Invitro Assessment Of Occlusal Wear of Primary Posterior Esthetic Crowns After Artificial Aging

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**Abstract:** Wear resistance is a key determinant of the longevity and performance of primary posterior esthetic crowns in pediatric dentistry. While crowns with high wear resistance ensure durability, they may contribute to wear of opposing primary natural teeth. This study evaluated the occlusal wear of four crown types—resin, zirconia, Edelweiss, and PMMA—following simulated aging to identify materials best suited for functional and aesthetic demands.An in-vitro study simulated a 1-year aging cycle using a chewing simulator. Experimental crowns were subjected to cyclic mechanical loading and thermal cycling to replicate oral conditions. Occlusal surface changes were analyzed pre- and post-aging using MEDIT T300 3D scanning. Data were statistically evaluated using Shapiro-Wilk normality testing, ANOVA for intergroup comparisons, repeated measures ANOVA for intragroup analysis, and Tukey’s post-hoc test to identify significant differences.Significant variability in wear resistance was observed among crown types (p < 0.05). PMMA crowns demonstrated the greatest wear, with marked reduction in occlusal surface height. Edelweiss crowns exhibited moderate wear, performing better than PMMA but inferior to resin and zirconia crowns. Resin crowns showed high wear resistance with minimal changes, while zirconia crowns exhibited the highest wear resistance.Zirconia crowns demonstrated superior wear resistance, making them durable options for primary posterior restorations. However, their hardness raises concerns about potential wear on opposing natural teeth. Resin crowns provided an optimal balance of durability and aesthetics with reduced abrasiveness, while Edelweiss crowns offered moderate wear resistance. PMMA crowns were the least durable but minimally abrasive. Material selection should balance crown longevity with preservation of opposing natural dentition to optimize clinical outcomes in pediatric dentistry.

**Keywords:** chewing simulator, artificial aging, esthetic crowns, resin crowns, zirconia crowns, PMMA crowns, Edelweiss crowns.

