

Comparative Evaluation of Wear of Natural Enamel Antagonist Against Glazed Monolithic Zirconia Crowns and Polished Monolithic Zirconia Crowns: An In Vivo Study

Jay Rahesh Dondani, BDS, MDS Prosth
Vikrant Pardeshi, BDS, MDS Prosth
Arti Gangurde, BDS, MDS Prosth
Almas Shaikh, BDS, MDS Prosth

Department of Prosthodontics, Government Dental College and Hospital, Mumbai, Mumbai, India.

Aushili Mahule, BDS, MDS (Prosth)

Department of Prosthodontics, Swargiya Dadasaheb Kalmegh Smruti Dental College, Nagpur, India.

Prachi Deval, BDS, MDS Prosth

Private practice, Mumbai.

Purpose: To comparatively evaluate the amount of wear of natural enamel against a glazed full coverage monolithic zirconia crown and a polished monolithic zirconia crown at 6 and 12 months. **Materials and Methods:** Thirty subjects within the age range of 18 to 35 years participated in this study. The subjects received a total of 60 single crowns, which were divided into two groups: (1) 30 glazed monolithic zirconia crowns opposed by natural enamel (group A); and (2) 30 polished monolithic zirconia crowns opposed by natural enamel (group B). Each subject received a crown from both groups, placed bilaterally in endodontically treated maxillary or mandibular first molars. An impression was made of the opposing arch at 24 hours, 6 months, and 12 months. The resulting casts were scanned with a 3D optical scanner. The recall scans were superimposed and compared to baseline scans using 3D AutoCAD software. A control group was included to compare the wear values to natural enamel against natural enamel. **Results:** No significant difference ($P = .855$) was found in enamel wear between groups A (42.80 μm) and B (42.50 μm) after 6 months of use. However, a significant difference ($P < .05$) in enamel wear was found between group A (81.87 μm) and group B (71.43 μm) after 12 months of use. **Conclusion:** Glazed monolithic zirconia crowns cause more wear to the opposing enamel than polished monolithic zirconia crowns after 12 months of clinical use. *Int J Prosthodont* 2022 August 18. doi: 10.11607/ijp.7798. Online ahead of print.

Wear of natural teeth in response to various biomaterials has always been a major concern in clinical dentistry. Tooth wear is a complex, multifactorial phenomenon involving the interplay of biologic, mechanical, and chemical factors.^{1,2} Wear comprises the combined processes of attrition (resulting from contact of the surfaces of the teeth), abrasion (wear by physical means other than opposing teeth), and erosion (chemical loss of tooth substance).³

Dental prosthetic materials should ideally have good physical properties that provide for long-term service in the oral environment. These materials must be able to withstand the stresses and wear caused by the repetitive forces of mastication.⁴ Additionally, patient demand for esthetic appearance has promoted the development of tooth-colored ceramic materials. This has led to the use of dental porcelains that are both esthetic and biocompatible, but at the cost of being brittle and fragile and causing high wear to the opposing tooth structure.⁵ On the other hand, there has been a decrease in clinical application of metal-ceramic crowns, which are less esthetic due to the metal coping.⁶

Correspondence to:
Dr Jay Rahesh Dondani
Room No. 238, Department of
Prosthodontics
GDC Mumbai, St. George Campus
P D'Mello Road, Fort, Mumbai
Email: dondanijay@gmail.com

Submitted May 2, 2021;
accepted December 9, 2021.
©2022 by Quintessence
Publishing Co Inc.



In the wake of these factors, zirconia has emerged as a viable alternative to conventional ceramics. It is a crystalline dioxide of zirconium, and its most useful mechanical properties are obtained in the form of the multiphase material known as partially stabilized zirconia (PSZ). High-strength zirconia is generally layered with veneering porcelain, which is prone to fracture because of its weak interface. Therefore, zirconia fixed dental prostheses without veneering ceramic, called monolithic zirconia restorations, are currently popular.^{7,8} Apart from the elimination of chipping, the reduced requirement for occlusal clearance seems to be a profound advantage of these monolithic zirconia restorations.⁹ The mechanical properties of zirconia are quite similar to stainless steel.¹⁰ Zirconia is the strongest and toughest of all dental ceramics,¹¹ with 900- to 1,200-MPa flexural strength and 910-MPa • m^{1/2} fracture toughness.¹²

Monolithic zirconia restorations, which are manufactured exclusively using CAD/CAM technologies, have many considerable advantages. They exhibit higher flexural strength, require less laboratory time and fewer dental sessions as well as more conservative dental preparation, minimize wear of the antagonists, exhibit satisfactory esthetics, and lack the unwanted complication of chipping.¹³ Until a few years ago, a main disadvantage was their inability to achieve satisfactory translucency. However, recent modifications in composition, structure, and fabrication methods have led to superior translucency of monolithic zirconia ceramics, although these modifications have also caused a significant reduction in strength.¹³ With such advantageous mechanical properties, zirconia has been used for crowns, multiunit and complete-arch frameworks, implant abutments, and complex implant superstructures for fixed and removable prostheses.¹⁴⁻¹⁶

