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Comparison the degree of enamel wear behavior opposed to Polymer-infiltrated ceramic and feldspathic porcelain

Alireza Hashemi Ashtiani[1], Mohammad Azizian[2], Ali Rohani[1]

[1]Departments of Prosthodontics, School of Dental Medicine, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, [2]Department of Prosthodontics, School of Dental Medicine, Ilam University of Medical Sciences, Ilam, Iran

ABSTRACT

Background: The degree of tooth enamel wear is an important aspect of the clinical acceptability of all-ceramic restorations. The purpose of this study was to compare the degree of enamel wear by feldspathic porcelain and polymer-infiltrated ceramic.

Materials and Methods: In this *in vitro* study, 10 polymer-infiltrated ceramics were prepared by creating the sections of Vita Enamic® blocks (18 mm × 14 mm × 4 mm). A total of 10 porcelain cylinders were built, and feldspathic porcelain (VMK 95, Vita) was used and fired over the metal discs. A total of 20 human maxillary premolars were assigned as antagonist. Then, 10 teeth were arranged and placed oppose to porcelain samples and 10 others were placed oppose to polymer-infiltrated-ceramic specimens in the chewing simulator. The samples were photographed before and after the chewing simulation. The difference between the two photograph was measured by stereomicroscope and Motic Image plus software 2.0 three times, and then, the mean of these three times was recorded as the amount of wear. Data were analyzed using independent samples *t*-test and SPSS version 16. The level of significancy was 0.05.

Results: The mean wear rate teeth oppose to the feldspathic porcelain group (377.294 µ) was significantly higher than that of the polymer-infiltrated ceramic group (101.755 µ) ($P = 0.002$).

Conclusion: In the present study, the amount of enamel wear of the natural teeth opposed to polymer-infiltrated ceramic was significantly lower than feldspathic porcelain.

Key Words: Enamel wear, feldspathic porcelain, polymer-infiltrated ceramic

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Address for correspondence:
Dr. Ali Rohani,
School of Dental Medicine,
Ahvaz Jundishapur
University of Medical
Sciences, Ahvaz, Iran.
E-mail: alirohani172@gmail.com

INTRODUCTION

Occlusal wear of teeth and restorative materials are a complex and multifactorial phenomenon with the interaction of biological, mechanical, chemical, and tribological factors. The wear rate can be affected by several factors such as muscular strength, the presence or absence of saliva, the patient habits, and the type of restorative material used in the mouth.[1-3] The correct choice of restorative materials to maintain occlusal harmony and normal chewing function is essential. The enamel wear rate under masticatory force has been reported to range between 20 and 40 µm per year.[3] Ideally, the wear of dental restorative material should be similar to enamel wear. However, the wear rate can be affected by the use of restorations whose wear characteristics are very different from the enamel.[2,3] Highly abrasive restorative materials can

