Comparative Evaluation of Occlusal Wear of Aesthetic Crowns in Primary Teeth- In-Vitro Study

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**Abstract:** Occlusal wear resistance is a key factor in determining the longevity and clinical performance of esthetic crowns in pediatric dentistry. While high wear resistance ensures crown durability, it may also contribute to wear of opposing natural teeth.To evaluate and compare the occlusal wear resistance of four types of crowns—resin, zirconia, Edelweiss, and stainless steel crowns (SSC)—in primary teeth under simulated aging conditions.An in vitro study was conducted using a chewing simulator to mimic one year of clinical function through cyclic mechanical loading and thermocycling. Pre- and post-aging occlusal surface changes were analyzed using the MEDIT T300 3D scanner. Data were statistically analyzed using ANOVA, repeated measures ANOVA, Shapiro-Wilk test, and Tukey's post-hoc test.Significant differences were observed among the crown types (p < 0.05). Zirconia crowns exhibited the highest wear resistance, followed by Edelweiss crowns. SSCs demonstrated the greatest occlusal wear.Zirconia crowns offer superior wear resistance but may pose a risk of wear to opposing teeth due to their hardness. Resin crowns showed a favorable balance between durability and minimal abrasiveness, making them a viable esthetic option for pediatric posterior restorations.