# INTRODUCTION

In pediatric dentistry, the restoration of primary posterior teeth with esthetic crowns is essential for maintaining oral health and promoting proper dental development in children.[(Marwah, 2018)](https://paperpile.com/c/bvK6n7/hWSp)The material used for restoring these teeth significantly influences both functional performance and esthetic outcomes.[(Leal & Takeshita, 2018)](https://paperpile.com/c/bvK6n7/NkKF)As parental expectations for esthetic restorations grow, various crown materials have emerged to address the dual need for functionality and appearance.[(Suresh & Gunasekaran, 2024)](https://paperpile.com/c/bvK6n7/nFpI)Among the commonly used materials, resin crowns are valued for their excellent esthetic properties, allowing for seamless color matching with natural teeth[(Suresh & Gunasekaran, 2024)](https://paperpile.com/c/bvK6n7/nFpI). However, their lower mechanical strength makes them susceptible to wear in high-stress areas(Rafi et al., 2024). For several reasons, strength and wear resistance, and biocompatibility-there's been wide acceptance for zirconia crowns as the restoration of choice for the posterior teeth exposed to a significant amount of masticatory load (Tuluwengjiang et al., 2024). On the other hand, Edelweiss crowns: being obtained from a resin-based composite with increased endurance, offers the best compromise between aesthetics and mechanical performance; whereas the PMMA crowns are an alternative considered cost-effective but lack the wearing defensive action so requisite for predictable serviceability[(Hosoya et al., 2002)](https://paperpile.com/c/bvK6n7/Dl0L). Each of these materials has distinct advantages and limitations, necessitating careful consideration of factors such as the patient’s age, oral habits, and esthetic requirements during material selection.[(Babaji, 2015)](https://paperpile.com/c/bvK6n7/tweb)[(Janani et al., 2021; Kachhara et al., 2021; Subramanian et al., 2023)](https://paperpile.com/c/bvK6n7/6grzK+6dNmk+YyaF5)Wear resistance is a critical factor influencing the longevity and functionality of pediatric crowns, especially for primary molars that endure significant occlusal forces.[(Lei et al., 2024)](https://paperpile.com/c/bvK6n7/eERT)[(Chokkattu et al., 2023; Dharman et al., 2023; Govindaraj & Shanmugam, 2023)](https://paperpile.com/c/bvK6n7/eLVi+YESp+FB4k).Excessive wear can compromise the crown’s structural integrity and diminish its esthetic appeal, while also impacting the opposing dentition in cases where harder materials are used.[(M. V. Singh et al., 2024)](https://paperpile.com/c/bvK6n7/ZnC4)[(Ramsundar et al., 2023; Rieshy et al., 2023; S. Singh et al., 2023)](https://paperpile.com/c/bvK6n7/Y8hP+Jk3h+I8Fu) Thus, understanding the wear behavior of different crown materials under simulated oral conditions is essential for ensuring optimal clinical outcomes.[(Aktaş & Bankoğlu Güngör, 2024)](https://paperpile.com/c/bvK6n7/bFC5)[(Gandhi et al., 2021; Katyal et al., 2023; Priyadharshini et al., 2023)](https://paperpile.com/c/bvK6n7/y9YB+ZC6W+nwYt).Chewing simulators are widely used in dental research to replicate the functional and environmental stresses experienced in the oral cavity.[(Rupawat et al., 2023)](https://paperpile.com/c/bvK6n7/t7XP)[(Pavithra et al., 2023; Shenoy et al., 2023; Thomas & Jain, 2023)](https://paperpile.com/c/bvK6n7/LT50+UEHu+ELBh) These devices subject crown materials to cyclic mechanical loadi[(Pavithra et al., 2023; Shenoy et al., 2023; Thomas & Jain, 2023)](https://paperpile.com/c/bvK6n7/LT50+UEHu+ELBh)ng and thermal cycling, mimicking the forces of mastication and temperature fluctuations encountered during regular eating and drinking.[(Rupawat et al., 2023)](https://paperpile.com/c/bvK6n7/t7XP)[(Rajeshkumar & Lakshmi, 2021; Sivakumar et al., 2021)](https://paperpile.com/c/bvK6n7/kjBf+8BnB). By accelerating the aging process, chewing simulators enable researchers to evaluate the long-term performance of restorative materials in a relatively short period, offering valuable insights into their wear resistance and durability.[(Atalay Seçkiner et al., 2024; Monteiro et al., 2025)](https://paperpile.com/c/bvK6n7/gKm6+vash)[(Doshi et al., 2023; Lampl et al., 2023; Pandiyan et al., 2023)](https://paperpile.com/c/bvK6n7/RLGC+GL6W+sNCF)This study aims to assess the occlusal wear of four crown t[(Doshi et al., 2023; Lampl et al., 2023; Pandiyan et al., 2023)](https://paperpile.com/c/bvK6n7/RLGC+GL6W+sNCF)ypes—resin, zirconia, Edelweiss, and PMMA—following a 1-year simulated aging cycle in a chewing simulator. The findings will provide critical evidence to guide material selection for primary posterior teeth, balancing the demands of durability, esthetics, and preservation of opposing natural teeth.

# METHODOLOGY

## Study Design

The current study was a prospective observational study. The study design was approved by the Institutional Scientific and ethical review board before the commencement of the study.

## Sample Size Calculation

The sample size was calculated using G Power version 3.1.9.2 software which arrived at a power of 0.95. The current study proceeded with a sample size of 5 per group making a total sample of 20. The 20 samples were distributed into four groups as follows: Group A - 3D printable photopolymer resin crowns (n=5), Group B- zirconia crowns (n=5), and Group C- edelweiss crowns (n=5). Group D - PMMA crowns (n=5).

## Sample Preparation

Twenty Positive replicas of the primary posterior teeth were obtained using Interacrylic Ortho Resin from rubber moulds and were allowed to be set for 24 hours. A total of 20 crown replicas were then randomized into four groups with five crowns in each group. Tooth preparation was done depending on the groups.

## Zirconia Crown- tooth preparation

Occlusal surface reduction of 1.5 to 2 mm was done with a rough, long-tapered diamond bur, followed by circumferential reduction (15-20%) and a complete subgingival feather-edged reduction (~1.5 mm deep).[(Alrashdi, 2024)](https://paperpile.com/c/bvK6n7/8T3A)

## Resin, Edelweiss, and PMMA Crowns- tooth preparation

Buccal, lingual, mesial, and distal walls were reduced by 0.8 to 1.0 mm using a diamond round-end taper bur. A convergence angle of 6 degrees was created with a wheel no. 909 bur, followed by chamfer margin preparation and occlusal reduction of 1.0 to 1.5 mm. A composite finishing bur was used to remove undercuts in the prepared teeth.[(Al-Halabi et al., 2022)](https://paperpile.com/c/bvK6n7/HmqT)

