Research Article

Comparative Evaluation of Occlusal Wear of Two Types of Zirconia Crowns and Opposing Natural Teeth: A Split-Mouth Clinical Study

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Abstract

Background: Tooth wear is a multifaceted issue influenced by various factors contributing to enamel loss, altered vertical dimension, masticatory difficulties and aesthetic concerns, highlighting the importance of material selection in restorative dentistry. Aim: The aim of this study was to evaluate and compare the wear of high translucent and super high translucent zirconia crowns and the antagonist natural teeth at time intervals of 1 week,3 months and 6 months. Study Setting and Design: In vivo study. Materials and method: Twenty patients were selected and divided into two groups of 10 each. Group A: High Translucent (Zolid HT+) and Group B: Super High Translucent (Zolid FX Multilayer). After tooth preparation, casts at 1 week, 3 months and 6 months were prepared and scanned with 3D white light scanner (Smart SCAN 3D HE Scanner, Spectrum). Wear pattern of the high translucent, super high translucent and antagonist natural teeth were evaluated with High Resolution Optical profilometer at 1 week, 3 months and 6 months follow up visits. Statistical analysis used: The statistical software SPSS 16.0 was used for analysis of data. The test of significance difference of mean wear between two materials (Inter-group comparison) was tested by one way ANOVA and for various pairs repeated measures of ANOVA (RMA) followed by Bonferroni test. Level of statistical significance was kept at $p<0.05$. Results: The results indicated a significant difference in wear of Super High Translucent Zirconia crowns and High Translucent zirconia crowns across all time intervals ($p<0.05$). There was a statistically significant increase in wear of enamel opposing Super High Translucent Zirconia as compared to High Translucent zirconia ($p<0.05$). Conclusion: It was concluded that wear of Super High Translucent Zirconia crowns is more than that of High Translucent zirconia crowns. The wear of antagonist natural teeth is more with Super High Translucent Zirconia crowns than with High Translucent crowns. Hence, use of Super High Translucent Zirconia Crowns, if needed, should be restricted to regions with high aesthetic demand and less occlusal forces.

Keywords: occlusal wear, enamel, zirconia, vertical dimension.

1. Introduction

Tooth wear is a multifaceted issue influenced by various factors beyond decay, impacting dental health and function significantly. It encompasses erosion from acids (often dietary), attrition from mechanical forces (like chewing), and abfraction due to habits such as aggressive brushing or clenching. These factors contribute to enamel loss, altered vertical dimension, masticatory difficulties, and aesthetic concerns, highlighting the importance of material selection in restorative dentistry [1,2].

The wear that occurs between the enamel of natural teeth and restorations should be considered in the selection of the restorative materials. Restorative materials, such as zirconia, play a crucial role in mitigating wear-related issues. Zirconia, introduced in dentistry as yttria-stabilized tetragonal zirconia polycrystal (Y-TZP), has undergone significant evolution to enhance both mechanical properties and aesthetic appeal. The transition from opaque first-generation zirconia to more translucent varieties has addressed early concerns about aesthetics while retaining high strength and durability necessary for functional restoration [3-6].

The first-generation 3Y-TZP zirconia provided excellent mechanical strength but was limited by its opacity, necessitating veneering with porcelain to achieve acceptable aesthetics. However, this veneering often led to

complications such as chipping, especially in high-stress areas. The second-generation zirconia, characterized by reduced alumina content to enhance translucency, marked a significant advancement. This formulation maintained robust mechanical properties while improving aesthetic outcomes, particularly suitable for posterior restorations [7-10].

In recent years, the development of third-generation ultra-translucent zirconia has further refined material properties. By increasing the cubic phase content and optimizing chemical composition, manufacturers have achieved superior translucency approaching that of natural dentition. This advancement allows for monolithic restorations that eliminate the need for veneering porcelain, reducing complications associated with chipping and enhancing long-term durability [11,12].

