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ORIGINAL RESEARCH

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In vitro comparison of surface roughness and gloss of prefabricated zirconia crowns before and after simulated brushing

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Abstract

Background: Prefabricated zirconia crowns (PZCs) are widely used in pediatric dentistry due to their superior esthetics and durability. However, limited information is available regarding their surface behavior after long-term brushing. This study aimed to evaluate and compare the surface roughness (Ra) and gloss values of three different PZC brands—NuSmile, ProfZr Crown, and Kids Crown—before and after brushing. **Methods**: Thirty PZCs (n = 10 per group) were embedded in transparent cold-cure acrylic blocks, with the labial surface oriented parallel to the ground to standardize positioning for the brushing procedure. Specimens were subjected to standardized brushing using an oscillating-rotating electric toothbrush and low-abrasive children's toothpaste. Surface roughness was measured using a contact profilometer, and gloss was assessed with a glossmeter. Measurements were recorded before and after brushing. Intragroup and intergroup comparisons were performed using Wilcoxon, Kruskal-Wallis, and analysis of variance (ANOVA) tests depending on data distribution (α = 0.05). **Results**: Pre-brushing Ra values differed significantly between groups (p = 0.0012), with ProfZr showing the highest initial roughness. Post-brushing Ra values did not differ significantly (p = 0.668), but ΔRa values were significantly higher in NuSmile and Kids Crown compared to ProfZr (p = 0.0017). A significant increase in Ra was observed after brushing in NuSmile (p = 0.002) and Kids Crown (p = 0.006), but not in ProfZr. Gloss values decreased in all groups, though not significantly (p = 0.108). Initial gloss values significantly differed between brands (p = 0.0096), with NuSmile exhibiting the lowest gloss. ΔGloss values were not significantly different among groups (p = 0.565). **Conclusions**: Surface roughness and gloss of PZCs vary by brand and respond differently to brushing. While ProfZr maintained surface stability, NuSmile and Kids Crown showed increased roughness and gloss loss. Surface finishing may influence these outcomes and should be considered in crown selection.

Keywords

Prefabricated zirconia crowns; Surface roughness; Gloss; Toothbrushing simulation

1. Introduction

Dental caries is a prevalent public health concern in childhood that, if left untreated, can result in infection, pain, and nutritional deficiencies. This condition may negatively impact children's overall health and quality of life [1]. In this context, pediatric crowns are effective treatment options for restoring masticatory function, preserving tooth structure, and managing biofilm-induced caries. In recent years, PZCs have gained popularity as an alternative to traditional stainless steel crowns (SSCs). Although both crown types offer similar retention and support periodontal health, SSCs are less esthetic and tend to accumulate more plaque [2–4]. Furthermore, their metallic appearance has been associated with lower acceptance, particularly among parents [5–7]. The conspicuous appearance of SSCs may lead to self-consciousness or discomfort in children, especially in social settings involving peers. These concerns have contributed to a growing parental preference for more natural-looking and esthetic alternatives such as zirconia crowns [6, 7]. In contrast, PZCs offer significant advantages in terms of natural tooth-like esthetics, high strength, and biocompatibility with gingival tissues [8].

Currently, various PZC brands are available on the market, including NuSmile® ZR Crowns, EZ-Pedo™ (Sprig EZ Crowns), Cheng Crowns™, Kinder Krowns®, Kids Crown ZR™, and ProfZr Crown™. The existing literature, particularly studies on NuSmile zirconia crowns, shows that these crowns have high success rates and are frequently preferred. However, scientific data on brands such as Kids Crown ZR and ProfZr Crown remain limited. Therefore, it is necessary to

examine parameters such as surface roughness, which is important for plaque retention, and gloss, which affects aesthetic appearance, in these materials.

Surface roughness refers to microscopic irregularities, such as pits and peaks, that directly influence properties like adhesion, gloss, and biofilm accumulation [9]. The most used parameter, mean surface roughness (Ra), quantitatively evaluates surface quality. An increase in Ra facilitates the adhesion of oral microorganisms, promoting biofilm formation and increasing the risk of caries and periodontal disease. Studies indicate that maintaining surface roughness at or below 0.2 μm on intraoral surfaces is critical for minimizing bacterial plaque retention [10–13].

The roughness and esthetic properties of zirconia surfaces can be enhanced through surface treatments such as glazing or polishing during the manufacturing process [14]. Well-polished zirconia surfaces result in less plaque accumulation and reduced gingival irritation [10–13]. Gloss is defined as the surface's ability to reflect light and can be quantitatively measured using a gloss meter [15, 16]. High gloss is associated with specular reflection, while low gloss is linked to diffuse reflection [17]. Beyond its esthetic function, gloss may also contribute to clinical performance by enhancing surface smoothness, thereby reducing plaque retention and the risk of gingival inflammation. Clinical evidence from pediatric patient studies also supports the association between smoother zirconia surfaces and improved gingival health [3, 4]. Several studies have demonstrated an inverse relationship between surface roughness and gloss; increased roughness typically leads to decreased gloss. Although this relationship has been primarily studied in composite materials, the findings also provide a meaningful framework for other restorative materials such as PZC [18, 19].