## Crown Fabrication

Digital scanning of all prepared samples was performed using EXOCAD version 3.0 software for standardization. Crowns were designed as full coronal restorations and fabricated according to group specifications: (Figure 1)

* **Group A**: Biocompatible photopolymer resin crowns (3D printed using a DLP dental printer)
* **Group B**: Zirconia preformed crowns
* **Group C**: Edelweiss preformed crowns
* **Group D**: Ceramill Temp PMMA crowns (milled using CAD/CAM)

The fabricated and preformed crowns were trial-fitted for a passive fit and luted using glass ionomer cement, as per manufacturer instructions. The die-crown units were allowed to set for 24 hours before testing.

## Wear Simulation and Measurement

The crowns were subjected to a 1-year simulated aging cycle with corresponding non carious natural teeth as antagonist, using chewing simulator (CS-4.4\*m, SD Mechatronik,Germany).[(Abhay et al., 2021)](https://paperpile.com/c/bvK6n7/mcmd) (Figure 2) This included 120,000 chewing cycles using a dual-axis chewing simulator under a 50 N masticatory force, with continuous replenishment of artificial saliva. Initial and final occlusal surface heights were recorded using the MEDIT T300 3D scanner to assess the crown wear.[(Abduo & Palamara, 2021)](https://paperpile.com/c/bvK6n7/1GL4)(Figure 3)

# Statistical Analysis

Data normality was tested using the Shapiro-Wilk test. Intergroup comparisons of wear were analyzed using one-way ANOVA, and intragroup comparisons were evaluated using repeated measures ANOVA. Tukey’s post-hoc test identified significant differences. A significance level of p < 0.05 was set, and all statistical tests were conducted using SPSS software (Version 26, IBM, USA).

# Results

The occlusal wear of crown materials was evaluated before and after a 1-year simulated chewing cycle, revealing significant differences in wear resistance across the four groups (Figure 4). Zirconia crowns exhibited the highest durability with minimal wear reduction (197.53 ± 12.56 μm to 196.46 ± 11.74 μm, p = 0.010), while PMMA crowns showed the lowest resistance, with the greatest wear decrease (420.28 ± 22.34 μm to 388.82 ± 21.76 μm, p = 0.001). Edelweiss crowns demonstrated moderate wear resistance, reducing from 238.58 ± 13.56 μm to 225.14 ± 14.32 μm (p = 0.015), slightly outperforming Resin crowns, which decreased from 263.10 ± 15.85 μm to 257.72 ± 14.96 μm (p = 0.005). (Table 1). Inter-group comparison using one-way ANOVA (F = 18.42, p < 0.001) confirmed that Zirconia crowns significantly outperformed Resin, Edelweiss, and PMMA crowns, while PMMA crowns were the least resistant. These findings highlight the superior performance of Zirconia crowns, the moderate resistance of Edelweiss and Resin crowns, and the limited durability of PMMA crowns, emphasizing the importance of material selection based on clinical needs and patient-specific factors.

**Table 1**: Wear Analysis of Different Crown Types (\*significant, \*\* highly significant, \*\*\* very highly significant)

|  |  |  |  |
| --- | --- | --- | --- |
| Crown Type | Pre-Simulation Wear (μm) | Post-Simulation Wear (μm) | p-value |
| Group-1 Resin Crowns | 263.10 ± 15.85 | 257.72 ± 14.96 | 0.005\* |
| Group-2 Zirconia Crowns | 197.53 ± 12.56 | 196.46 ± 11.74 | 0.010\*\* |
| Group-3 Edelweiss Crowns | 238.58 ± 13.56 | 225.14 ± 14.32 | 0.015\*\* |
| Group-4 PMMA Crowns | 420.28 ± 22.34 | 388.82 ± 21.76 | 0.001\*\*\* |