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cause damage to the occlusal surface, redirect the functional pathways of mastication movement, loss of the anterior guidance, and esthetic problems.[3] Gold due to its high biocompatibility and easy modular functionality, long durability, and low abrasion of the enamel was a long-term selective restorative material in areas with severe occlusal stress.[4] However, with the increasing desire to make the more beautiful and natural appearances of restoration, the use of all-ceramic restorations has considerably increased.[4] All-ceramic crowns with reinforced ceramic cores such as alumina, zirconia, or lithium disilicate have been developed to reduce the need for a metal structure, as well as to create better optical properties, and more natural appearance.[5] Recent advances in ceramics have significantly enhanced the functional and esthetic properties of restorative materials. New ceramic materials made an esthetic and functional oral rehabilitation.[4] As the demand for more natural-looking crowns has increased, dentists and porcelain manufacturers have presented several ways to increase porcelain strength including the use of aluminum oxide, lucite, lithium disilicate, and zirconia.[5,6] The other disadvantages of ceramic crowns are that they wear down opposing teeth.[7] Tooth wear also known as tooth surface loss is an insidious and cumulative multifactorial process involving the destruction of enamel and dentine which can threaten tooth survival and the oral health-related quality of life of affected individuals. Tooth wear can be classified as either mechanical or chemical. The most important is that the material of the new crown matches the material of the teeth. Glazed dental porcelains are almost far more worn down the opposing teeth than gold alloys.[5] A new type of polymer-infiltrated ceramic network material, Enamic, has been recently introduced by the Vita Company in which porous ceramics are infiltrated by the polymer (similar to glass-infiltrated ceramics). This tooth-colored hybrid material offers material properties that are almost identical to those of natural teeth. This innovative hybrid ceramic guarantees particularly high load capacity after adhesive bonding. As a result, this material is perfectly suited for posterior crown restorations and also enables the reduction of wall thicknesses for minimally invasive restorations. The manufacturer's goal is to build a tooth-colored material for computer-aided design/computer-aided manufacturing (CAD/CAM) technology to combine the properties of both ceramic and composite materials. This monomer will become polymer in the curing stage.[8] The degree of hardness of polymer-infiltrated ceramic (2.5 Gpa) is much lower than conventional dental ceramics and veneer porcelains.[9] For example, Vita MARKII ceramic hardness value is equivalent to 6.24 Gpa and for Vita VM9 is equivalent to 6.29 Gpa, respectively, which is far more than this new material.[10] Some studies showed that porcelains and dental ceramics may influence the wear of opposing tooth structure.[10-12] The aim of present study was to compare the degree of enamel wear by feldspathic porcelain and polymer-infiltrated ceramic. Based on company specification, Enamic material has low wearability; therefore, it is necessary to investigate the impartial investigation of the validity of this claim. Our null hypothesis was that abrasiveness on the enamel of the polymer-infiltrated ceramic is equal to the porcelain.

MATERIALS AND METHODS

In this *in vitro* study, there were two groups each containing 10 samples (According to similar articles[10,12] and statistical advice). Vita Enamic blocks (Vita Zahnfabrik, Bad Säckingen, Germany) with dimensions of 18 × 14 × 12 were used to fabricate polymer-infiltrated samples. A total of 10 block sections (4 mm) were prepared using saw microtome (SP1600, Leica Microsystems, Basel Switzerland). All of the samples (18 × 14 × 4) were polished in two stages by Vita Enamic Kit (Vita Zahnfabrik, Bad Säckingen, Germany) according to manufacturer's instruction. To make porcelain samples, first, 10 metal-ceramic alloy cylinders (VERA BOND, Aalba Dent, USA) were made by pouring wax (Degussa, Degudent, Germany) inside a plastic mold with the dimension of 7 mm × 10 mm, then their casting was made. The feldspathic porcelain Vita VMK 95 (Vita Zahnfabrik, Bad Säckingen, Germany), was fired with a thickness of 2 mm on the surface of these cylinders.

In the next step, the samples were polished using the porcelain polish kit (Drendel and Zweiling GmbH and Co, Berlin, Germany). Each specimen was polished with rubbers of three different grains beginning with the most abrasive one for the prepolishing (EXA CERAPOL, white-gray color), then an intermediate one for polishing (EXA CERAPOL ROSA, pink color) and the last, a less abrasive one for high brightness polishing (CERAPOL SUPER, gray color). All the rubbers were fitted to a low speed, calibrated at a speed of 6000–10000 rpm to control the speed of the handpiece. Afterward, diamond felt discs (FGM, Joinville, SC, Brazil) were used with a diamond polishing paste (Diamond Excel, FGM, Joinville, SC, Brazil), also at low speed (counter-angle) for 30 s.