Studies have consistently shown that zirconia, particularly the latest generations, exhibits exceptional wear resistance against natural teeth. Its high hardness and stability under masticatory forces ensure minimal wear on both the restoration itself and the opposing dentition. This wear-friendly characteristic makes zirconia a preferred choice for dental prosthetics, especially in cases where longevity and minimal maintenance are paramount [13-17].

Studies on the wear of unlayered first- generation zirconia are rare, since their occluding surfaces are usually layered with veneering porcelain. Studies comparing the wear behavior of different restorative materials revealed that the materials with high strength toughness and fatigue crack growth resistance showed low material and/or opposing antagonist wear. Increasing the yttria content is known to lower the fracture toughness and strength of zirconia ceramics but increases its translucency and hence being more aesthetic. The hydrothermal aging of zirconia induces the tetragonal to monoclinic phase transformation and can roughen the surface of the zirconia component along with the formation of surface and subsurface microcracks, which may then cause detrimental consequences on the wear rate of the opposing counter face [18-20]. Investigating the wear performance of these new high translucent zirconia stabilized with different amounts of yttria is therefore important. There is paucity of literature on the wear pattern of high translucent and super high translucent zirconia.

Hence the present study was conducted to compare the wear of high translucent and super high translucent zirconia crowns and the antagonist natural teeth at different time intervals.

The null hypothesis of the study was that there were no difference wear of high translucent and super high translucent zirconia crowns and the antagonist natural teeth at different time intervals.

2.MATERIALS AND METHOD

The study was conducted in Department of Prosthodontics after obtaining approval from the institutional review board (ITSCDSR/IIEC/2021-24/Prostho/04). The protocol was clearly explained to all the patients and informed consent was obtained from all the recruits. Using the formula (S2)(Z1-α/2 +Z1-β)2 and power analysis by software G*Power version 3.1.9.7, where the actual power and the effect size were 96.63 % and 1.27 respectively, it was found that the total sample size was 22 with 11 samples in each group.

A total number of 10 patients aged 18 to 45 years, with minimum coronal height of the maxillary / mandibular posterior tooth as 5 mm, natural opposing antagonist without crowns or extensive restorations and who were ready for follow-up visits were included for the study. Patients with active dental caries, attrition, developmental defects of enamel or dentin, high activity of the masseter muscle at night (bruxism), temporomandibular disorders, fluorosis, calcium metabolic disorders, osteoporosis, special needs, extremely poor oral hygiene and with periodontal disease were excluded from the study. Group A included High Translucent (Zolid HT+) and was further divided into two subgroups:

A1: (Zolid HT+) crown at right side

A2: Antagonist with natural enamel Group B included Super High Translucent (Zolid FX Multilayer) and was further divided in two subgroups

B1: (Zolid FX Multilayer) crown at left side

B2: Antagonist with natural enamel

All participants were treated by a single operator and all the zirconia crowns were fabricated in a single laboratory for standardization. Standard procedures were followed to fabricate the crowns (figure1,2) from monolithic yttrium-stabilized zirconia by a computer aided design and computer-aided manufacturing process (AMANNGIRBACH).

For wear analysis of both crown material and opposing tooth enamel, 3D superimposition techniques were utilized. Impressions of upper and lower arches were taken initially (1-week post-cementation) and at follow-ups (3 months and 6 months) using custom trays and monophase impression material (Aquasil Monophase, Dentsply, Germany). Type IV dental stone (Ultrarock, Kalabhai) models were created from these impressions (figure 3).