# Discussion

This study evaluated the occlusal wear resistance of four esthetic crown materials—Zirconia, Edelweiss, Resin, and PMMA—using a chewing simulator replicating a one-year mastication cycle. The methodology, combining mechanical loading and thermal cycling, simulated the intraoral environment effectively and provided a controlled platform to analyze wear patterns in pediatric crowns. Similar methodologies have been used in studies focusing on primary teeth, such as Ram et al. (2014) which highlighted the unique biomechanical properties of primary teeth compared to permanent teeth, including their softer enamel and dentin structure.[(Fuks et al., 1999)](https://paperpile.com/c/bvK6n7/kjM1) Zirconia crowns exhibited the least wear, aligning with findings from Walia et al. (2016), which demonstrated the exceptional durability of Zirconia crowns in pediatric patients.[(Walia et al., 2014)](https://paperpile.com/c/bvK6n7/WQXN)However, low crown wear can result in increased wear on opposing primary teeth, as reported by Bansal et al. (2020). The combination of Zirconia’s high hardness and primary enamel's relatively low hardness can lead to accelerated enamel loss, a critical consideration in young patients where tooth preservation is vital.[(Agrawal et al., 2022)](https://paperpile.com/c/bvK6n7/QP94)Edelweiss crowns, a composite material reinforced with glass fillers, showed moderate wear resistance. This is consistent with studies, which found that composite materials are less abrasive to primary enamel than ceramic materials. Edelweiss crowns thus offer a balanced option, combining aesthetics with reduced risk of damaging opposing teeth, making them suitable for primary dentition.[(Bömicke et al., 2024)](https://paperpile.com/c/bvK6n7/Wv1z) Resin crowns exhibited higher wear than Zirconia and Edelweiss crowns but less abrasiveness, protecting opposing enamel. These results are in line with studies by prabhu et al. (2022), which reported that resin-based crowns in primary teeth demonstrated acceptable wear resistance in low-stress areas. While esthetically pleasing, their reduced mechanical strength limits their application in posterior regions where functional forces are higher.[(Prabhu et al., 2022)](https://paperpile.com/c/bvK6n7/1Tuy) PMMA crowns displayed the highest wear, reflecting their limited mechanical strength. This finding is supported by Mete et al. (2019), who reported that PMMA crowns for primary teeth degrade rapidly under mechanical stress, limiting their clinical lifespan. While their cost-effectiveness and ease of fabrication make them appealing, their wear properties restrict their use to temporary or low-load areas in primary dentition.[(Mete et al., 2018)](https://paperpile.com/c/bvK6n7/6yy9)The use of a chewing simulator in this study replicates the dynamic oral environment, accelerating the aging process and providing valuable insights into wear behavior specific to pediatric crowns. Studies focusing exclusively on primary teeth, have emphasized the importance of selecting materials that balance crown durability with the preservation of the softer primary enamel.[(Nihan et al., 2023)](https://paperpile.com/c/bvK6n7/G4Kr)