Wear is a complex phenomenon defined by wear tribology and biotribocorrosion. It has been described in five terms: two-body abrasion, three-body abrasion, fatigue wear, tribochemical wear, and adhesive wear.¹⁷ Dental materials should ideally achieve wear behavior similar to that of enamel, and their wear is usually characterized in relation to that of tooth tissues.¹⁸ However, wear behavior can not only be affected by the type of ceramic material used but also by the finishing process applied before seating. During placement, dentists may adjust the fixed dental prosthesis by grinding the ceramic surface with a diamond rotary instrument to achieve an optimal occlusal surface, then glazing and polishing for smoothness.¹⁹ Kim et al suggested that surface glazing reduced the wear on opposing teeth; however, this glazed layer is easily removed by chairside occlusal adjustment or after a short period in function.⁴ Studies have identified finishing and polishing techniques that would create surfaces comparable to, or better or worse, than glazed porcelain.²⁰⁻²²

Ideally, natural antagonistic teeth should not be damaged by ceramic. However, the antagonist enamel wear has been proven to be higher than that of ceramic under clinical conditions.¹⁸ Due to various laboratory and chairside procedures prior to the final cementation of a prosthesis that are accompanied by complex mechanisms in the oral cavity affecting the wear process, a clinical study is needed to study wear effectively.

Thus, this *in vivo* study aimed to investigate and comparatively evaluate the amount of wear of natural enamel against a glazed monolithic zirconia crown, a polished monolithic zirconia crown, and natural enamel at 6 and 12 months.

The null hypothesis for this study was that there would be no difference in the wear of natural enamel against a glazed monolithic zirconia crown and a polished monolithic zirconia crown.

MATERIALS AND METHODS

This study was approved by the Institutional Ethics Committee (Reference No. GDCHM/ETHICAL COMMITTEE MEETING/6312-21/2018). Sample size was determined using the mean and SD values from the literature using the formula:

$$n = 2 (Z\alpha + Z\beta)^2 [s]^2 d^2$$

In the above formula, $Z\alpha$ is the z variate of alpha error (ie, a constant with a value of 1.96), and $Z\beta$ is the z variate of beta error (ie, a constant with a value of 0.84).

The approximate estimates were as follows:

- 80% power
- Type I error = 5%
- Type II error = 20%
- True difference of at least 0.69 units between groups
- Pooled SD of 0.62

Using these values in the formula results in the following:

$$n = 2(2.8)^2 [0.62]^2 (0.69)^2$$

$$n = 12.65$$

Therefore, approximately 13 samples per group were needed in the present study. Due to the chances of patient burnout in a long-term study with interventions at two time intervals, 30 samples were considered.

Thirty subjects (female and male) aged between 18 and 35 years participated, and all subjects were enrolled after obtaining their informed verbal and written consent. The main prerequisite was that they should have healthy opposing teeth and also a full complement of teeth present in both arches. Detailed history-taking and

**Table 1** Crown Materials and Processing Used in the Study (n = 30)

Group	Material	Manufacturer	Surface preparation	Antagonist
A	Monolithic zirconia	Vita VM9, Vita Zahnfabrik	Glazed: Glaze applied, heated at 715°C, unlocked at 250°C	Natural enamel
B	Monolithic zirconia	CeraGlaze Porcelain Adjusting & Polishing Lab Set, Kerr	Polished: NTI Coarse Green polisher, NTI Blue Refining polisher, and NTI Yellow High-Shine polisher	Natural enamel

oral examination were performed in order to rule out patients who did not conform to the required criteria. Criteria for exclusion were: < 18 years of age; medically compromised; developmental defects of enamel and dentin; caries/attrition; parafunctional habits; occlusal interferences; and known allergic reactions to the materials used. These criteria were evaluated from the patient's answers to specific questions from the examiner. Subjects fulfilling the inclusion criteria were further tested for jaw muscle electromyographic (EMG) activity during sleep with the help of an EMG device (GrindCare 3, Medotech).²³ Six subjects exhibited high EMG activity during the 7 hours of sleep and were thus excluded from the study. They were replaced with other healthy subjects meeting the inclusion criteria. All subjects had comparable oral hygiene status and similar dietary preferences. Dietary preferences were also determined by asking the patients specific questions (frequency of meals; quality and quantity of diet; type of diet pertaining to cereals, fruits, cooked and raw vegetables, dairy products, nonvegetarian food items; inability to take food items, etc), and patients with a diet containing acidic foods and drinks with high titrable acidity were excluded.²⁴

Thirty subjects received a total of 60 single crowns placed bilaterally on endodontically treated maxillary or mandibular first molars. These 60 crowns were divided into two groups: (1) 30 glazed monolithic zirconia crowns opposed by natural enamel (group A); and (2) 30 polished monolithic zirconia crowns opposed by natural enamel (group B). Each patient received one crown from each group, and the crowns were cemented bilaterally on the right and left maxillary or mandibular endodontically treated first molars opposed by natural enamel.

Clinical Treatment and Laboratory Procedures

Radiographic and clinical examinations of the selected teeth were performed to evaluate the endodontic treatment. Diagnostic impressions of both arches were made using irreversible hydrocolloid (Chromatex, DPI). The impressions were poured using type III dental stone (Kalstone, Kalabhai Karson). A 3-mm-thick layer of modeling wax (DPI) was adapted on the dentate area to allow for the required thickness of impression material. Custom trays were fabricated on the casts using

light-polymerized tray material (Elite LC Tray, Zhermack) and placed in distilled water at 20°C for 24 hours.