One of the key factors that may influence the surface properties of pediatric zirconia crowns (PZCs) is the surface finishing technique applied during manufacturing [20]. Glazing, mechanical polishing, or a combination of both can be used for zirconia surface finishing. For example, NuSmile® ZR Crowns are known to undergo mechanical polishing and manual surface flattening during production [21]. However, detailed information regarding the finishing methods used by other manufacturers remains limited, which further supports the need for comparative studies on PZCs.

There are only a few studies in the literature that evaluate the gloss and surface properties of PZCs [21, 22]. One such study reported that gloss and Ra values vary by brand and surface location, with an inverse relationship between gloss and surface roughness [21]. However, no external force was applied in that study. Yet, it is known that mechanical forces such as tooth brushing can erode the glaze layer and alter surface properties [23, 24]. Moreover, mechanical abrasion has been reported to affect the roughness and gloss of ceramic materials regardless of the surface finishing method used [18, 25]. Although some researchers have explored these effects, studies investigating the impact of tooth brushing on the surface properties of PZCs remain limited [25].

In this study, the surface roughness (Ra) and gloss values (gloss units, GU) before and after brushing of three different PZC brands (NuSmile, ProfZr Crown, and Kids Crown) were evaluated. The findings aim to address gaps in the current literature concerning the surface stability and esthetic performance of these materials.

2. Materials and methods

2.1 Sample size

The sample size was calculated using the G*Power 3.1.9.2 software (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, NRW, Germany) at a 95% confidence level. Based on the analysis, using a significance level of $\alpha = 0.05$ and a statistical power of 0.80, the standardized effect size was set at 1.36, as reported in a previous similar study [26]. The minimum required sample size was calculated to be 30 in total, with 10 samples per group.

2.2 Sample procurement and preparation

A total of 30 prefabricated zirconia crowns (PZCs) from three widely available CE-certified (Conformité Européenne) brands—NuSmile, ProfZr Crown, and Kids Crown—were selected. These brands represent different countries of origin and are commonly used in clinical practice; NuSmile, in particular, has been frequently evaluated in previous *in vitro* studies [21, 26]. All selected crowns were upper right primary central incisors. Each crown was embedded in transparent cold-cure acrylic blocks using a standardized silicone mold (10 mm × 8 mm × 10 mm) to ensure proper placement within the glossmeter device. The labial surface of each crown was positioned perpendicular to the mold wall and parallel to the ground surface to standardize the brushing procedure (Fig. 1). The blocks were polymerized at room temperature for 15 minutes, and the full exposure of the labial surface was visually verified. After setting, the acrylic blocks were stored at room temperature until surface roughness and gloss measurements and the brushing procedure.

2.3 Gloss measurement

Gloss measurements were conducted on all 30 PZCs before and after brushing using a glossmeter (Novo-Gloss, Rhopoint Instruments Ltd., East Sussex, UK) capable of measuring gloss at three different angles. To eliminate the influence of ambient light and ensure consistent sample positioning, a black cardboard template was placed over each specimen during measurement (Fig. 1). The device was calibrated prior to use using a black glass standard provided by the manufacturer. Each sample was measured three times, slightly repositioning the specimen laterally between each measurement. Measurements were conducted according to the working principle of the glossmeter, using 60° incident and reflection angles for each specimen, focusing on the labial surface area that provided the widest and flattest possible region for measurement. The mean of the three readings was recorded, and the results were expressed in gloss units (GU).

2.4 Surface roughness measurement

Surface roughness measurements were performed before and after brushing using a profilometer (Perthometer, Mahr GmbH,