**keywords:** Zirconia Crown- tooth preparation, Edelweiss, and SSC Crowns- tooth preparation, Crown Fabrication

# INTRODUCTION

Pediatric dentistry is based on preservation of primary teeth because they guide the eruption of permanent teeth and help maintain space to enable the development of the child's oral functions like mastication, speech, and aesthetics.[(Duggal et al., 2021)](https://paperpile.com/c/jyXT3v/UJcE) Damage to these primary teeth or their loss causes complications, such as malocclusion or loss of space with eruption of the permanent teeth, which may adversely affect the self-esteem of a child on aesthetic grounds.[(Tiplady & Karia, 2024)](https://paperpile.com/c/jyXT3v/hFkO) Thus, primary tooth restorations need to be not only durable but also aesthetic to meet functional and psychological needs[(Ajay et al., 2023; Chokkattu et al., 2023; Padarthi et al., 2023)](https://paperpile.com/c/jyXT3v/34UQG+2oz2Z+xFT78)Traditionally, gold was the standard for restorative interventions in primary molars: SSCs excelled in durability and longevity.[(Soxman, 2016)](https://paperpile.com/c/jyXT3v/IIH4) Their most robust performance made SSCs one of the most preferred strategies of restoration; however, the generation of natural tooth-like appearance is not possible with SSCs.[(Babaji, 2015)](https://paperpile.com/c/jyXT3v/EPZ9) Thus, it generated a growing, dissatisfied set of patients and parents and invited the development and growing demand for aesthetic restorative materials for the pediatric patient[(Dharman et al., 2023; S. Sindhu et al., 2023; Sreenivasagan et al., 2023)](https://paperpile.com/c/jyXT3v/dYwet+Q37in+ezDIC)The Crown aesthetics of primary dentition have changed from composite resin, strip crowns, pre-veneered crowns, and most recently into prefabricated zirconia and composite-based crowns with Edelweiss crowns within the last few decades[(Ramakrishnan et al., 2023; Shenoy & Maiti, 2023; J. S. Sindhu et al., 2023)](https://paperpile.com/c/jyXT3v/H01ro+7Jrmq+sin6t). Although crowns do not intrinsically provide advantages in aesthetics due to the necessity in sacrificing aesthetics for function, these crowns do boast a fortuitous dualism towards strength as well as more life-like and realistic aesthetics when compared to the counterparts, conferring durability, and being able to withstand the masticatory forces a pediatric patient can exert, though desirability towards more aesthetic offerings has raised questions about the longevity or wear resistance of such a solution.[(Cameron & Widmer, 2013)](https://paperpile.com/c/jyXT3v/920h) Occlusal wear is considered to be among the most critical factors affecting the success of any restorative material, especially within the dynamic setting of a child's mouth, where restorations may be subjected to masticatory forces, grinding, and parafunctional habits[(Kasabwala et al., 2021; Rajeshkumar & Lakshmi, 2021; Varghese et al., 2023)](https://paperpile.com/c/jyXT3v/LZC7W+0OvlH+Zlmq5). Excessive wear can lead to diminished vertical dimension, compromised occlusal function, sensitivity, and even failure. Therefore, it is great importance that research is done with regard to how different crowns cope with occlusal forces as they age over time.[(Pinkham & Casamassimo, 1999)](https://paperpile.com/c/jyXT3v/XOSK)Zirconia crowns are amongst the latest aesthetic crown options and have now become one of the most preferred crowns because they exhibit excellent strength and biocompatibility, besides achieving extremely good esthetic outcomes[(Keerthana & Ramesh, 2021; Murugesan, 2021; Tiwari & Jain, 2021)](https://paperpile.com/c/jyXT3v/jIdeN+PLD7a+sg4r2)[(Keerthana & Ramesh, 2021; Murugesan, 2021; Subramanian et al., 2021; Tiwari & Jain, 2021)](https://paperpile.com/c/jyXT3v/jIdeN+PLD7a+sg4r2+gwNM9). High-strength zirconium dioxide is integrated and manufactured into crowns since they have very good fracture and wear resistant properties, thus giving these crowns their form.[(Leal & Takeshita, 2018)](https://paperpile.com/c/jyXT3v/rrZ1) They offer an excellent reason for having a tooth-colored restoration, which can very well integrate with the natural dentition-an aspect that makes them appealing in pediatric patients where aesthetics become an issue. Studies have reported that zirconia crowns possess good mechanical strength, but their wear resistance compared with other crowns placed in primary teeth has not been studied sufficiently.[(Lopez Cazaux et al., 2017)](https://paperpile.com/c/jyXT3v/kYvT)Zirconia crowns are the latest addition to aesthetic crown forms, with unmatched incorporation as crowns in demand, their advantageous strength, biocompatibility, and really good esthetic results[(G. & Ganapathy, 2022; Kumar & Ramesh, 2021)](https://paperpile.com/c/jyXT3v/KMMOi+ENkFk)). The crowns are made from high-strength zirconium dioxide, which resists fracture and wear. These crowns can provide a tooth-colored restoration so well integrated into the natural dentition as to be very attractive in children, where the aesthetics will be the point of concern.[(Alrashdi, 2024)](https://paperpile.com/c/jyXT3v/iAjEe) Studies show that zirconia crowns manifest good mechanical properties; however, little research has been done in comparison between the wear resistance of zirconia crowns and other crowns for primary teeth.[(Vishnu & Jeevanandan, 2024)](https://paperpile.com/c/jyXT3v/jE8v)The Edelweiss crown is another recent entrant among prefabricated fiber-reinforced crowns that aims to have its territory as a heavy, aesthetic-looking restorative alternative for the long term [(Pranati et al., 2021; Sakthi et al., 2021)](https://paperpile.com/c/jyXT3v/fXvG3+oN4EJ). It has entered as real-tooth replication with great hardness and bonding capabilities; however, being fiber reinforced based on composite, its resistance to long-term wear as compared to zirconia is yet to be resolved.[(Clark et al., 2016)](https://paperpile.com/c/jyXT3v/p5SI)Natural teeth are generally considered to create a gold standard for occlusal wear comparisons, just because they are, for the most part, the natural baseline by which to evaluate restorative materials. Of course, enamel confers some degree of resistance to wear, but primary teeth are, by their nature, softer than permanent dentitions and are more susceptible to wear. An understanding of how these restorative crowns compare against the wear of natural teeth holds important implications for clinical viability.[(Vishnu & Jeevanandan, 2024)](https://paperpile.com/c/jyXT3v/jE8v)Because of the important long-term service in primary teeth represented by the wear resistance of the restoration, a significant amount of work is needed to compare and assess wear characteristics under occlusal load for different aesthetic crowns.[(Abhay et al., 2021)](https://paperpile.com/c/jyXT3v/gqGE) While zirconia crowns have excellent aesthetics with superior strength, their wear performance within the pediatric population is yet to be evaluated. Similar to it, even though the Edelweiss crown may be relatively aesthetically more pleasing, much more will be done in obtaining the necessary information on how these crowns perform in harsh environments such as that of the child's oral cavity.

# MATERIALS AND METHOD

## 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 - natural teeth (n=5), Group B- zirconia crowns (n=5), and Group C- edelweiss crowns (n=5). Group D - stainless steel crowns (n=5).