Randomization was performed (simple randomization) using the lottery method. The abutment teeth were prepared to receive zirconia crowns (glazed vs polished) according to the randomization. Tooth preparation guidelines for the zirconia crowns were a reduction of 1 to 1.5 mm axially, 1.5 to 2 mm occlusally, and a shoulder margin design. The definitive impression was made after gingival displacement (Ultrapak 00, Ultradent) in the prepared custom tray with medium-body polyvinyl siloxane material (Reprosil, Dentsply Sirona). Interim crowns of bis-acrylate resin (Protemp Plus, 3M Espe) were cemented with zinc oxide noneugenol interim cement (TempBond NE, Kerr) on the prepared teeth before cementation of the definitive crowns. The impressions were poured using type IV gypsum product (Kalrock, Kalabhai Karson). The resulting casts were scanned with a 3D white light optical scanner (smartSCAN 3D-HE, Breukmann). Full coverage monolithic zirconia crowns were designed and fabricated using CAD/CAM technology from zirconia blocks (DC Zirkon Premium, Dental Concept Systems). Postmilling sintering was carried out, and one glazed zirconia crown (group A) and one polished zirconia crown (group B) were placed in each patient (Table 1).

The crowns were adjusted using the following methods:

- Glazing was performed in a vacuum in a ceramic furnace using glazing paste (Vita Akzent Plus, Vita Zahnfabrik). The temperature was raised to 715°C at a firing rate of 30°C/minute, maintained for 30 seconds, and cooled down to 250°C at 15°C/minute.
- Polishing was performed in three steps with a sequence of diamond-impregnated silicone discs: NTI green coarse polisher; NTI blue refining polisher for initial shine; and NTI yellow high shine polisher (NTI CeraGlaze Polishers, Kerr). Each step was carried out at 5,000 rpm for 60 seconds. The crowns were cemented with glass-ionomer cement (Xtralute Glass-Ionomer Luting Cement, Medicept) in accordance with the manufacturers' instructions. All patients received an oral hygiene briefing after cementation.

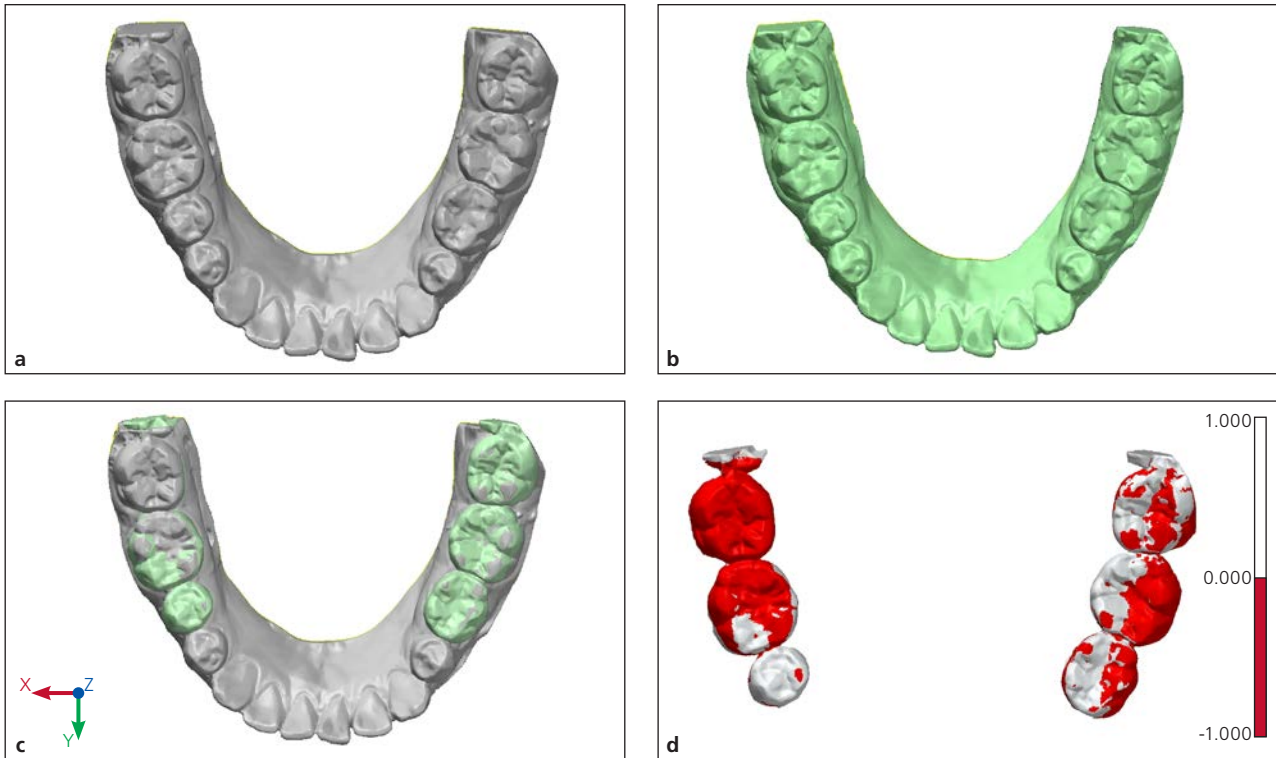


Fig 1 Scanned 3D images of natural enamel of mandibular premolar and first molar opposing a glazed monolithic zirconia crown at (a) baseline, (b) 6 months, and (c) 12 months. (d) Superimposed image. Red areas represent enamel wear on the buccal and lingual cusps between 6 and 12 months of clinical use.