Figure 1: Tooth Preparation of 34 and 44 and gingival retraction cord placement

Figure 2: Cementation of Zirconia Crowns on 34 and 44

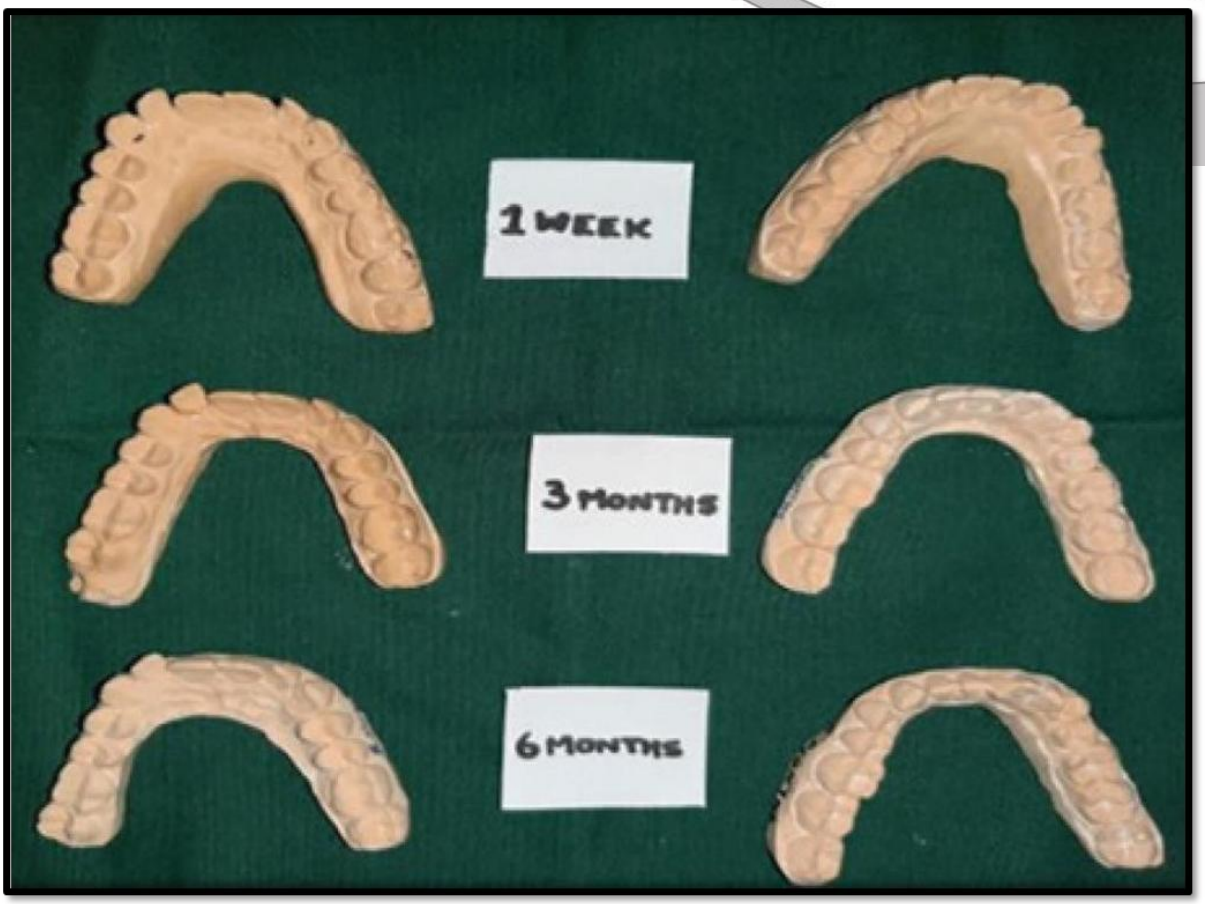

Figure 3: Casts obtained at 1 week, 3 months and 6 months for wear analysis.

At each time point (1 week, 3 months, and 6 months), the models were scanned using a 3D white light scanner (Smart SCAN 3D HE Scanner, Spectrum) based on Miniature Projection Technique (MPT). The scanned images were processed with Polyworks software (Innovmetric Software Inc.) for superimposition. Baseline scans (1 week) were overlaid with scans from 3 months and 6 months to assess wear in micrometers using a color scale.