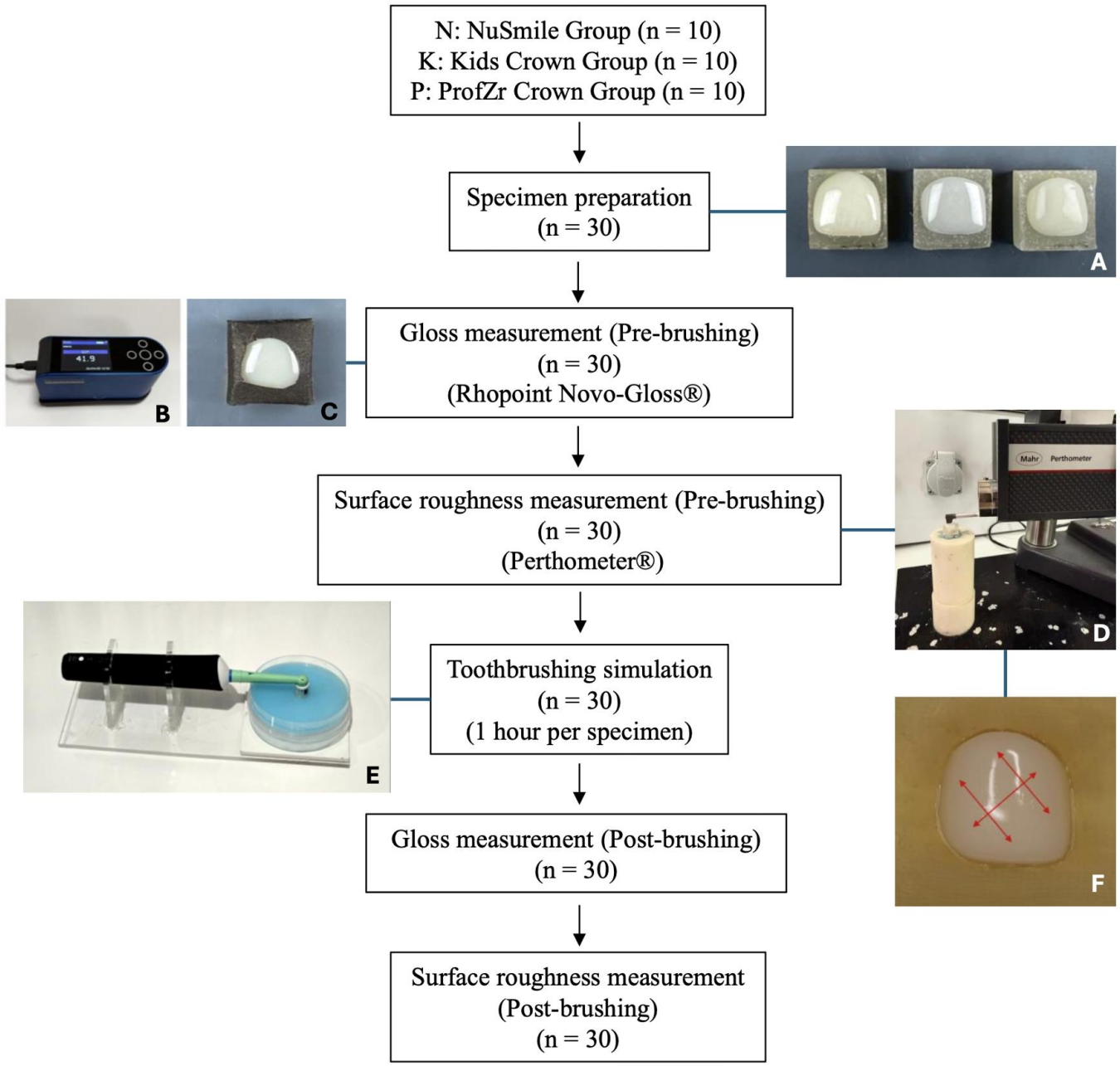

FIGURE 1. Flowchart. (A) Crown samples. (B) Glossmeter (Novo-Gloss, Rhopoint Instruments Ltd., East Sussex, United Kingdom). (C) A black opaque cardboard template was placed over the samples sequentially to eliminate ambient light and maintain consistent positioning. (D) Profilometer (Perthometer, Mahr GmbH, Ingolstadt, Germany). (E) Brushing simulator apparatus with tootbrush (Oral-B Vitality Pro Kids, Procter & Gamble, Germany). (F) Three measurement locations for profilometric analysis.

Ingolstadt, BY, Germany) equipped with a stylus having a 5 μm tip diameter (Fig. 1D) [21, 26]. Following the approach used in a previous study three measurements were taken from different regions on the labial surface of each crown (Fig. 1F) [27]. The results were recorded as mean surface roughness (Ra).

2.5 Tooth brushing simulation

The brushing simulation was performed using a medium-bristled rechargeable electric toothbrush (Oral-B Vitality Pro Kids, Procter & Gamble, Germany), intended for the pediatric age group and mounted on a custom brushing apparatus designed based on previous studies [28, 29]. This model was selected due to its wide availability in the market, the manufacturer's specification of its suitability for the pediatric age group (3 years and older), and its soft brush head. This toothbrush operates with a 2D cleaning action consisting of oscillation and rotation at approximately 7600 oscillations per minute. Brushing was performed in standard (non-sensitive) mode to simulate normal clinical conditions. A toothpaste slurry was prepared by mixing a 1000 ppm fluoride toothpaste (Sensodyne Pronamel Kids, ages 3–5) with distilled water at a 1.6:1 ratio (38 g toothpaste to 60 g water) [26, 28, 30, 31]. A low-RDA (Relative Dentin Abrasivity) toothpaste was

preferred to avoid excessive surface roughness beyond levels typically expected under normal clinical conditions during brushing simulation. Each crown was brushed in this slurry using the brushing simulator. The brushing simulation was conducted under closed and controlled laboratory conditions at room temperature (23 ± 1 °C). After environmental conditions were standardized, further precautions were taken to ensure mechanical consistency across samples. A new toothbrush head was used for each sample. The device was fully recharged between each sample, and all brushing sessions began with a full charge. Brushing was consistently applied to a single designated area on each specimen. A vertical force of 2 N was applied to the toothbrush head using orthodontic elastics and verified with a laboratory-grade force gauge (Shimpo FGJN-5B, Shimpo Instruments, Kyoto, Japan) [29]. Based on previous studies, each specimen was brushed for one hour, to simulate the cumulative effect of daily brushing over an extended period. This duration corresponds to approximately one year of regular oral hygiene, assuming that each tooth surface is exposed to toothbrush bristles for about 5 seconds per session, twice daily [32, 33].

2.6 Statistical analyses

The normality of the data was assessed using the Shapiro-Wilk test, and the homogeneity of variances was evaluated using Levene's test. Based on the distribution characteristics, appropriate statistical tests were selected to analyze surface roughness (Ra), gloss, and the respective changes after brushing (ΔRa, ΔGloss).

