is a routine clinical procedure that may result in alteration of the glazed surface. Occlusal adjustment of an all-ceramic restoration is not recommended prior to bonding because of the brittle nature of the unbonded restoration.[36]

Chairside polishing after adjustment may result in a smooth or rough surface, depending on the level of adjustment required and the mode of polishing. So this present study results value concludes that PEEK disc showed the least amount of enamel wear followed by Fiber reinforced composite disc and gradually increase in Polished metal ceramic disc then by Autoglazed metal ceramic disc and highest enamel wear by Overglazed metal ceramic disc.Enamel wear produced by polished metal ceramic disc is substantially less than autoglazed and over glazed metal ceramic disc. This study indicates that any potential damage to ceramic can directly affect enamel and suggests that ceramic should be polished instead of over glazed.

Conclusion :

An artificial oral environment was created in this in vitro study to evaluate the wear rate of enamel when opposed to different restorative material and after analyzing the data statistically the following conclusions were drawn:

- PEEK showed the statistical significant least amount of enamel wear gradually increased enamel wear by Fiber reinforced composite. PEEK is a newer material as compare to composite or ceramic. However, there is few clinical data about PEEK's abrasion with other materials such as metal alloys, ceramics, dentin or enamel.
- Fiber reinforced composites cause more enamel wear than PEEK and fiber reinforced composites cause less enamel wear than dental ceramics.
- Enamel wear produced by polished metal ceramic disc is substantially less enamel wear than autoglazed and overglazed metal ceramic disc. Thus, this study indicates the any potential damage to ceramic surface can inflict directly upon enamel that leads to enamel wear so ceramic should be polished instead of overglazed.

Future Research:

As PEEK is quite novice material in prosthetic dentistry when compared to composite and ceramics. After completing this in-vitro study, it has been felt that there is a need for further research to determine the wear of PEEK both in-vitro and in-vivo when opposed to materials such as metal alloys, ceramics, composites, dentin or enamel and also to translate in-vitro results into in-situ and in-vivo studies investigating the potential effectiveness of wear of PEEK. However, there is less clinical data available regarding PEEK's abrasion with other material and thus PEEK as a potentially newer restorative material needs to be investigated.

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