## Sample Preparation

Twenty Positive replicas of the primary posterior teeth were obtained using Inter Acrylic 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/jyXT3v/iAjEe)

## Edelweiss, and SSC 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

## 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: Natural teeth
* Group B: Zirconia preformed crowns
* Group C: Edelweiss preformed crowns
* Group D: Stainless steel crowns

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/jyXT3v/gqGE) (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(Saadh et al., 2024). 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/jyXT3v/EfL9y)(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 (Almatrafi et al., 2024).. 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

## Natural Teeth (Group 1)

Minimal changes were observed in both upper and lower natural teeth. Pre-simulation wear for the upper teeth was 179.20 μm, which slightly decreased to 179.02 μm post-simulation. For the lower teeth, pre- and post-simulation wear values were 126.12 μm and 123.30 μm, respectively. A statistically significant difference was found only in the lower teeth (p = 0.001), suggesting increased susceptibility to occlusal wear due to load distribution patterns.

## Zirconia Crowns (Group 2)

Zirconia crowns exhibited high pre-simulation wear values (upper: 251.48 μm; lower: 187.44 μm), with minimal changes post-simulation (upper: 251.83 μm; lower: 186.22 μm). The reduction in wear for lower crowns was statistically significant (p = 0.001), indicating zirconia’s superior wear resistance under functional loading, particularly in the lower arch.

## Edelweiss Crowns (Group 3)

Moderate wear values were observed in Edelweiss crowns. Pre-simulation wear measured 238.58 ± 13.56 μm (upper) and 217.65 μm (lower), while post-simulation values were 225.14 ± 14.32 μm and 219.21 μm, respectively. A significant reduction in wear was noted in the upper crowns (p = 0.001), whereas the change in the lower crowns was not statistically significant (p = 0.4), suggesting stable wear behavior and clinical applicability.

## Stainless Steel Crowns (SSC) (Group 4)

SSCs demonstrated the highest wear among all groups. Upper crowns showed a significant reduction from 420.28 ± 22.34 μm to 388.82 ± 21.76 μm post-simulation (p = 0.001). In contrast, the lower crowns showed negligible change (125.06 μm to 125.14 μm), which was not statistically significant. These results reflect SSCs' high initial wear yet sustained performance under functional load, supporting their continued use in high-stress pediatric cases.Across all groups, significant inter-group differences in wear behavior were observed. Natural lower teeth and zirconia lower crowns showed statistically significant wear reduction, emphasizing occlusal load sensitivity in the lower arch. Edelweiss crowns exhibited favorable wear patterns in the upper arch, while SSCs showed significant wear reduction only in upper crowns, affirming their structural durability despite aesthetic limitations.