Recalls

Patients were recalled at 24 hours, 6 months, and 12 months postcementation. Definitive impressions were made of the opposing arch at these appointments using the aforementioned technique. Casts were fabricated from the impressions and scanned using the 3D white light scanner (smartSCAN 3D-HE), as mentioned above. The specifications of the scanner were as follows:

- Principle: miniature projection technique (MPT; Gray code + phase-shifting method)
- Camera number: 2
- Camera type: 1.4-MP RGB cameras
- Projector type: fringe pattern projector (geometry + texture)
- Field: 90 mm
- Precision: 9 μm

The extraoral scans at 24 hours, 6 months, and 12 months were designated as T0, T1, and T2, respectively. In the scanned images, the first molars depicted wear against the zirconia crowns (glazed [group A] or polished [group B]), and the first premolars depicted wear against natural enamel (control group [group C]). In the first premolars, the highest value of wear was considered.

Wear Measurement

The baseline scanned images (T0) were superimposed over the images made at T1 and T2 with 3D software, and the wear amount was calculated using 3D AutoCAD software (Innovmetric Polyworks, Canada). A standard computer algorithm was used to superimpose the follow-up images on the baseline image and to calculate the amount of wear (Figs 1 and 2). In the software, the IMAlign command was used to align the baseline and follow-up images accurately so that the position of both images was in the same coordinate system based on the shape of the scanned cast. The IMMerge command was then used to create a polygonal model from the contents of the IMAlign project and to merge the baseline and successive images.

After the IMInspect command inspected the digitized parts of the aligned and merged data, it checked the deviations in all three axes (x , y , and z) by taking interactive measurements. The software had a color scale ranging from $+50 \mu\text{m}$ to $-50 \mu\text{m}$. The scale is as follows:

- 150 to $-50 \mu\text{m}$: Dark red
- -50 to $0 \mu\text{m}$: Light red
- 0 to $50 \mu\text{m}$: Light green
- 50 to $150 \mu\text{m}$: Olive green

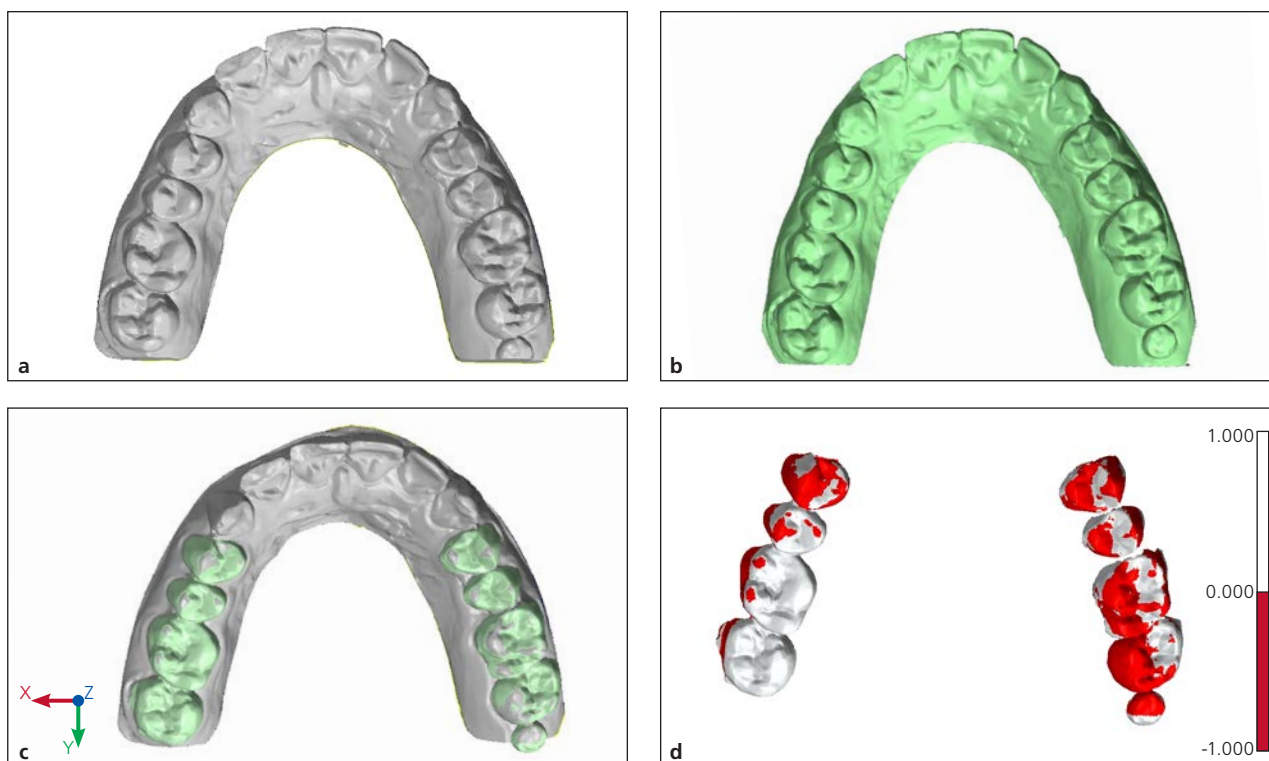


Fig 2 Scanned 3D images of natural enamel of maxillary premolar and first molar opposing a polished monolithic zirconia crown at (a) baseline, (b) 6 months, and (c) 12 months. (d) Superimposed image. Red areas represent enamel wear on the buccal and lingual cusps between 6 and 12 months of clinical use.