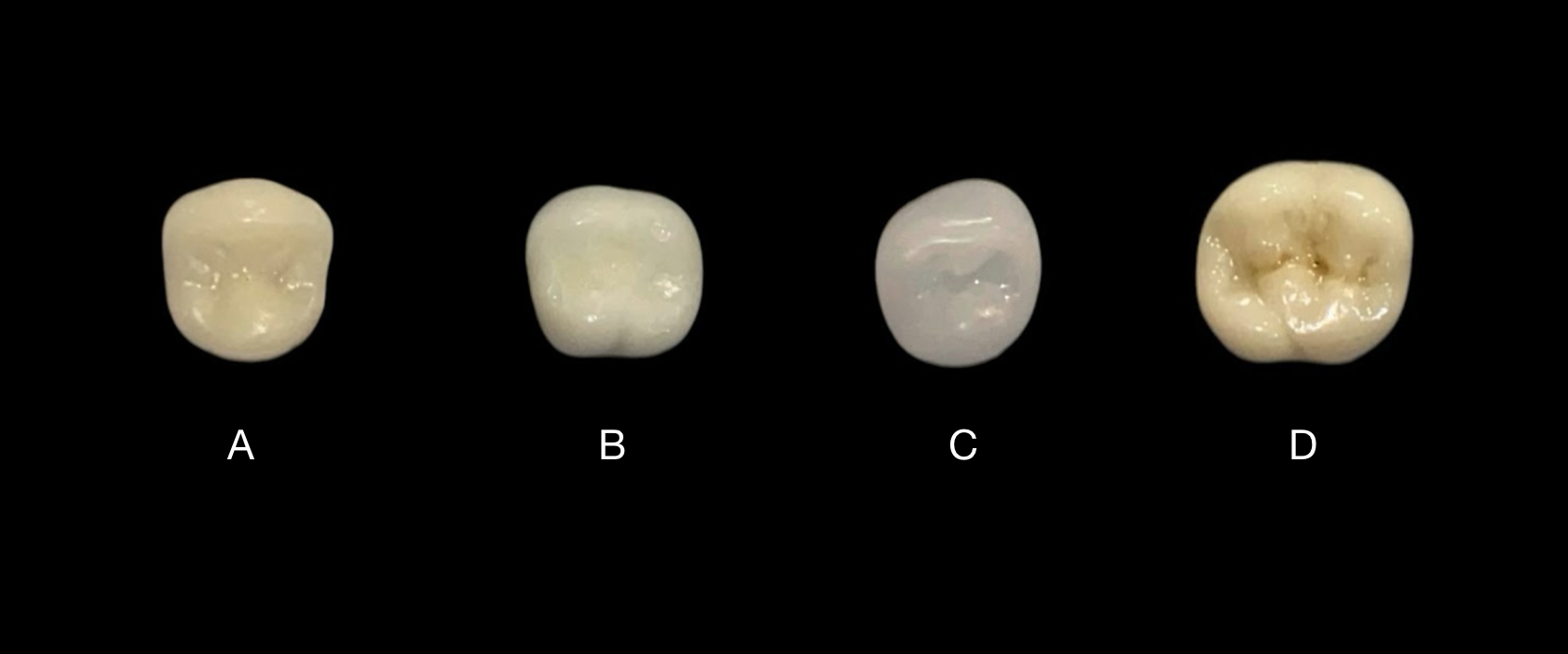
## Clinical Significance

Material selection for pediatric crowns must consider both crown wear resistance and the preservation of opposing primary teeth. Zirconia crowns, despite their durability, may accelerate enamel wear on opposing teeth and are best suited for posterior restorations in high-load areas. Edelweiss crowns provide a balance between moderate wear resistance and enamel preservation, making them suitable for anterior or moderate-load regions. Resin crowns offer esthetic benefits with lower abrasiveness, ideal for anterior teeth or low-stress regions. PMMA crowns, with their high wear, are best reserved for temporary or low-load applications.

# Conclusion

This study evaluated crown wear specific to primary teeth under simulated conditions, highlighting significant differences among materials. Zirconia crowns showed the highest wear resistance, ideal for high-stress areas but potentially abrasive to primary enamel. Edelweiss crowns offered a balance between aesthetics, durability, and enamel preservation, making them versatile for moderate-load restorations. Resin crowns demonstrated acceptable wear resistance with reduced abrasiveness, suitable for anterior or low-stress regions. PMMA crowns, with their rapid wear, are appropriate for temporary use. These findings emphasize the importance of selecting crown materials that align with the unique clinical needs of primary dentition.