# DISCUSSION

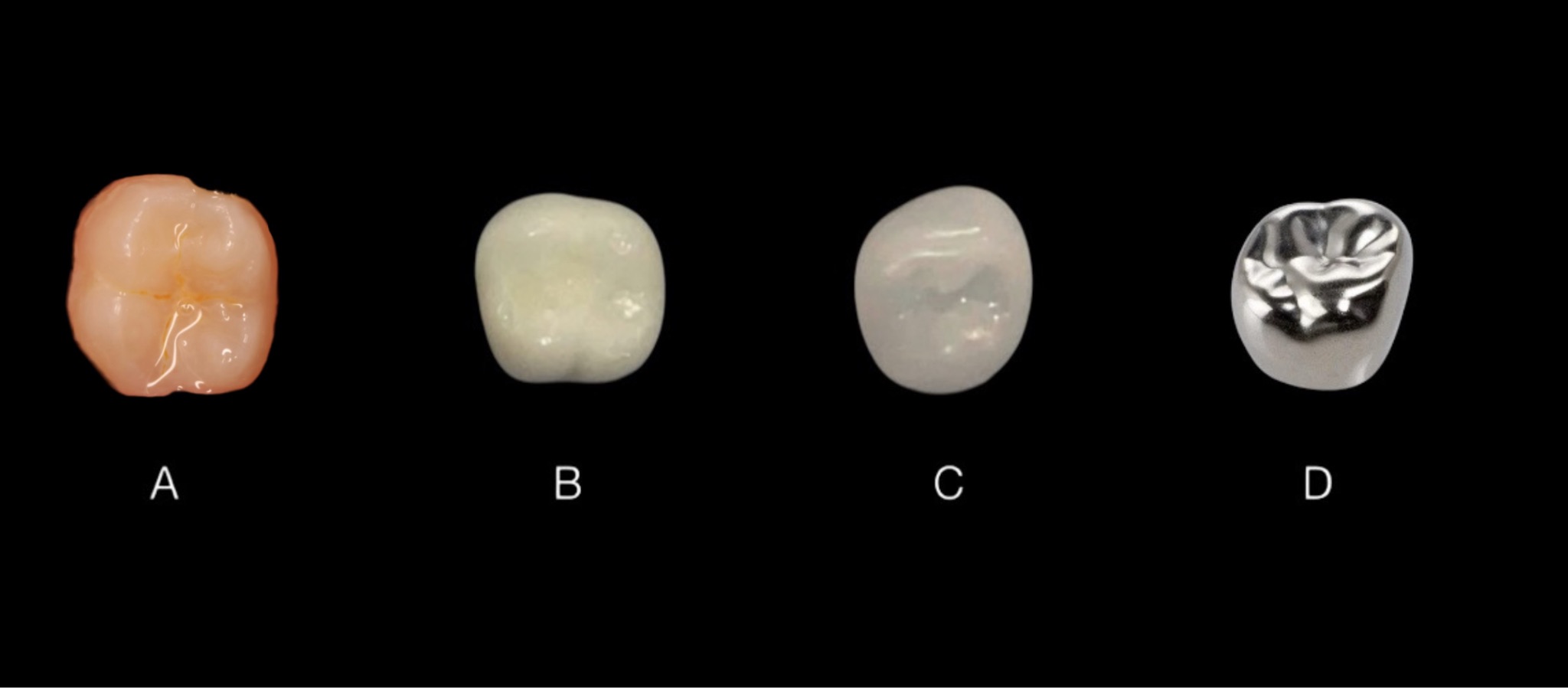
The study showed that noticeable differences were present in the resistant ability of occlusal wear among the different types of crowns that underwent simulated aging. Each material showed defined characteristics of wear, which were evaluated pre- and post-simulation using three-dimensional scanning to assess alterations on the occlusal surface.

Before and then after aging simulation, the natural teeth that acted as controls were very similar in their differentiation through wear. Among all the occlusal heights, the upper primary teeth (Group 1A) had an almost immeasurable reduction, meaning that natural enamel had very little wear under the simulated conditions. On the other hand, the lower primary teeth (Group 1B) had a significance score indicating reduction in wear. This observation may suggest that the lower primary teeth might be more susceptible to wear in this setup. This observation highlights the softer nature of the primary teeth as contrasted to the permanent ones which are more prone to wear summoning from masticatory forces with time.[(Abdou et al., 2025)](https://paperpile.com/c/jyXT3v/9ZNZ) Group 2 included crowns made of zirconia, which demonstrated great resistance to wear. Upper zirconia crowns (Group 2A) showed no severe wear on their occlusal surfaces, with heights virtually unchanged after the aging simulation. Lower zirconia crowns (Group 2B) were much appreciated, as indicated by a barely noticeable loss of occlusal wear, suggesting that the zirconia crown stands the test of chewing force without alteration of its form and structure. Further corroboration of its high wear resistance and durability is reflected in the lower arch, where chewing forces are exerted much more greatly. The outstanding serviceability of these crowns under this condition makes them fit for pediatric dentistry purposes for posterior restorations.[(Abdou et al., 2025)](https://paperpile.com/c/jyXT3v/9ZNZ) Edelweiss crowns (Group 3) are made from a fiber-reinforced composite material; this material has exhibited moderate resistance to wear. The upper Edelweiss crowns (Group 3A) showed a marked progressive wear but still held up better than SSCs, as witnessed with the significant reduction in occlusal surface height. This might mean Edelweiss crowns will suit those child patients who are a little focused on aesthetics while not compromising the resistance to wear. For the lower arch (Group 3B), edelweiss crowns showed lesser wear on them, with no significant difference between before and after the simulation. These findings imply that Edelweiss crowns manage the balance between aesthetics and resistance to wear, thus making them a good alternative for children in need of aesthetically pleasing functional restorations.[(Jadhav et al., 2024)](https://paperpile.com/c/jyXT3v/GARi)SSCs (Group 4) were stout and durable types of materials that wore the most among the testified materials. Upper SSCs (Group 4A) notably had a significantly reduced occlusal surface height portraying severe wear after simulated aging cycles, while lower SSCs (Group 4B) had only a subtle change in wear and little reduction in occlusal surface height. This shows that while SSCs are durable and ideal for high-stress environments, they have lower wear resistance compared to zirconia and Edelweiss crowns. Besides, aesthetic disadvantage compared to other materials remains a significant limitation in using SSCs in patients needing aesthetic restorations. [(Clark et al., 2016)](https://paperpile.com/c/jyXT3v/p5SI)