Since the occlusal load on a tooth is different on different parts of the occlusal surface, the maximum wear readings on the corresponding points of the antagonist occlusal surfaces of the opposing molars were taken into consideration for the purpose of standardization.

All data were entered into a computer by a coding system and proofed for entry errors. The obtained data were compiled on a Microsoft Excel Sheet (2019). Data were subjected to statistical analysis using SPSS version 26.0 (IBM). Normality of numeric data was checked using Shapiro-Wilk test, and it was found that the data followed a normal curve. Hence, parametric tests were used for comparisons. Intergroup comparisons were performed using one-way analysis of variance (ANOVA) followed by pairwise comparison using post hoc Tukey test. Intragroup comparison was performed using paired *t* test (up to 2 observations). For all statistical tests, $P < .05$ was considered to be statistically significant, keeping α error at 5% and β error at 20%, thus giving a power to the study of 80%.

RESULTS

The mean \pm SD values for wear of enamel at T1 were as follows:

- Against glazed zirconia (group A) = 42.8 ± 5.798 μm (Table 2)
- Against polished zirconia (group B) = 42.5 ± 6.817 μm (Table 3)
- Against enamel (group C) = 14.7 ± 4.036 μm (Table 4)

The mean \pm SD values for wear of enamel at T2 were as follows:

- Against glazed zirconia (group A) = 81.87 ± 8.007 μm (Table 2)
- Against polished zirconia (group B) = 71.43 ± 9.687 μm (Table 3)
- Against enamel (group C) = 15.97 ± 4.214 μm (Table 4)

Intragroup Tests

The *P* values obtained by Student *t* tests for all three groups were $< .01$, signifying a statistically significant difference seen between the time intervals in each group, with higher values at T2 (Tables 2–4).

**Table 2** Intragroup Comparison of Wear (μm) Between Time Points in Glazed Zirconia Group

	Mean	SD	SEM	Mean difference	SD of difference	T value	P^a
6 mo	42.80	5.798	1.059	-39.067	8.542	-25.051	< .01*
12 mo	81.87	8.007	1.462				

*Highly significant ($P < .05$).^aPaired t test.**Table 3** Intragroup Comparison of Wear (μm) Between Time Points in Polished Zirconia Group

	Mean	SD	SEM	Mean difference	SD of difference	T value	P^a
6 mo	42.50	6.817	1.245	-28.933	10.632	-14.906	< .01*
12 mo	71.43	9.687	1.769				

*Highly statistically significant difference ($P < .01$).^aPaired t test.**Table 4** Intragroup Comparison of Wear (μm) Between Time Points in Control Group

	Mean	SD	SEM	Mean difference	SD of difference	T value	P^a
6 months	14.70	4.036	.737	-1.267	1.172	-5.917	< .01*
12 months	15.97	4.214	.769				

*Highly statistically significant difference ($P < .01$).^aPaired t test.**Table 5** Intergroup Comparison of Wear (μm) According to One-Way ANOVA

	Group	n	Mean (μm)	SD	SE	95% CI		Minimum	Maximum	F value	P
						Lower bound	Upper bound				
6 mo	A	30	42.80	5.798	1.059	40.64	44.96	31	52	243.221	< .01*
	B	30	42.50	6.817	1.245	39.95	45.05	30	55		
	C	30	14.70	4.036	.737	13.19	16.21	7	23		
12 mo	A	30	81.87	8.007	1.462	78.88	84.86	65	94	642.642	< .01*
	B	30	71.43	9.687	1.769	67.82	75.05	50	88		
	C	30	15.97	4.214	.769	14.39	17.54	7	26		

Group A = glazed zirconia antagonist; group B = polished zirconia antagonist; group C = natural enamel antagonist.

*Highly statistically significant difference ($P < .01$).

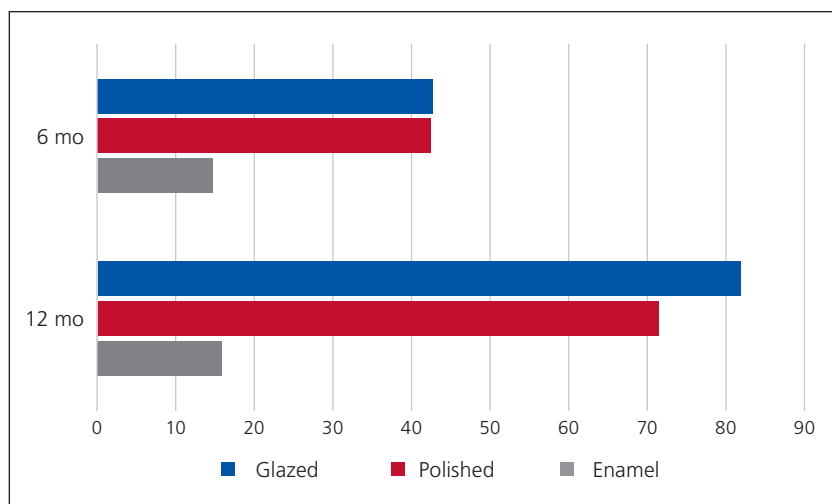
Intergroup Tests

The P value obtained by one-way ANOVA was $< .01$ (Table 5), signifying a statistically significant difference among the mean wear values of the groups at 6 months and 12 months (Figs 3 and 4). The decreasing order of wear at both time intervals was group A, followed by group B, followed by group C.