The experimental groups included wear analysis of zirconia crowns (High Translucent and Super High Translucent-Multilayer) and natural enamel opposing them (posterior teeth excluding third molars). Control groups consisted of non-restored posterior natural teeth (first premolar and second molar) in the opposing arch. Each participant's eight regions of contact were evaluated:

HT Crowns (High Translucent)

FX Crowns (Super High Translucent-Multilayer)

NE-M (Natural enamel opposing natural enamel in molar region)

NE-PM (Natural enamel opposing natural enamel in premolar region)

NE-HT-M (Natural enamel opposing High Translucent crowns in molar region)

NE-FX-M (Natural enamel opposing Super High Translucent crowns in molar region)

NE-HT-PM (Natural enamel opposing High Translucent crowns in premolar region)

NE-FX-PM (Natural enamel opposing Super High Translucent crowns in premolar region)

The 3D superimposition process (figure 4,5) facilitated precise measurement and analysis of wear over time, providing insights into the durability and interaction of different materials within the oral environment.

All the data were collected and analysed using statistical software SPSS 16.0. The descriptive statistics like mean, median, S.d of data was calculated. The test of significance difference of mean wear between two materials (Inter

group comparison) was tested by one way ANOVA and for various pairs, repeated measures of ANOVA (RMA) followed by Bonferroni test was used.

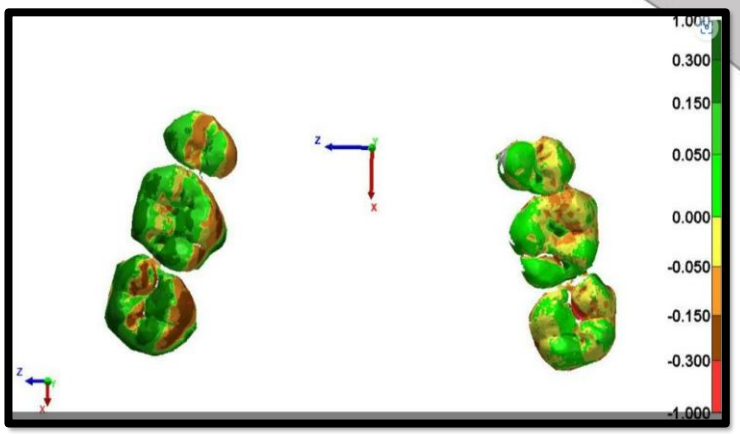

Figure 4: Chromatographic representation of Superimposed Images of casts

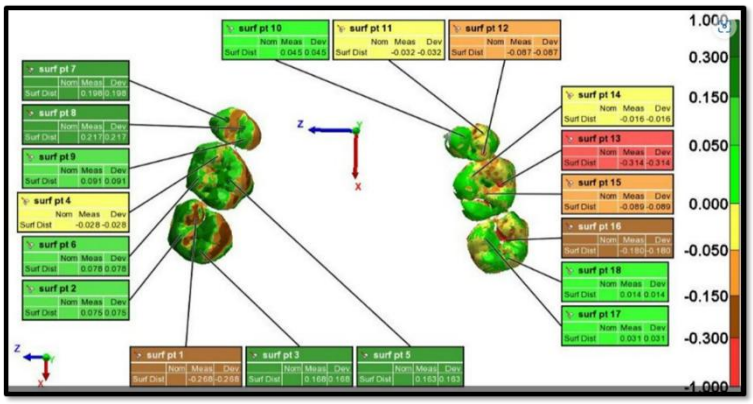

Figure 5: Wear values on Superimposed Image of baseline and follow up cast

3. RESULTS

The difference in mean wear depth in teeth having zirconia crowns was statistically insignificant ($p>0.05$) in high translucent zirconia (A1) and super high translucent zirconia (B1) at one week follow up. However, difference in the wear depth in teeth having zirconia crowns was significantly lesser (table 1) in high translucent zirconia (A1) than super high translucent zirconia (B1) at 3 months and 6 months follow-up ($p<0.05$). Similar findings were noted for difference in mean wear volume for high translucent zirconia (A1) and super high translucent zirconia (B1) at all time intervals (table 2).