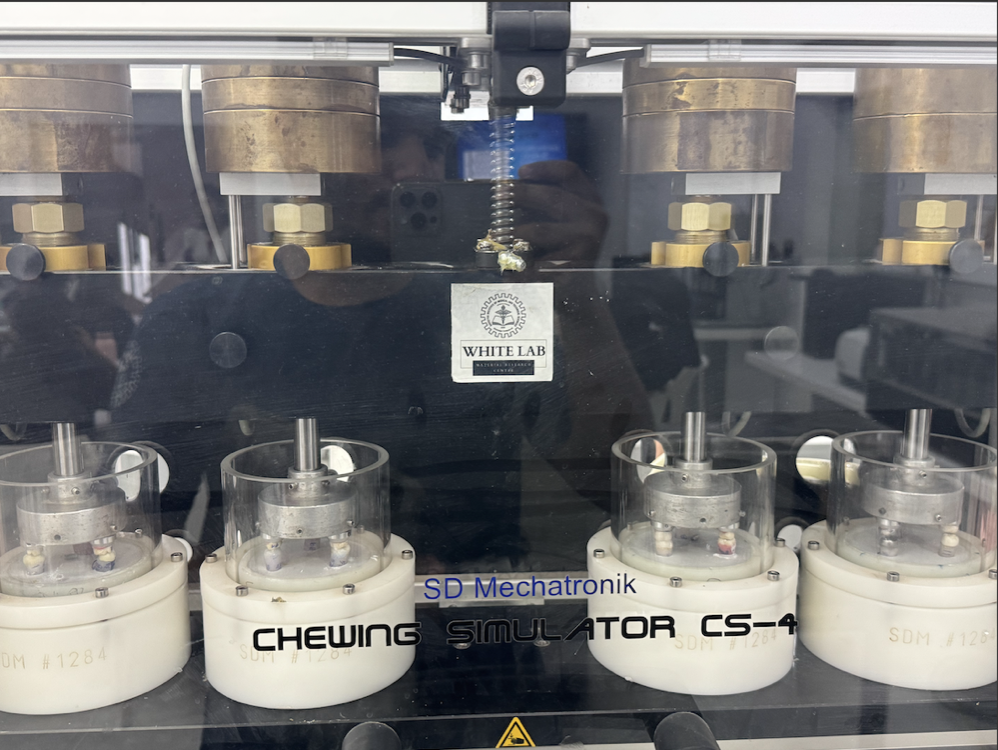
# CONCLUSION

Zirconia crowns demonstrated the highest wear resistance but may contribute to increased wear of opposing dentition. Resin and Edelweiss crowns offered a favorable balance between durability and esthetics, making them suitable alternatives in cases prioritizing conservative wear. Despite limited esthetics, SSCs remain a robust and reliable choice for high-stress clinical scenarios. Material selection should be guided by functional demands, esthetic considerations, and preservation of opposing natural teeth. Further longitudinal clinical studies are warranted to validate these findings.