Since the roughness data did not follow a normal distribution, non-parametric tests were employed. Intragroup comparisons between pre- and post-brushing measurements were conducted using the Wilcoxon signed-rank test. Differences in ΔRa values among the groups were analyzed using the Kruskal-Wallis test, followed by pairwise comparisons using the Dunn-Bonferroni *post-hoc* test when significant differences were observed.

For gloss data, the normality of each variable (pre-gloss, post-gloss, and ΔGloss) was assessed individually. As the data met the normality assumption, a two-way repeated measures ANOVA was performed to simultaneously evaluate the effects of time (pre *vs.* post) and group (NuSmile, ProfZr Crown, Kids Crown). Group differences in ΔGloss values were analyzed using one-way ANOVA, and when significant, Tukey's Honestly Significant Difference (Tukey HSD) *post hoc* tests were used for pairwise comparisons.

All statistical analyses were conducted using IBM SPSS Statistics software (version 25.0, Armonk, NY, USA), and the level of statistical significance was set at $\alpha = 0.05$.

3. Results

3.1 Evaluation of surface roughness measurements before and after brushing

The mean surface roughness values (Ra, μm) before and after brushing, along with the corresponding ΔRa values, were calculated for each group (NuSmile = N, ProfZr Crown = P, and Kids Crown = K). The P group exhibited the highest initial surface roughness, while the K group demonstrated the highest post-brushing Ra values (Table 1).

When the differences between pre- and post-brushing Ra values were evaluated within each group, a significant increase in Ra was observed in the N and K groups, while no significant change was found in the P group ($p > 0.05$) (Table 2).

When comparing the groups based on pre-brushing Ra, post-brushing Ra, and ΔRa values, no statistically significant difference was observed for post-brushing Ra values ($p = 0.668$); however, significant differences were found for pre-brushing Ra and ΔRa values ($p < 0.05$) (Table 3).

Pairwise comparisons of the statistically significant values are presented in Table 4. Significant differences in ΔRa values were found between the P–N ($p = 0.007$) and P–K ($p = 0.005$) groups ($p < 0.05$), while no significant difference was observed between the N–K groups ($p = 1.000$). For the pre-brushing Ra values, significant differences were detected between the K–P ($p = 0.0012$) and N–P ($p = 0.0319$) groups, but not between the N–K groups ($p = 0.9647$). These findings suggest that while some differences existed in initial surface roughness among the groups, the more prominent differences emerged in the ΔRa values, which reflect changes in surface characteristics following brushing.

3.2 Evaluation of gloss measurements before and after brushing

The mean values of gloss measurements before brushing (Pre-gloss), after brushing (Post-gloss), and the changes in gloss (ΔGloss) for the PZCs are presented in Table 5.

According to the results, neither the main effect of brushing nor the interaction effect between brushing and group was statistically significant ($p > 0.05$). However, the main effect of group was found to be significant ($p = 0.0096$). This indicates that the gloss levels varied among the different groups, although the brushing procedure did not significantly influence these differences. In other words, the effect of brushing on gloss was observed similarly across all groups (Table 6).

As a result of the statistical analysis, for pre-brushing gloss values, the N group had significantly lower gloss compared to the other groups ($p = 0.0034$). On the other hand, post-brushing gloss values did not show statistically significant differences among the groups ($p > 0.05$) (Table 6).

Finally, ΔGloss values (post − pre differences) showed no statistically significant differences among the groups ($p = 0.565$).

4. Discussion

This *in vitro* study evaluated and compared the surface roughness (Ra) and gloss values of three different PZC brands—NuSmile, ProfZr Crown, and Kids Crown—both before and after brushing. Pre-brushing Ra values differed significantly among the groups ($p = 0.0012$), with the highest initial roughness observed in the ProfZr Crown group. The pre-brushing Ra values observed for NuSmile crowns in the present study are consistent with the findings of a recent study investigating NuSmile zirconia crowns [34]. In contrast, post-brushing Ra values did not differ significantly among the groups (p

TABLE 1. Mean surface roughness values (Ra, μm) before and after brushing, and changes in surface roughness (ΔRa, post–pre) for each group.

Group	n	Pre Ra (Mean ± SD)	Pre Ra (Min–Max)	Post Ra (Mean ± SD)	Post Ra (Min–Max)	ΔRa (Mean ± SD)	ΔRa (Min–Max)
N	10	0.045 ± 0.038	0.015–0.114	0.170 ± 0.048	0.104–0.243	0.125 ± 0.063	0.040–0.226
P	10	0.184 ± 0.136	0.018–0.476	0.141 ± 0.089	0.023–0.276	−0.043 ± 0.115	−0.221–0.223
K	10	0.028 ± 0.025	0.013–0.080	0.229 ± 0.216	0.059–0.640	0.201 ± 0.227	−0.021–0.622

N: NuSmile; P: ProfZr Crown; K: Kids Crown; SD: standard deviation; Min: minimum; Max: maximum; Ra: mean surface roughness.

TABLE 2. Comparison of surface roughness values (Ra, μm) before and after brushing.

Group	Pre Ra (Mean ± SD)	Post Ra (Mean ± SD)	*p*-value
N	0.045 ± 0.038	0.170 ± 0.048	0.002*
P	0.184 ± 0.136	0.141 ± 0.089	0.160
K	0.028 ± 0.025	0.229 ± 0.216	0.006*

*Test: Wilcoxon signed-rank. N: NuSmile; P: ProfZr Crown; K: Kids Crown; SD: standard deviation; Ra: mean surface roughness. *$p < 0.05$.*

TABLE 3. Comparison of surface roughness (Ra, μm) values among the groups.