However, the intergroup pairwise comparison using Tukey post hoc test revealed a statistically

nonsignificant difference ($P = .977$) between the mean wear in groups A and B at 6 months, and a statistically significant difference ($P < .05$) between these two groups at 12 months (Table 6). A box plot summary is shown in Table 7. The mean wear in group 3 (enamel group) was the lowest at both the 6-month and 12-month time points, respectively, which was statistically significant ($P < .05$) compared to the other groups.

Fig 3 Intergroup comparison of wear at 6 and 12 months.



DISCUSSION

Dental wear is defined as tooth loss or surface damage caused by direct contact between teeth, or between teeth and other materials. It occurs as a complex form of chemical and mechanical wear.²⁵ Dental wear of natural teeth is generally considered normal.²⁶ Seghi et al suggested that a restorative dental material should have a similar degree of wear to that of natural enamel; therefore, the wear that occurs between the enamel of teeth and the restorations should be considered while selecting restorative materials.²⁷ If restorative dental materials have wear properties that are different from natural teeth, they can change the wear rate of antagonistic natural teeth. Particularly, excessive wear on the occlusal surface can cause an abnormal load and lead to further deleterious consequences, such as occlusal instability and hampering of esthetics.^{26,28}

Dental porcelain, which was introduced approximately 100 years ago, has been used extensively for more lifelike restorations. Unfortunately, its use has drawbacks such as fracture, and hence improved ceramics such as zirconia were introduced.²⁹ Zirconia has a polymorphic structure with chemical stability and volume stability. It suppresses crack progression via the volume extension caused by the transformation toughening mechanism, which occurs during the phase transition. Monolithic zirconia crowns have a mechanical advantage over previous all-ceramic crowns due to an en bloc configuration. Also, more strength can be obtained even in the case of less abutment removal while using such zirconia restorations.^{10,30}

To estimate the degree of wear of natural teeth caused by a restorative dental material, surface hardness and friction coefficient must be evaluated. However, studies provide no proportional relation between the restoration hardness and the degree of wear of antagonistic teeth.

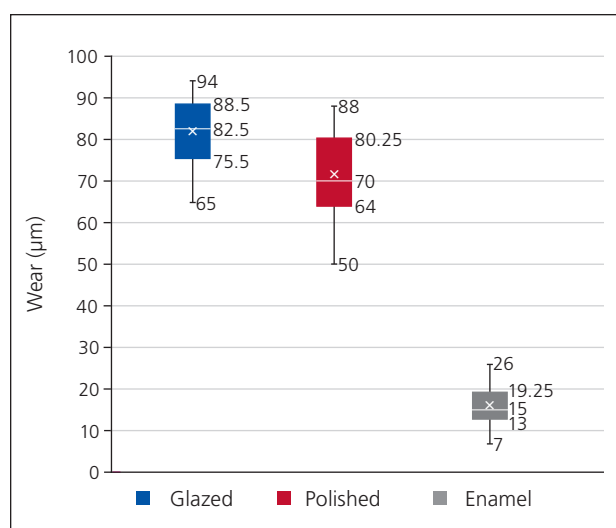


Fig 4 Intergroup comparison of wear after 12 months.

This is because the degree of wear is also affected by factors like the surface structure and roughness of the restorations and environmental factors.³ Thus, the present in vivo study was conducted to evaluate the amount of wear of natural enamel against glazed and polished monolithic zirconia crowns.

The outcome of this study led to the rejection of the null hypothesis that there is no difference in the wear of natural enamel against a glazed monolithic zirconia crown or a polished monolithic zirconia crown. Glazed monolithic zirconia crowns caused more wear of the antagonist enamel compared to polished monolithic zirconia crowns. This was in accordance with previously conducted in vitro studies concluding that full coverage polished zirconia crowns without glazing were more

**Table 6** Intergroup Pairwise Comparison Using Tukey Post Hoc Test

Dependent variable	(I) Group	(J) Group	Mean difference (I-J)	SE	P	95% CI	
						Lower bound	Upper bound
6 mo	A	B	0.300	1.463	.977	-3.19	3.79
	A	C	28.100*	1.463	< .01*	24.61	31.59
	B	C	27.800*	1.463	< .01*	24.31	31.29
12 mo	A	B	10.433*	1.976	< .01*	5.72	15.15
	A	C	65.900*	1.976	< .01*	61.19	70.61
	B	C	55.467*	1.976	< .01*	50.75	60.18

Group A = glazed zirconia antagonist; group B = polished zirconia antagonist; group C = natural enamel antagonist.
*Highly statistically significant difference ($P < .01$).

Table 7 Box Plot Summary (μm)

Box plot numbers	Glazed	Polished	Enamel
Minimum	65	50	7
Q1	75.5	64	13
Median	82.5	70	15
Q3	88.5	80.25	19.25
Maximum	94	88	26

effective in reducing antagonistic teeth wear than polished zirconia crowns with glazing.^{8,19,31,32} The present study also reiterated the conclusions of previous *in vivo* studies that monolithic zirconia crowns caused greater wear of antagonist enamel than natural teeth.^{33,34} Gou et al³⁵ concluded in their systematic review that well-polished monolithic zirconia exhibited similar or more antagonist enamel wear than natural teeth.