After polishing and finishing process, all ceramic specimens were examined for the absence of subsurface damage and poor surface finishing using an optical polarizing microscope (Nikon Alphaphot-2, YS2, ×20). After preparing the ceramic samples infused with polymer and feldspathic porcelain, all specimens were mounted on a special chewing simulator with acrylic resin (Acropars, Marlic, Iran). Then, 20 healthy human maxillary premolars which were extracted from orthodontic causes were stored in distilled water at 37°C for one week to 2 months until abrasion. The teeth were examined under 10× magnifications using light microscopy (Alphaphot YS2, Nikon, Tokyo, Japan). The exclusion criteria included dental caries, enamel defects, and wear facet. Initially, all specimens were mounted by a survivor in a semi-cylindrical plastic generator in its self-hardening resin (Acropars, Marlic, Iran). Then, 10 teeth were selected randomly and arranged and placed oppose to porcelain samples and 10 others were placed oppose to polymer-infiltrated ceramic specimens in the chewing simulator (Williytec, Munich, Germany). The mounted teeth were attached to the upper jaw and the polymer-infiltrated ceramic specimens were attached to the lower jaw. The upper jaw model was movable in position relative to the lower jaw model. The site movement was 1 mm with a lateral speed of 20 mm/s, and the vertical movement was 2 mm with a vertical speed of 60 mm/s. The samples were loaded with 5 kg (49 N) for 120,000 cycles, and the frequency of the antagonist movement was 1.6 Hz (Ivoclar wear method).[13] The Specimens were immersed in distilled water at the time of teeth wear.[14] On each sample at a distance of 4 mm from the tip of the cusp of the tooth, a groove was created as a reference to determine the change in cusp height after wear. The samples were mounted in such a way that constant and repeating condition on a stereomicroscope for precise measurement was possible. Then, the samples were photographed using a stereomicroscope (SF-100B, Lomo, Russia) with 16× magnification in a fixed position. The distance between the tip of the cusp and the groove location created was measured by Motic Image plus 2.0 Software (Motic, Hong Kong, China).[15,16] After teeth wear, the specimens were again photographed by a stereomicroscope in the previous position, and the distance between the tip of the cusps and the target area was remeasured and the difference was considered as the amount of abrasion.[16] The measurements were repeated three times for each specimen, and the average of these three measurements was calculated and considered as a measure of abrasion. To study the qualitative properties of the wear pattern, a random sample was selected from each of the two groups, and after coating the samples with gold were examined using scanning electron microscope with ×1000 magnification (Supra 55 VP, Carl-Zeiss, Oberkochen, Germany). Data were analyzed using independent samples *t*-test and SPSS version 16 (IBM, Chicago, United States). The level of significancy was 0.05.

RESULTS

As shown in Table 1, the mean teeth wear in the feldspathic porcelain group was 377.294 μm and in the polymer-infiltrated ceramic group was 101.755 μm. First, the normality of the observations was examined by the Shapiro–Wilk test, and it was found that the distribution of observations follows the normal distribution. Independent samples *t*-test showed that there was a significant difference between two groups ($P = 0.002$).

DISCUSSION

Our null hypothesis was that abrasiveness on the enamel of the polymer-infiltrated ceramic is equal to the porcelain; in the present study, the amount of enamel wear in polymer-infiltrated ceramic was less than the feldspathic porcelain. Several tests (Pin-on-block, pin-on-disk, Three-body wear, and Toothbrush simulation) can be used to investigate the wear performance of dental materials, and antagonist wear has been confirmed to be closely associated with ceramic material types and testing conditions.[17-19] In the present study, the two-axe wear test device was used since it is practical, durable, and cost-effective and has been widely used. Wear is related to interactions between surfaces and specifically the

Table 1: Wear results of the teeth and their opposing crowns

Group	*n*	Mean±SD (μm)	*P*
Feldspathic porcelain	10	377.294±210.24	0.002
Polymer-infiltrated ceramic	10	101.755±43.69	0.002

removal and deformation of material on a surface as a result of mechanical action of the opposite surface.[20,21]