Group: Mean ± SD		*p*-value
Pre-Brushing Ra		
	K: 0.028 ± 0.025	
	N: 0.045 ± 0.038	0.0012*
	P: 0.184 ± 0.136	
Post-Brushing Ra		
	K: 0.229 ± 0.216	
	N: 0.170 ± 0.048	0.6680
	P: 0.141 ± 0.089	
ΔRa (Post − Pre)		
	K: 0.201 ± 0.227	
	N: 0.125 ± 0.063	0.0017*
	P: −0.043 ± 0.115	

*Test: Kruskal-Wallis. N: NuSmile; P: ProfZr Crown; K: Kids Crown; SD: standard deviation; Ra: mean surface roughness. *$p < 0.05$.*

TABLE 4. Pairwise comparisons of pre-brushing Ra (μm) and ΔRa values among the groups.

Groups	Pre Ra *p*-value	ΔRa *p*-value
K–N	0.9647	1.000
K–P	0.0012*	0.005*
N–P	0.0319*	0.007*

*Test: Dunn-Bonferroni Post-Hoc. N: NuSmile; P: ProfZr Crown; K: Kids Crown; SD: standard deviation; Ra: mean surface roughness. *$p < 0.05$.*

TABLE 5. Mean gloss values before and after brushing and changes in gloss (ΔGloss, GU) among the groups.

Group	n	Pre-gloss (Mean ± SD)	Pre-gloss (Min–Max)	Post-gloss (Mean ± SD)	Post-gloss (Min–Max)	ΔGloss (GU)
N	10	47.78 ± 3.29	42.3–53.4	46.55 ± 2.18	43.4–49.9	−1.23 ± 2.50
P	10	54.04 ± 5.32	46.0–63.3	50.77 ± 4.90	44.8–58.3	−3.26 ± 4.91
K	10	52.75 ± 2.41	50.3–56.3	50.36 ± 3.47	43.9–56.2	−2.39 ± 4.82

N: NuSmile; P: ProfZr Crown; K: Kids Crown; SD: standard deviation; Min: minimum; Max: maximum; GU: gloss units.

TABLE 6. Effects of time and crown type on gloss values.

Analysis Type	Effect/Comparison	*p*-value
ANOVA		
	Brushing (Pre *vs.* Post)	0.1080
	Group	0.0096*
	Brushing × Group Interaction	0.8340
Tukey HSD		
	Pre: K *vs.* N	0.0207*
	Pre: K *vs.* P	0.7402
	Pre: N *vs.* P	0.0034*
	Post: K *vs.* N	0.0712
	Post: K *vs.* P	0.9654
	Post: N *vs.* P	0.0516

*N: NuSmile; P: ProfZr Crown; K: Kids Crown; ANOVA: Analysis of Variance; Tukey HSD: Tukey's Honestly Significant Difference test; *p < 0.05.*

= 0.668), suggesting that all brands exhibited similar surface behavior after brushing. However, the change in Ra (ΔRa) from pre- to post-brushing was significantly different between groups (p = 0.0017). This increase was most notable in the NuSmile and Kids Crown groups, both of which exhibited increased surface roughness and decreased gloss. No significant change in surface roughness was observed in the ProfZr group. These findings suggest an inverse relationship between initial surface smoothness and susceptibility to mechanical alteration after brushing, as well as between surface roughness and gloss. In particular, groups with smoother initial surfaces (*e.g.*, the Kids Crown group) exhibited more pronounced increases in Ra values after brushing, whereas groups with rougher initial surfaces (*e.g.*, the ProfZr group) demonstrated greater surface stability. This relationship is likely attributable to differences in surface finishing protocols during manufacturing—possibly due to the zirconia block's microstructure or specific treatments such as glazing or polishing—as all specimens were brushed under standardized conditions using the same electric toothbrush and a low-RDA pediatric toothpaste. Maintaining surface roughness below 0.2 μm has been highlighted as critical for minimizing bacterial plaque accumulation and reducing the risk of secondary caries and periodontal complications [10, 12, 13]. In the present study, all groups maintained Ra values at or below this threshold following brushing—at the limit for the Kids Crown group and below it for the NuSmile and ProfZr groups.

Gloss measurements showed that brushing, as an independent factor, did not result in a statistically significant change (p = 0.108), indicating a similar effect across all groups. However, the group factor was significant (p = 0.0096), suggesting that the initial gloss values differed among brands. The NuSmile group exhibited the lowest gloss, while the ProfZr group had the highest. In a previous study comparing NuSmile, EZCrowns, and Kinder Krowns, gloss values measured for NuSmile crowns were consistent with those observed in the present study (GU ± SD: labial 42.7 ± 6.1, lingual 51.7 ± 7.5). Notably, NuSmile crowns showed the highest gloss in that study, contrary to the current findings [21]. NuSmile crowns are known to undergo mechanical polishing and manual surface flattening [21, 35], yet the relatively lower pre-brushing gloss observed in the current study may be attributed to the absence of a glaze layer. Similarly, the high initial gloss observed in the Kids Crown group may indicate the presence of a glaze-based surface coating, although this has not been confirmed by the manufacturer. No surface treatment information has been disclosed for the ProfZr Crown either, but the pre-brushing gloss findings suggest that a glaze-like coating may also have been applied. Interestingly, in some groups (*e.g.*, NuSmile and Kids Crown), a significant increase in surface roughness was observed without a corresponding statistically significant change in gloss. Although the gloss reduction was not statistically significant, a downward trend was observed across all groups. Notably, the Kids Crown group—which exhibited a significant increase in Ra—also demonstrated a broader gloss value range (from 50.3–56.3 to 43.9–56.2). Gloss changes of ~6.4 GU are barely perceptible, while those >35.7 GU are deemed clinically unacceptable