The results of the present study indicated a significant difference in the wear of enamel opposed by glazed monolithic zirconia crowns after 12 months of clinical usage. Polished zirconia crowns caused less amount of antagonist enamel wear compared to glazed zirconia crowns. This study measured the wear caused by monolithic zirconia full coverage crowns, which required long-term clinical follow-up. The study subjects were recalled at 6 and 12 months, and the opposing arches were scanned with the help of a 3D optical scanner in order to compare wear. The 6-month scans showed an almost similar amount of wear of the antagonist enamel for both glazed and polished monolithic zirconia crowns; however, the 12-month scans showed considerable wear of antagonist enamel for glazed compared to polished monolithic zirconia crowns.

After 12 months of clinical use of the glazed zirconia crowns, there was a loss of the veneering glass-ceramic, exposing the underlying zirconia, which was rough compared to its earlier smooth glazed surface. This rough surface was critical for producing wear. Glass particles

that detach during wear might behave as an abrasive medium and lead to a three-body wear mechanism.³⁶ These grit particles from the wearing of glass might accentuate the consequences of enamel wear. Also, the rough edges of the worn glass glaze added to the wear. Therefore, this wear can be explained by the loss of the soft glazed surface, which contributed to greater wear of opposing enamel due to its contact with rough sub-surface zirconia and the production of abrasive particles.

Polished zirconia demonstrated less wear of the enamel antagonists than glazed zirconia, likely due to the absence of a thin glazed glass layer, which may disrupt and act as an abrasive particle. Thus, the polished surface seems more effective in limiting the progression of enamel wear. However, the wear of polished zirconia depends on the polishing apparatus used. Differences in wear may exist depending on the size of the polisher used; ie, coarse, medium, or fine grit.

Molars have a large occlusal surface, a greater number of cusps, greater occlusal contacts, and are subjected to greater vertical forces. Owing to this, molars will always exhibit a higher wear compared to premolars when other factors like duration of occlusal loading and occlusal forces during mastication are constant within the same patient. Thus, it was considered better to use premolars as a control group in the present study, as they exhibit the real and moderate wear of enamel per the occlusal condition.^{37,38}

The limitations of the present study include the failure to investigate the crown surfaces at recall appointments



using replica impressions. Patients who exerted more occlusal forces owing to physiologic reasons may exhibit increased wear of teeth. Long-term follow-up may increase the chances of subject compliance and result in less burnout.

CONCLUSIONS

Despite the limitations of this *in vivo* study on the evaluation of antagonistic teeth wear, glazed monolithic zirconia crowns caused more wear to the opposing enamel than polished monolithic zirconia crowns ($P < .05$). The difference in the degree of wear was not significant after 6 months of clinical service, but was significant after 12 months.

ACKNOWLEDGMENTS

J.D.: conceptualization, methodology, software, validation, writing, original draft preparation; V.P.: data curation, software, writing/reviewing/editing; A.G.: visualization, investigation, writing/reviewing/editing; A.S.: software, writing/reviewing/editing; A.M.: software, writing/reviewing/editing; P.D.: software, writing/reviewing/editing. The authors report no conflicts of interest.