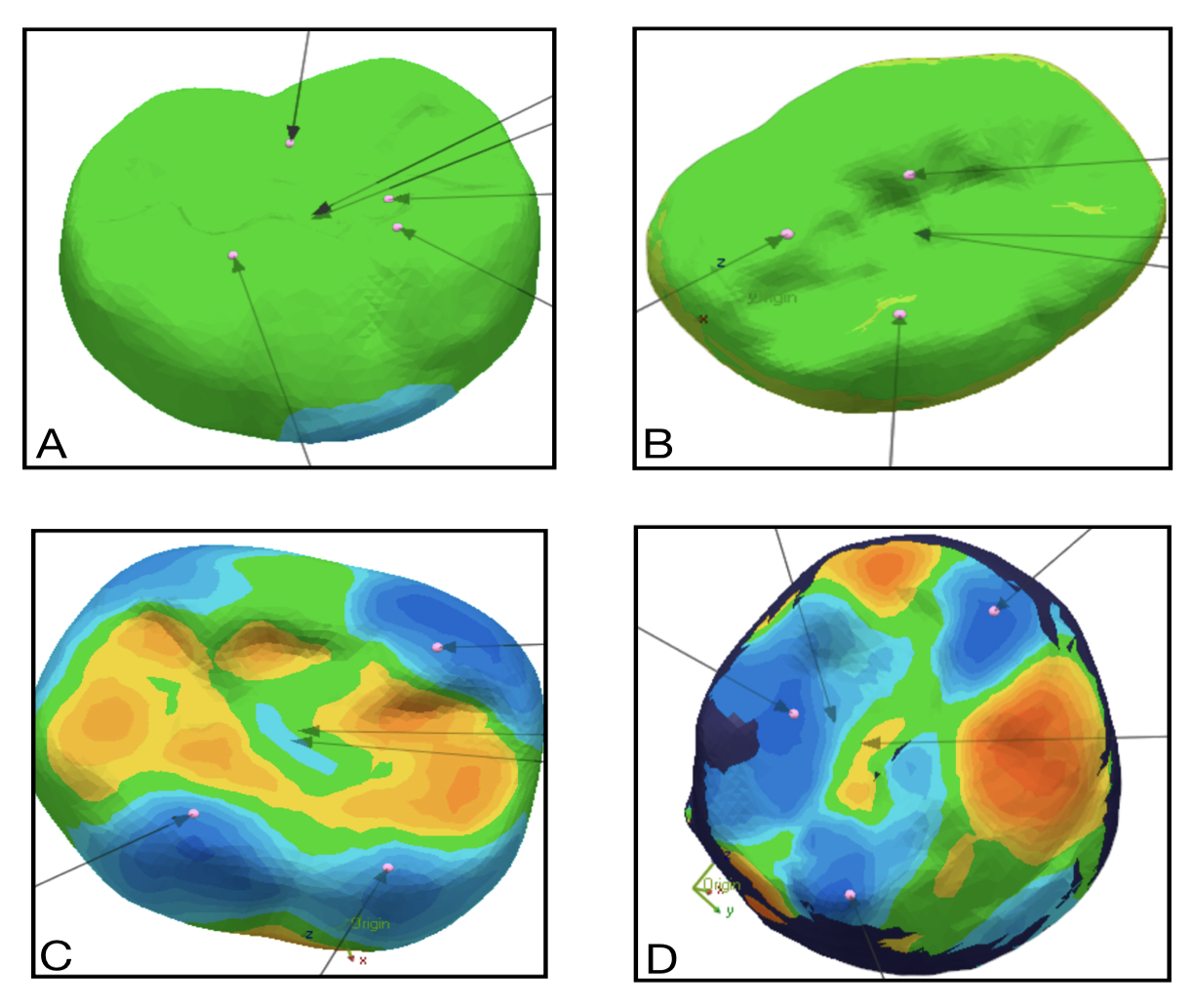
**Figure 1:** Experimental crowns; A: Natural teeth; B: Zirconia preformed crown; C: Edelweiss preformed crown; D: Stainless steel crowns