[36]. Therefore, the gloss changes observed in this study are likely not visually perceptible in a clinical context. Additionally, only the labial surfaces of the crowns were brushed in this study, which—given the translucent nature of zirconia—may have helped preserve optical properties.

Previous studies investigating zirconia finishing techniques have shown that glaze application can enhance translucency while reducing surface roughness [37, 38]. However, these studies did not assess the impact of external factors such as brushing. A recent study with brushing simulation found that although surface roughness may decrease after brushing, gloss can still decline due to abrasion of the glaze layer and exposure of the underlying matte surface [39], which is consistent with the present findings for the ProfZr group, where gloss reduction occurred despite stable Ra values. Another study found that brushing affects the surface texture of high-translucency zirconia but does not alter its optical properties [29]. However, these findings are mostly based on disc-shaped samples rather than PZCs. In contrast, the present study employed actual PZCs, and to ensure consistent and representative surface measurements, three different locations were measured on each crown, following a previously described method [27] (Fig. 1). This approach was chosen because static vertical forces during brushing may cause uneven abrasion by toothbrush bristles.

In this study, a single low-RDA toothpaste was used during the brushing simulation to standardize conditions and eliminate variability related to toothpaste abrasiveness. In a study focusing on PZCs, toothpastes with low RDA (0–70) values caused only minimal changes in surface roughness (ΔRa <0.05 μm) [26], which was attributed to the generally low abrasiveness of toothpastes formulated specifically for children. Notably, products with high RDA levels—typically above 100—may compromise the surface integrity of zirconia restorations [29]. Moreover, considering the structural differences of primary teeth and the unique dietary habits of children, pediatric toothpaste formulations are recommended to have lower abrasivity [40]. Therefore, the use of low-RDA toothpastes may be appropriate for pediatric patients to help preserve the long-term surface quality of zirconia crowns. Sensodyne Pronamel is known to have a low RDA in its adult version [41]. Notably, the children's version used in this study (Sensodyne Pronamel Kids, ages 3–5) has a confirmed low RDA—lower than the 35 reported for the adult version—as stated in the manufacturer's product information.

Nonetheless, the significant increase in surface roughness observed in the NuSmile and Kids Crown groups suggests that the oscillating-rotating electric toothbrush (Oral-B Vitality series, ~7600 oscillations and rotations per minute) may have contributed to greater abrasion. While similar powered brushing mechanisms have been used previously [29, 32, 42, 43], this is the first study specifically evaluating their effect on prefabricated pediatric zirconia crowns. In contrast, a comparable study employing the V8 manual brushing machine (Sabri Dental, Downers Grove, IL, USA) reported smaller surface changes [26], indicating potentially higher abrasiveness with powered toothbrushes. Further research is needed to clarify whether this difference arises solely from the brushing mechanism itself or other factors such as bristle properties, applied force, or brushing motion.

This study has certain limitations due to its *in vitro* design. Despite standardization, the brushing simulation does not reflect real-life intraoral factors such as saliva, plaque, or brushing technique. To minimize variability, a powered toothbrush was mounted in a fixed position and operated under a consistent vertical load throughout the simulation. However, even electric toothbrushes can be operated with inconsistent pressure, which may be more pronounced in pediatric patients due to limited motor skills, potentially affecting the surface integrity of restorations in different ways. In addition, only one type of toothpaste with a low RDA value and a 2D electric toothbrush (oscillation and rotation only) was used. Whether more advanced 3D brushes with pulsating motion would have different effects on zirconia surfaces should be evaluated in future studies. Furthermore, clinical research is needed to determine whether the observed surface changes affect performance or crown longevity under real-life conditions, especially considering the lubricating and buffering effects of saliva. Given the wide variability in brushing habits (*e.g.*, frequency and dominant hand used) and toothbrush types among children, future *in vivo* studies involving different age groups are essential to evaluate how developmental differences may impact the long-term success of PZCs. The lack of advanced surface analysis methods limits the microstructural interpretation of gloss and roughness changes, especially in light of the uncertainty regarding whether surface coatings such as glaze are present—an issue that remains unresolved due to limited manufacturers' transparency. Therefore, further studies using scanning electron microscopy (SEM) or atomic force microscopy (AFM) are warranted to confirm the surface characteristics of PZCs.

5. Conclusions

Considering the nature of this *in vitro* experiment, it can be concluded that the surface characteristics of prefabricated zirconia crowns may be influenced by the surface finishing techniques applied during the manufacturing process. Therefore, both esthetic and functional properties should be considered when selecting pediatric zirconia crowns. While direct clinical recommendations are limited, crowns that exhibited greater resistance to surface changes after brushing may be considered by clinicians when selecting prefabricated zirconia crowns for pediatric patients with high plaque accumulation risk or inadequate oral hygiene. Nonetheless, further clinical studies are necessary to confirm these results.