In the present study, it seems that the dominant mechanism for enamel wear is fatigue and abrasive wear. In this way, friction related to wearing of feldspathic porcelain and polymer-infiltrated ceramic on enamel surface applies compressive, tensile, and shear force on enamel. The gliding movement causes an area of compression ahead of motion and a zone of tension behind the motion in the subsurface of the material. Force transmission to subsurface areas leads to intermolecular bond split in enamel and substrate. Consequently, these microcracks transmit to the surface and result in loss of superficial particles both in the enamel antagonist, inducing fatigue wear. The displaced fragment can become interpolated between the two surfaces in contact, giving rise to three body abrasion. One of the factors that can justify the higher degree of abrasion of the enamel of feldspathic porcelain compared to the polymer-infiltrated ceramics is higher degree fracture toughness of the polymer-infiltrated ceramic (1.5 MPa√m) than the feldspathic porcelain (0.82 MPa√m).[22-24] In this way, the fracture toughness and low flexural strength of the feldspathic porcelain cause the porcelain surface with abrasive forces produce high localized stresses and microfracture than the polymer-infiltrated ceramic. This condition leads to the appearance of crystalline inclusions at the surface of the feldspathic porcelain that protrude from the surface of the material, which in turn causes a lot of stress accumulation in the enamel and gauge at its surface. Similarly, the separated particles themselves can act as an abrasive and generate a three-body wear. Therefore, it is expected that in the polymer-infiltrated ceramic due to increased fracture toughness and less abrasion this will not occur and less wear on the antagonist to be created.[25] Another factor that can justify hairline cracks and as a result, less brittle in polymer-infiltrated ceramics than feldspathic porcelain is the deviation mechanism of cracks in the ceramic in which the cracks created in the ceramic phase are either stopped or diverted after they reach to the polymer phase. This mode prevents the crack from spreading and reaches the surface area, which results in the reduction of hairline crack and brittle fracture.[24] In a study by Mormann *et al*.[26] It was concluded that polymer-infiltrated ceramics other than zirconia tend to be less abrasive than other ceramics used in CAD/CAM. Moreover, polymer-infiltrated ceramics showed similar enamel wear in opposing to acrylic composites and polymers. The results of this study are consistent with the results of the present study. In this study, as in the present study, a chewing simulator with a force of 49 N was used to measure the wear of the samples. In Mormann's study,[26] the number of cycles used was 1.2 million, which is approximately equal to 5–6-year mouth restoration, while in the present study, the number of chewing cycles was 120,000, which is approximately equivalent to 6-month mouth restoration.[13,27] Therefore, it can be concluded that polymer-infiltrated ceramics with long-term stresses also cause less abrasion in the opposing enamel. According to Coldea *et al*.,[28] the hardness of the polymer-infiltrated ceramics, feldspathic porcelain, and tooth enamel measured by the Vickers indentation test was 1.71–2.4, 6.29, and 3–5.3 Gpa, respectively.[28] Park *et al*.[29] concluded that the hardness of feldspathic porcelain was higher than the enamel and the hardness of the polymer-infiltrated ceramic was less than the enamel and usually the higher the hardness of a material the greater the antagonist wear.[29] Therefore, it is expected that the amount of abrasion of the enamel oppose to the feldspathic porcelain is more than that of the enamel oppose to the polymer-infiltrated ceramic, which is also consistent with the results of the present study. In a study by Coldea *et al*.,[28] the hardness of the feldspathic ceramic blocks and polymer-infiltrated ceramics with different ceramic densities (59%–72%) was examined by Vickers test. Then, the images were prepared by an electron microscope from the test area. The results showed a marked crack at the surface of the feldspathic porcelain, while no progressive crack was made in polymer-infiltrated ceramic.[24] The results of this study indicate the higher potential of the polymer network in deviating and preventing of the progressive crack.[24] Mormann *et al*.'s[26] study also showed that the edges of the antagonist contact region in the polymer-infiltrated ceramic are in the shape of sharp lines and the contact surface shows only a small amount of pitting.[26] In the present study, the images of the electron microscope show the reasonably smooth surface without any cracks in the ceramic infiltrated with (ENAMIC) polymer after the wear process, while in the feldspathic porcelain samples, rough surfaces with distinct parallel grooves with broken and detached particles of porcelain are observed. This could be explained by the increasing degree of enamel wear on the feldspathic porcelain compared to the polymer-infiltrated ceramic.

CONCLUSION

Despite the limitations of the present study, the results of this study showed that polymer-infiltrated ceramic has a less abrasive effect than feldspathic porcelain in the natural tooth.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

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