Table 2: Mean wear volume of high translucent and super high translucent zirconia crowns at different time intervals

Timeframe	Group	Mean (mm^3)	SD	t value	p value
1 Week	A1	0.136	0.029	-5.012	0.114
	B1	0.142	0.016		
3 Months	A1	0.190	0.011	-6.463	0.004*
	B1	0.213	0.013		
6 Months	A1	0.230	0.018	-8.216	0.003*
	B1	0.262	0.017		

The difference in enamel wear depth in teeth opposing zirconia crowns was statistically insignificant (p>0.05) in high translucent zirconia (A2) and super high translucent zirconia (B2) at one week follow up. However, difference in enamel wear depth in teeth (table 3) opposing zirconia crowns was significantly lesser in high translucent zirconia (A2) than super high translucent zirconia (B2) at 3 months and 6 months follow-up (p<0.05). Similar findings were noted for difference in enamel wear volume (table 4) in teeth opposing high translucent zirconia (A2) and super high translucent zirconia (B2) at all time intervals.

Table 3: Mean wear depth of antagonistic natural teeth opposing high translucent and super high translucent zirconia crowns at different time intervals

Timeframe	Group	Mean (µm)	SD	t value	p value
1 Week	A2	24.266	1.42	-0.701	0.742
	B2	24.672	1.19		
3 Months	A2	38.23	1.41	-6.913	0.031*
	B2	44.90	0.81		
6 Months	A2	50.554	1.06	-7.321	0.004*
	B2	56.162	1.54		

Table 4: **Mean wear volume of antagonistic natural teeth opposing high translucent and super high translucent zirconia crowns at different time intervals**

Timeframe	Group	Mean (mm^3)	SD	t value	p value
1 Week	A2	0.410	0.017	-0.794	0.951
	B2	0.411	0.012		
3 Months	A2	0.443	0.012	-7.201	0.003*
	B2	0.519	0.011		
6 Months	A2	0.490	0.012	-5.431	0.002*
	B2	0.501	0.017		

There was statistically significant increase in mean wear depth and mean wear volume in both teeth with high translucent zirconia crowns and super translucent zirconia as well as in teeth opposing these teeth having crowns at 1 week, 3 months and 6 months follow up (table 5,6).

Table 5: Intergroup comparison of mean wear depth (µm) at different time intervals

Timeframe	**A1**	**B1**	**A2**	**B2**
1 week	8.16±0.57	8.54±0.58	24.26 ±1.42	24.67±1. 19
3 months	12.81± 0.86	16.64 ±0.50	38.23±1. 41	44.90 ± 0.81
6 months	16.79 ±1.62	20.49 ±1.28	50.55 ±1.06	56.16 ± 1.54
P value	>0.001*	> 0.001*	> 0.001*	> 0.001*

Table 6 Intergroup comparison of mean wear volume (mm^3) at different time intervals

Timeframe	A1	B1	A2	B2
1 week	0.136 ±0.029	0.142 ±0.016	0.410±0.017	0.408 ± 0.012
3 months	0.190 ± 0.011	0.213 ±0.013	0.443±0.012	0.519±0.011
6 months	0.230 ± 0.018	0.262±0.017	0.490±0.012	0.564 ±0.017
P value	> 0.001*	> 0.001*	> 0.001*	> 0.001*

4.DISCUSSION

The null hypothesis of study that there was no difference in occlusal wear in high translucent and super high translucent zirconia crown and opposing natural teeth antagonist was rejected. A significant difference ($p<0.05$) was found in occlusal wear in high translucent and super high translucent zirconia crown and opposing natural teeth antagonist at various time intervals.

Based on the results of the study, it was found that super high translucent zirconia (Zolid FX Multilayer) caused more wear on natural enamel compared to high translucent zirconia (Zolid HT+). Also, the wear increased significantly at 3 months and 6 months as compared to 1 week ($p<0.05$). The study highlighted wear mechanisms influenced by physical, microstructural, chemical factors, and surface finish. Monolithic zirconia, due to high fracture resistance and minimal occlusal thickness, is recommended for posterior restorations, minimizing porcelain chipping issues. The hypothesis that wear behavior is unaffected by microstructural variations between zirconia generations was not supported by the study's results, which noted statistical differences.