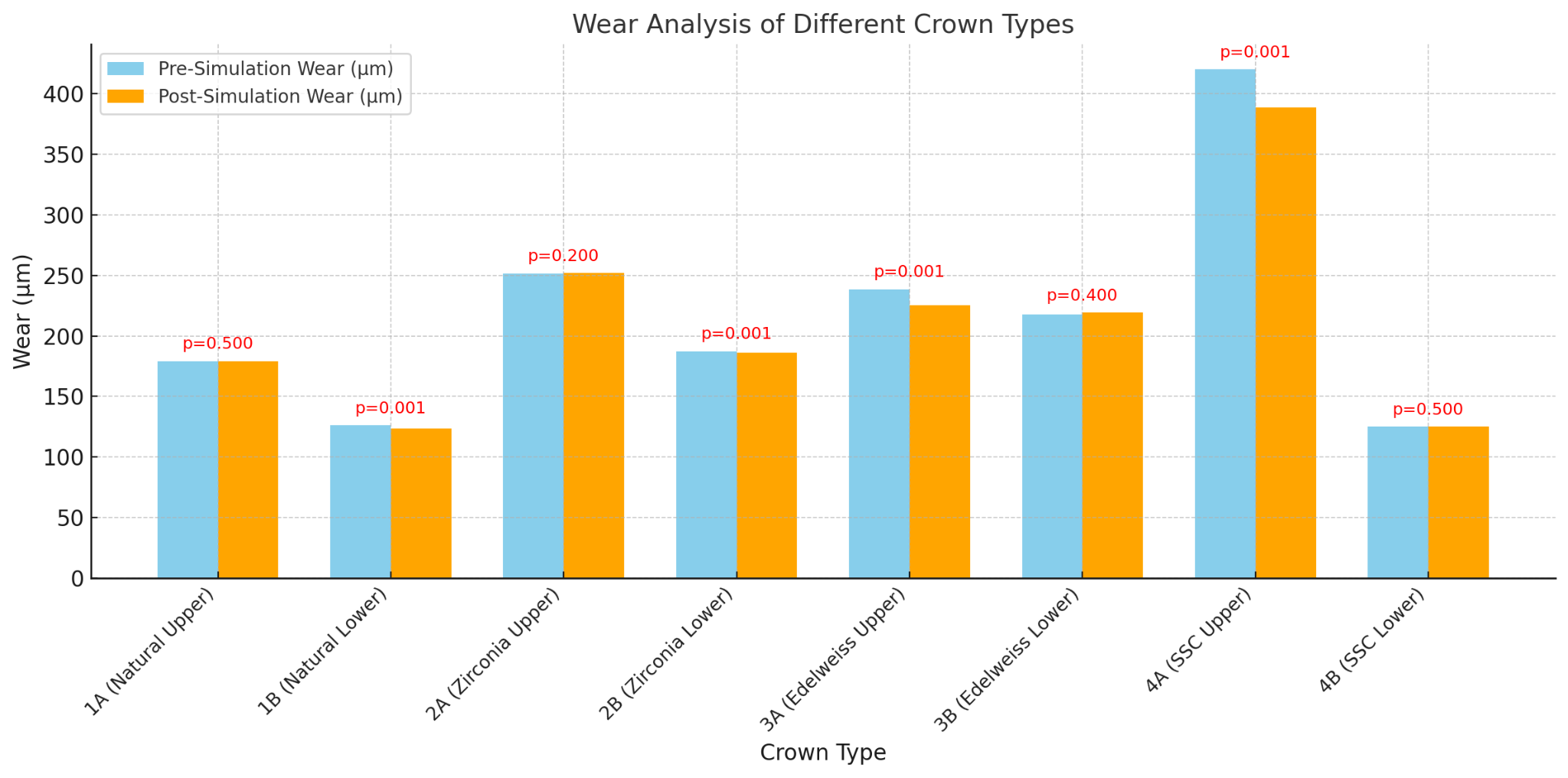
**Figure 2:** Samples subjected to chewing simulation



**Figure 3:** Superimposition of Pre and Post artificial aging using 3D systems; A: Natural teeth; B: Zirconia preformed crown; C: Edelweiss preformed crown; D: Stainless steel crowns



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



**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- Natural teeth  1A- Upper  1B- Lower | 179.2004  126.1183 | 179.0183  123.2954 | 0.5  0.001\*\*\* |
| Group-2 Zirconia Crowns  2A- Upper  2B- Lower | 251.4776  187.4436 | 251.829  186.2198 | 0.2  0.001\*\*\* |
| Group-3 Edelweiss Crowns  3A- Upper  3B- Lower | 238.58 ± 13.56  217.6504  122.7465 | 225.14 ± 14.32  219.2112  122.8132 | 0.001\*\*\*  0.4 |
| Group-4 SSC  4A- Upper  4B- Lower | 420.28 ± 22.34  125.0629  201.9024 | 388.82 ± 21.76  125.1378  200.9445 | 0.001\*\*\* |

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