AVAILABILITY OF DATA AND MATERIALS

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

AUTHOR CONTRIBUTIONS

HC—designed the research study; analyzed the data. HC and EEÇ—performed the research; wrote the manuscript; read and approved the final version of the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable. This *in vitro* study did not involve human participants, human data, or human tissue.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

[1] Boing AF, Bastos JL, Peres KG, Antunes JLF, Peres MA. Social determinants of health and dental caries in Brazil: a systematic review of the literature between 1999 and 2010. Revista Brasileira de Epidemiologia. 2014; 17: 102–115.

[2] Donly KJ, Méndez MJC, Contreras CI, Liu JA. Prospective randomized clinical trial of primary molar crowns: 36-month results. American Journal of Dentistry. 2020; 33: 165–168.

[3] Taran PK, Kaya MS. A comparison of periodontal health in primary molars restored with prefabricated stainless steel and zirconia crowns. Pediatric Dentistry. 2018; 40: 334–339.

[4] Mathew MG, Samuel SR, Soni AJ, Roopa KB. Evaluation of adhesion of *Streptococcus mutans*, plaque accumulation on zirconia and stainless steel crowns, and surrounding gingival inflammation in primary molars: randomized controlled trial. Clinical Oral Investigations. 2020; 24: 3275–3280.

[5] Mathew MG, Roopa KB, Soni AJ, Khan MM, Kauser A. Evaluation of clinical success, parental and child satisfaction of stainless steel crowns and zirconia crowns in primary molars. Journal of Family Medicine and Primary Care. 2020; 9: 1418–1423.

[6] Akhlaghi N, Hajiahmadi M, Golbidi M. Attitudes of parents and children toward primary molars restoration with stainless steel crown. Contemporary Clinical Dentistry. 2017; 8: 421–426.

[7] Moslemi F, Yasaie AM, Shojaiepour R. Is the metallic color of stainless steel crown satisfying for cooperative children and their parents? A preliminary study. Journal of Dentistry. 2022; 23: 480.

[8] Rocha MCM, Inácio GC, Taira TM, Delgado RZR, Maciel SM, Frítola M. Zirconia crowns as an esthetic alternative for oral rehabilitation in pediatric dentistry: a review. Pediatric Dental Journal. 2021; 31: 224–234.

[9] Cerci BB, Roman LS, Guariza-Filho O, Camargo ES, Tanaka OM. Dental enamel roughness with different acid etching times: atomic force microscopy study. European Journal of General Dentistry. 2012; 1: 187–191.

[10] Bollenl CML, Lambrechts P, Quirynen M. Comparison of surface roughness of oral hard materials to the threshold surface roughness for bacterial plaque retention: a review of the literature. Dental Materials. 1997; 13: 258–269.

[11] Quirynen M, Bollen CML. The influence of surface roughness and surface-free energy on supra- and subgingival plaque formation in man: a review of the literature. Journal of Clinical Periodontology. 1995; 22: 1–14.

[12] Song F, Koo H, Ren D. Effects of material properties on bacterial adhesion and biofilm formation. Journal of Dental Research. 2015; 94: 1027–1034.

[13] Teughels W, Van Assche N, Sliepen I, Quirynen M. Effect of material characteristics and/or surface topography on biofilm development. Clinical Oral Implants Research. 2006; 17: 68–81.

[14] Janyavula S, Lawson N, Cakir D, Beck P, Ramp LC, Burgess JO. The wear of polished and glazed zirconia against enamel. The Journal of Prosthetic Dentistry. 2013; 109: 22–29.

[15] Kuivalainen K, Oksman A, Peiponen KE. Definition and measurement of statistical gloss parameters from curved objects. Applied Optics. 2010; 49: 5081–5086.

[16] Leloup FB, Pointer MR, Dutré P, Hanselaer P. Luminance-based specular gloss characterization. Journal of the Optical Society of America A. 2011; 28: 1322–1330.

[17] Juds S. Photoelectric sensors and controls: selection and application. 1st edn. CRC Press: Boca Raton. 1988.

[18] Heintze S, Forjanic M, Ohmiti K, Rousson V. Surface deterioration of dental materials after simulated toothbrushing in relation to brushing time and load. Dental Materials. 2010; 26: 306–319.

[19] Heintze SD, Forjanic M, Rousson V. Surface roughness and gloss of dental materials as a function of force and polishing time *in vitro*. Dental Materials. 2006; 22: 146–165.

[20] Vohra M, Pandurangan KK, Shenoy A, Keskar V. A comprehensive review of the surface and chromatic properties of monolithic zirconia: evaluating the impact of polishing and finishing methods on aesthetics and performance. Cureus. 2024; 16: e66029.

[21] Theriot AL, Frey GN, Ontiveros JC, Badger G. Gloss and surface roughness of anterior pediatric zirconia crowns. Journal of Dentistry for Children. 2017; 84: 115–119.

[22] Pate JD, Wells MH, Morrow BR, Ragain JC, Garcia-Godoy F. Color stability of prefabricated pediatric zirconia crowns following sterilization. Pediatric Dentistry. 2021; 43: 50–56.