REFERENCES

- Mair LH, Stolarski TA, Vowles RW, Lloyd CH. Wear: Mechanisms, manifestations and measurement. Report of a workshop. *J Dent* 1996;24:141–148.
- Ramalho A, Miranda JC. The relationship between wear and dissipated energy in sliding systems. *Wear* 2006;260:361–367.
- Smith BG, Knight JK. A comparison of patterns of tooth wear with aetiological factors. *Br Dent J* 1984;157:16–19.
- Kim MJ, Oh SH, Kim JH, et al. Wear evaluation of the human enamel opposing different Y-TZP dental ceramics and other porcelains. *J Dent* 2012;40:979–988.
- Dental porcelain. In: O'Brien WJ (ed). *Dental Materials and Their Selection*, ed 4. Hanover Park: Quintessence, 2008:212–230.
- Jung YS, Lee JW, Choi YJ, Ahn JS, Shin SW, Huh JB. A study on the *in vitro* wear of the natural tooth structure by opposing zirconia or dental porcelain. *J Adv Prosthodont* 2010;2:111.
- Park JH, Park S, Lee K, Yun KD, Lim HL. Antagonist wear of three CAD/CAM anatomic contour zirconia ceramics. *J Prosthet Dent* 2014;111:20–29.
- Stawarczyk B, Özcan M, Schmutz F, Trottmann A, Roos M, Hämmerle CH. Two-body wear of monolithic, veneered and glazed zirconia and their corresponding enamel antagonists. *Acta Odontol Scand* 2013;71:102–112.
- Malkondu Ö, Tinastepe N, Akan E, Kazazoğlu E. An overview of monolithic zirconia in dentistry. *Biotechnol Equip* 2016;30:644–652.
- Piconi C, Maccauro G. Zirconia as a ceramic biomaterial. *Biomaterials* 1999;20:1–25.
- Al-Amleh B, Lyons K, Swain M. Clinical trials in zirconia: A systematic review. *J Oral Rehabil* 2010;37:641–652.
- Guess PC, Kulis A, Witkowski S, Wolkewitz M, Zhang Y, Strub JR. Shear bond strengths between different zirconia cores and veneering ceramics and their susceptibility to thermocycling. *Dent Mater* 2008;24:1556–1567.
- Kontonasaki E, Rigos AE, Iliá C, Istantsos T. Monolithic zirconia: An update to current knowledge. Optical properties, wear, and clinical performance. *Dent J* 2019;7:90.
- Conrad HJ, Seong WJ, Pesun IJ. Current ceramic materials and systems with clinical recommendations: A systematic review. *J Prosthet Dent* 2007;98:389–404.
- Larsson C, Vult von Steyern P, Nilner K. A prospective study of implant-supported full-arch yttria-stabilized tetragonal zirconia polycrystal mandibular fixed dental prostheses: three-year results. *Int J Prosthodont* 2010;23:364–369.
- Rojas-Vizcaya F. Full zirconia fixed detachable implant-retained restorations manufactured from monolithic zirconia: Clinical report after two years in service. *J Prosthodont* 2011;20:570–576.
- Lambrechts P, Debels E, Van Landuyt K, Peumans M, Van Meerbeek B. How to simulate wear? Overview of existing methods. *Dent Mater* 2006;22:693–701.
- Suputtamongkol K, Anusavice KJ, Suchatlampong C, Sithiamnuai P, Tulapornchai C. Clinical performance and wear characteristics of veneered lithia-disilicate-based ceramic crowns. *Dent Mater* 2008;24:667–673.
- Mitov G, Heintze SD, Walz S, Woll K, Muecklich F, Pospiech P. Wear behavior of dental Y-TZP ceramic against natural enamel after different finishing procedures. *Dent Mater* 2012;28:909–918.
- Campbell SD. Evaluation of surface roughness and polishing techniques for new ceramic materials. *J Prosthet Dent* 1989;61:563–568.
- Tholt de Vasconcellos B, Miranda-Júnior WG, Prioli R, Thompson J, Oda M. Surface roughness in ceramics with different finishing techniques using atomic force microscope and profilometer. *Oper Dent* 2006;31:442–449.
- Al-Wahadni A. An *in vitro* investigation into the surface roughness of 2 glazed, unglazed, and refinished ceramic materials. *Quintessence Int* 2006;37:311–317.
- Yachida W, Arima T, Castrillon EE, Baad-Hansen L, Ohata N, Svensson P. Diagnostic validity of self-reported measures of sleep bruxism using an ambulatory single-channel EMG device. *J Prosthodont Res* 2016;60:250–257.
- Bartlett DW, Fares J, Shirodaria S, Chiu K, Ahmad N, Sherriff M. The association of tooth wear, diet and dietary habits in adults aged 18-30 years old. *J Dent* 2011;39:811–816.
- De Gee AJ, Pallav P, Davidson CL. Effect of abrasion medium on wear of stress-bearing composites and amalgam *in vitro*. *J Dent Res* 1986;65:654–658.
- Sulong MZ, Aziz RA. Wear of materials used in dentistry: A review of the literature. *J Prosthet Dent* 1990;63:342–349.
- Seghi RR, Rosenstiel SF, Bauer P. Abrasion of human enamel by different dental ceramics *in vitro*. *J Dent Res* 1991;70:221–225.
- Yip KH, Smales RJ, Kaidonis JA. Differential wear of teeth and restorative materials: Clinical implications. *Int J Prosthodont* 2004;17:350–356.
- Coornaert J, Adriaens P, De Boever J. Long-term clinical study of porcelain-fused-to-gold restorations. *J Prosthet Dent* 1984;51:338–342.
- Guazzato M, Albakry M, Ringer SP, Swain MV. Strength, fracture toughness and microstructure of a selection of all-ceramic materials. Part I. Pressable and alumina glass-infiltrated ceramics. *Dent Mater* 2004;20:441–448.
- Heintze SD, Cavalleri A, Forjanic M, Zellweger G, Rousson V. Wear of ceramic and antagonist—a systematic evaluation of influencing factors *in vitro*. *Dent Mater* 2008;24:433–449.
- Amer R, Kürklü D, Kateeb E, Seghi RR. Three-body wear potential of dental yttrium-stabilized zirconia ceramic after grinding, polishing, and glazing treatments. *J Prosthet Dent* 2014;112:1151–1155.
- Stober T, Bermejo JL, Rammelsberg P, Schmitter M. Enamel wear caused by monolithic zirconia crowns after 6 months of clinical use. *J Oral Rehabil* 2014;41:314–322.
- Stober T, Bermejo JL, Schwindling FS, Schmitter M. Clinical assessment of enamel wear caused by monolithic zirconia crowns. *J Oral Rehabil* 2016;43:621–629.
- Gou M, Chen H, Kang J, Wang H. Antagonist enamel wear of tooth-supported monolithic zirconia posterior crowns *in vivo*: A systematic review. *J Prosthet Dent* 2019;121:598–603.
- Ratledge DK, Smith BGN, Wilson RF. The effect of restorative materials on the wear of human enamel. *J Prosthet Dent* 1994;72:194–203.
- Howell AH, Brudevold F. Vertical forces used during chewing of food. *J Dent Res* 1950;29:133–136.
- Mundhe K, Jain V, Pruthi G, Shah N. Clinical study to evaluate the wear of natural enamel antagonist to zirconia and metal ceramic crowns. *J Prosthet Dent* 2015;114:358–363.