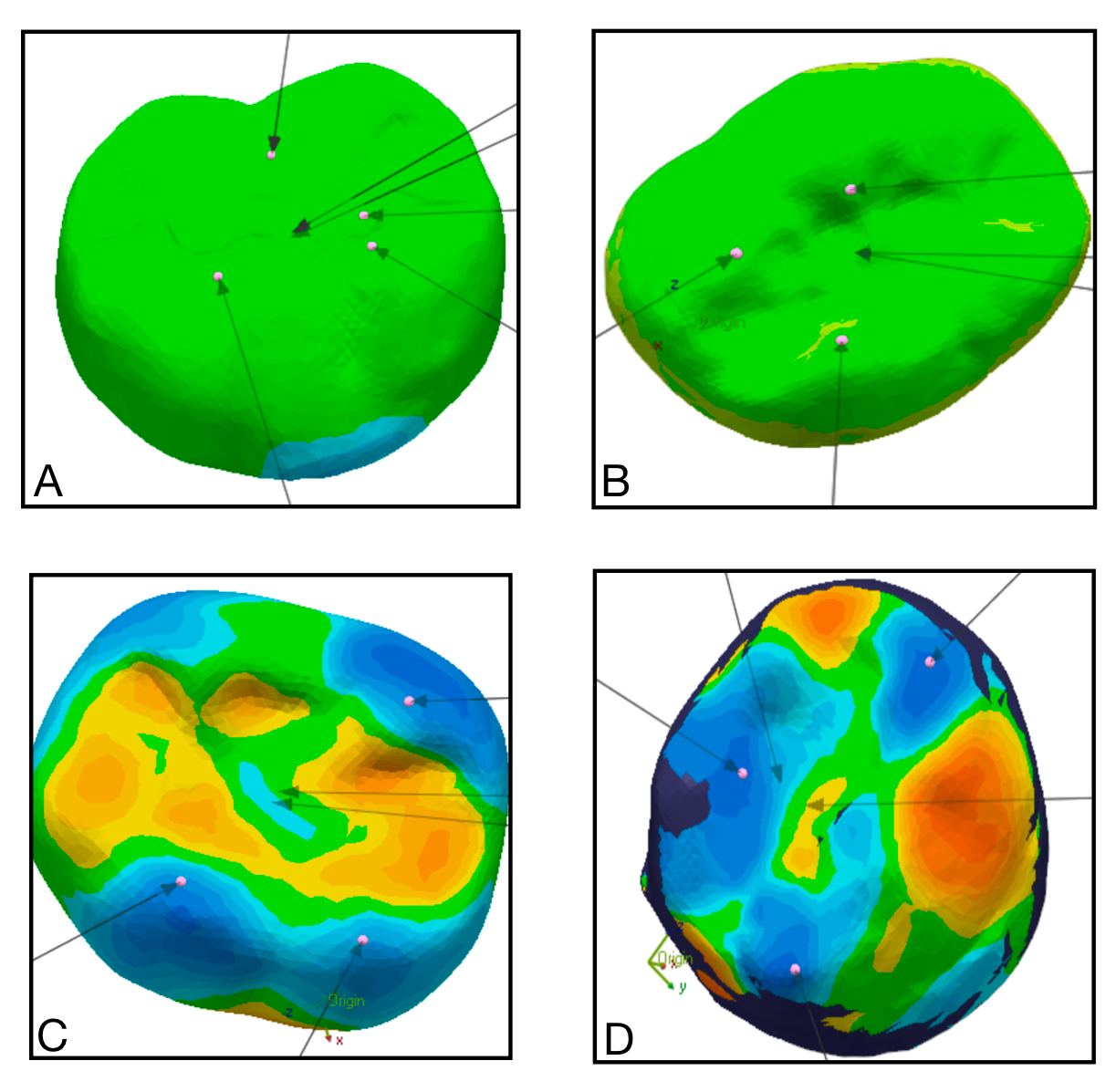
# FIGURES



**Figure 1:** Experimental crowns; **A**: Biocompatible photopolymer resin crown; **B**: Zirconia preformed crown; **C**: Edelweiss preformed crown; **D**: Ceramill Temp PMMA crown

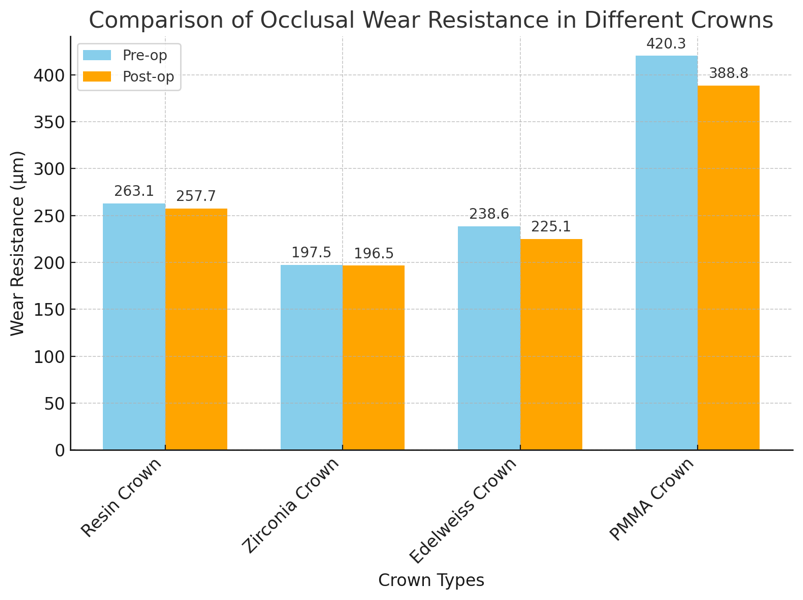


**Figure 2:** Samples subjected to chewing simulation



**Figure 3:** Superimposition of Pre and Post artificial aging using 3D systems;

**A**: Photopolymer resin crown; **B**: Zirconia preformed crown; **C**: Edelweiss preformed crown; **D**: Ceramill Temp PMMA crown



**Figure 4:** Comparison of occlusal wear in different crowns

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