[23] Bativala F, Weiner S, Berendsen P, Vincent GR, Ianzano J, Harris III WT. The microscopic appearance and effect of toothbrushing on extrinsically stained metal-ceramic restorations. The Journal of Prosthetic Dentistry. 1987; 57: 47–52.

[24] Yuan JC-C, Barão VAR, Wee AG, Alfaro MF, Afshari FS, Sukotjo C. Effect of brushing and thermocycling on the shade and surface roughness of CAD-CAM ceramic restorations. The Journal of Prosthetic Dentistry. 2018; 119: 1000–1006.

[25] Turssi CP, De Magalhaes CS, Serra MC, Rodrigues AL. Surface roughness assessment of resin-based materials during brushing preceded by pH-cycling simulations. Operative Dentistry. 2001; 26: 576–584.

[26] Shin BW, Donaldson M, Morrow BR, Ragain JC, Garcia-Godoy F. Surface roughness of prefabricated pediatric zirconia crowns following simulated toothbrushing. Pediatric Dentistry. 2022; 44: 363–367.

[27] Yilmaz N, Avci G, Ozkaya S, Tüzüner T, Baygin O. Comparison of the abrasive effects of children's toothpaste on glass ionomer cement. Pediatric Dental Journal. 2021; 31: 145–151.

[28] Pinto P, Carvalho A, Silva FS, Gomes JR, Carvalho O, Madeira S. Comparative toothbrush abrasion resistance and surface analysis of different dental restorative materials. Tribology International. 2022; 175: 107799.

[29] Lee JH, Kim SH, Han JS, Yeo ISL, Yoon HI. Optical and surface properties of monolithic zirconia after simulated toothbrushing. Materials. 2019; 12: 1158.

[30] Law V, Levy LC, Morrow BR, Garcia-Godoy F. Effect of whitening dentifrices on toothbrush abrasion on composites. American Journal of Dentistry. 2022; 35: 161–164.

[31] Roselino L de MR, Chinelatti MA, Alandia-Román CC, Pires-de-Souza F de CP. Effect of brushing time and dentifrice abrasiveness on color change and surface roughness of resin composites. Brazilian Dental Journal. 2015; 26: 507–513.

[32] Nogués L, Martinez-Gomis J, Molina C, Peraire M, Salsench J, Sevilla P, *et al*. Dental casting alloys behaviour during power toothbrushing with toothpastes with various abrasivities. Part I: wear behavior. Journal of Materials Science: Materials in Medicine. 2008; 19: 3041–3048.

[33] Hooper S, West NX, Pickles MJ, Joiner A, Newcombe RG, Addy M. Investigation of erosion and abrasion on enamel and dentine: a model *in situ* using toothpastes of different abrasivity. Journal of Clinical Periodontology. 2003; 30: 802–808.

[34] Sztyler K, Pajączkowska M, Nowicka J, Rusak A, Chodaczek G, Dubniański Ł, *et al*. Assessment of the physico-chemical, microbial, and cytotoxic characteristics of zirconia crowns utilized in pediatric dentistry. Applied Sciences. 2025; 15: 5444.

[35] Walia T, Brigi C, KhirAllah ARMM. Comparative evaluation of surface roughness of posterior primary zirconia crowns. European Archives of Paediatric Dentistry. 2019; 20: 33–40.

[36] Rocha RS, Fagundes TC, Caneppele TMF, Bresciani E. Perceptibility and acceptability of surface gloss variations in dentistry. Operative Dentistry. 2020; 45: 134–142.

[37] Ali MA, Nabil O, Elnaggar GAE. Surface roughness and translucency of glazed versus polished cubic ultra-translucent multi-layered zirconia: an *in-vitro* study. International Journal of Applied Dental Sciences. 2023; 9: 43–53.

[38] Manziuc M, Gasparik C, Burde AV, Colosi HA, Negucioiu M, Dudea D. Effect of glazing on translucency, color, and surface roughness of monolithic zirconia materials. Journal of Esthetic and Restorative Dentistry. 2019; 31: 478–485.

[39] Sahadi BO, Domingues BC, Soto-Montero J, de Araújo Neto VG, Riquieri H, Giannini M. Effect of toothbrushing on surface roughness, gloss, and topography of polished and glazed ultra-translucent zirconia. Journal of Prosthodontics. 2024; 33: 103–109.

[40] Stovell AG, Newton BM, Lynch RJM. Important considerations in the development of toothpaste formulations for children. International Dental Journal. 2013; 63: 57–63.

[41] Dzakovich JJ, Oslak RR. *In vitro* effects of acid challenge on incisal/occlusal cupping/cratering. The Journal of Prosthetic Dentistry. 2017; 117: 124–131.

[42] Klonowicz D, Czerwinska M, Sirvent A, Gatignol JP. A new tooth brushing approach supported by an innovative hybrid toothbrush-compared reduction of dental plaque after a single use versus an oscillating-rotating powered toothbrush. BMC Oral Health. 2018; 18: 1–9.

[43] Ccahuana-Vasquez RA, Adam R, Conde E, Grender JM, Cunningham P, Goyal CR, *et al*. A 5-week randomized clinical evaluation of a novel electric toothbrush head with regular and tapered bristles versus a manual toothbrush for reduction of gingivitis and plaque. International Journal of Dental Hygiene. 2019; 17: 153–160.

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