The results are in accordance with the study conducted by Chevalier et al. [14] who compared the wear behaviour of different restorative materials and found that the materials with high strength toughness and fatigue crack growth resistance showed low material and/or opposing antagonist wear. Increasing the yttria content is known to lower the fracture toughness and strength of zirconia ceramics. The hydrothermal aging of zirconia induces the tetragonal to monoclinic phase transformation and can roughen the surface of the zirconia component along with the formation of surface and subsurface microcracks, which may then cause detrimental consequences on the wear rate of the opposing counter face which could be the justification of the results of this study.

Likewise Jitwirachot et al. [15] stated that materials with high strength and high fracture toughness showed minimal material wear or antagonist wear. Scanning electron microscopy of zirconia also reveals a tightly bound grain structure which resists surface degradation. Previous reviews on the mechanical properties of super high translucent zirconia showed that the higher yttria content in cubic zirconia negatively influences fracture toughness and flexural strength of zirconia thus enhancing the crack propagation and the wear of antagonist.

Similarly, Vardhaman et al. [20] documented more susceptibility to fatigue wear in multilayered zirconia with a 5Y-TZP enamel layer and 4YTZP dentin layer as compared to monochromatic, monolithic 3Y-TZP. SEM evaluation also revealed a more advanced stage of wear progress in multilayered zirconia.

The results are corroborated with the study conducted by Tang et al. [16] to quantitate the wear of the highly transparent Yttria-stabilized tetragonal zirconia polycrystals (Y-TZP) ceramic monolithic zirconia crown on the enamel in vivo and discuss the prone position of the wear and the underlying mechanism. Although the self-wearing is insignificant, the monolithic zirconia crown can cause wear of the antagonist teeth via occlusal or early contact significantly; the amount of wearing is higher than that of natural teeth and increases over time. The wearing mechanism is mainly abrasive and fatigue wear.

However the results are contradictory to study conducted by Zhang et al. [17] who evaluated two-body wear of three zirconia ceramics stabilized with 3, 4 and 5 mol% yttria and compared their wear behaviour with that of a lithium-disilicate glass-ceramic. All three zirconia ceramics yielded a lower antagonist wear than the glass-ceramic and no significant differences were found between the zirconia ceramics.

Gou et al. [18] carried out a systematic review to identify and summarize clinical studies related to the antagonist enamel wear of tooth-supported monolithic zirconia posterior crowns. The results of the antagonist enamel wear varied widely, which made comparing them scientifically with absolute values difficult. This review indicated that the antagonist enamel wear of zirconia was similar to or more than that of natural teeth but less than that of metal-ceramics.

Based on the results of the study, it was found that the wear depth of zirconia crowns was significantly not different in high translucent zirconia (Zolid HT+) and super high translucent zirconia (Zolid FX Multilayer) at one week follow up. However, the wear depth of zirconia crowns and their antagonist natural teeth was significantly lesser in high translucent zirconia (Zolid HT+) than super high translucent zirconia (Zolid FX Multilayer) at 3 and 6 months follow up ($p<0.05$).

Although there are no direct studies for comparison but similar study conducted by Pathan et al. [19] assessed the clinical performance and survival of full-contour monolithic zirconia (MZ) crowns and enamel wear produced over a 1-year period. It was found that statistical significance ($p < 0.05$) was noted between the wear values at 6 months (15.5 µm) and at 12 months (16.3 µm). The survival rate for the crowns was 100%.

Limitations of the study include the small sample size and a short observation period. The factors like the abrasiveness of the diet and habits can be included in the selection criteria in the further studies. However, because the study design was split mouth, confounding variables (such as similarity of sites in a participant, simultaneous time of observation for test and control group and matched occlusal force factors in both the groups) were eliminated. Further studies with longer follow-up period and larger sample size should be included.

CONCLUSION

Based on the results of this study, the following conclusions were drawn:

1. Both High Translucent and Super High Translucent Zirconia crowns wear with time.
2. The wear of Super High Translucent Zirconia crowns is more than that of High Translucent Zirconia crowns.
3. The wear of antagonist natural teeth is more with Super High Translucent Zirconia crowns than with High Translucent crowns.
4. Super High Translucent Zirconia Crowns, if needed should be restricted to regions with high aesthetic demand and less occlusal forces.

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