Effect of Brushing Simulation on the Surface Roughness And Gloss of Various CompositesRunning Title: Impact of Brushing on Composite Surfaces

Yathin Reddy Putta1 , Peter Parker1,a)

Yathin dental clinic, Tirupathi, Andhra Pradesh, India

**Corresponding Author:** a)[spideysenseforever@gmail.com](mailto:spideysenseforever@gmail.com)

**Abstract:**Composite materials play a pivotal role in aesthetic and restorative dentistry , however their performance is hindered by the reduced wear resistance from brushing, leading to increased surface roughness and diminished gloss. Ivoclar Te-Econom Plus and KEDO E MAX are widely used composites, yet limited data exists on their comparative wear resistance following brushing, making this study significant for understanding their durability.To compare the effects of simulated brushing on the surface roughness and gloss retention of Ivoclar Te-Econom Plus and KEDO E MAX composites.Eight disc-shaped samples (N=8; n=4) were subjected to surface roughness and gloss retention measurements before and after 10,000 brushing cycles using a brushing simulator. Surface roughness was assessed with a Stylus profilometer, and gloss retention was evaluated using a gloss meter. Paired T-tests were used to statistically analyze the data (p < 0.05).Brushing significantly increased surface roughness and decreased gloss in both the composite groups. Ivoclar showed a greater increase in roughness, while KEDO E MAX elicited improved gloss retention when compared to Ivoclar Te- Econom group. The Ra values increased from 0.244 to 0.598 for Ivoclar and from 0.129 to 0.579 for KEDO. Gloss decreased from 55.02 to 11.1 for Ivoclar and from 54.97 to 14.42 for KEDO.Ivoclar Te Econom Plus and KEDO E MAX composites are affected by brushing, with KEDO E MAX showing better gloss retention and enhanced polishability. Regular maintenance may be needed to preserve their aesthetic and mechanical properties.

**Keywords**:Brushing simulation, composite resins, gloss, Ivoclar Te-Econom Plus, KEDO E MAX, surface roughness.

# Introduction

In today’s era of adhesive dentistry, composite resins are the ‘material of choice’, as they combine aesthetics with durability and ease of use. It has been demonstrated that the composition and microstructure of resin composites affect their mechanical properties and aesthetic appeal[(Rodrigues Junior et al., 2007)](https://paperpile.com/c/6FCELo/8Ikg),[(Suzuki et al., 2009)](https://paperpile.com/c/6FCELo/cA58). Numerous modifications have been made to the composition of the adhesive resins, such as the addition of coupling agents, organic matrix, and reinforcing fillers[(“Resin composite—State of the Art,” 2011)](https://paperpile.com/c/6FCELo/rUYd). In recent years, the advancements in composition of composites have mainly involved the incorporation of filler particles[(Alzraikat et al., 2018)](https://paperpile.com/c/6FCELo/3Z1J). The morphology (shape), particle size, and volume of the filler particles have an influence on the mechanical properties of resin composites[(Alzraikat et al., 2018; Rodrigues Junior et al., 2007)](https://paperpile.com/c/6FCELo/3Z1J+8Ikg),[(“Filler Characteristics of Modern Dental Resin Composites and Their Influence on Physico-Mechanical Properties,” 2016)](https://paperpile.com/c/6FCELo/DffF). In this study, we proposed to analyze the surface roughness and optical properties of KEDO E MAX composite, which is a nano hybrid composite with silica filler. Nanofilled composites incorporate the uniform distribution of nanosized particles within the resin matrix, whereas nanohybrid includes a mixture of nanosized and conventional filler particles. Composites consisting of nanoparticles are generally categorized into nanofilled, which use nano sized fillers throughout the resin matrix[(“An Application of Nanotechnology in Advanced Dental Materials,” 2003)](https://paperpile.com/c/6FCELo/QpRT), or nanohybrids, which contain a mix of conventional and nano sized filler particles[(Swift, 2005)](https://paperpile.com/c/6FCELo/EWO9). Literature suggests that the more fragile resin matrix will be shielded when finer particles are added to resin composites since they will result in less interparticle space and consequently, there will be less "plucking" of filler particles from the surface of the material[(Moraes et al., 2008; Turssi et al., 2003)](https://paperpile.com/c/6FCELo/P7FD+8CKB)**.** Surface characteristics are considered to be crucial components for the long-term survivability of resin composite restorations[(“Surface Roughness and Gloss of Polished Nanofilled and Nanohybrid Resin Composites,” 2021)](https://paperpile.com/c/6FCELo/pjuw). Rough surfaces result in plaque accumulation with subsequent secondary caries and hovering of stains with an unsatisfactory aesthetic appearance, which may cause the restorations to fail[(“Effects of Surface Properties of Polymer-Based Restorative Materials on Early Adhesion of Streptococcus Mutans in Vitro,” 2016)](https://paperpile.com/c/6FCELo/9ZRC). Tooth brushing is an inevitable daily event which increases the surface roughness of composite restorations. It has been proven that surface roughness of traditional composites is significantly affected after simulated toothbrushing [(Aytac et al., 2016; de Moraes Rego Roselino et al., 2019)](https://paperpile.com/c/6FCELo/rTZw+WnD9). A smooth surface improves patient comfort and aesthetics of the restoration, lessens discolouration, and allows the patient to maintain better hygiene[(“Abrasive Finishing and Polishing in Restorative Dentistry: A State-of-the-Art Review,” 2007, “Polishing Mechanism of Light-Initiated Dental Composite: Geometric Optics Approach,” 2016)](https://paperpile.com/c/6FCELo/O8LN+nY9V). A smooth surface finish on restorations can create an environment that is less hospitable to bacterial growth and biofilm formation[(Raghavendra et al., 2014)](https://paperpile.com/c/6FCELo/fO8s).The durability and surface topography of composite fillings are significantly influenced by their resistance to wear and polishability [(Yesil et al., 2008)](https://paperpile.com/c/6FCELo/vIft). Factors like daily brushing can gradually erode the surface of these restorations, potentially affecting their aesthetic appeal and function[(“Influence of Filler Charge on Gloss of Composite Materials before and after in Vitro Toothbrushing,” 2013; Yesil et al., 2008)](https://paperpile.com/c/6FCELo/vIft+tbT3). The composition of the composite material, particularly the filler- resin interaction , plays a crucial role in determining its wear resistance.[(Ajay et al., 2023; Chokkattu et al., 2023; Padarthi et al., 2023)](https://paperpile.com/c/6FCELo/RgcCt+fLqps+ofdRo) With the recent advancements in material sciences, the evaluation of long-term performance of next generation composites such as KEDO E MAX, in real-world settings is essential for clinical applications.[(Dharman et al., 2023; S. Sindhu et al., 2023; Sreenivasagan et al., 2023)](https://paperpile.com/c/6FCELo/xLhir+LdIxy+qyBc9) This study is focused on analyzing the surface roughness and gloss of the KEDO E MAX and conventional composite before and after brushing simulation.

# Materials and methods

## Sample preparation

Eight samples were prepared in total, out of which 4 were fabricated conventionally using Ivoclar Te-Econom Plus composite and 4 using KEDO E MAX composite. The composite pellets were prepared using a teflon coated cylindrical mold (8 mm in diameter and 2 mm in height), which were ﬁlled with the respective composite resins and in order to to obtain a flat surface, the excess material was removed by compressing between two glass slides. Later, the glass slides were withdrawn from the samples, which were covered by a polyester matrix(Saadh et al., 2024). The samples were polymerized using a light-emitting diode (LED) curing light (LED Elipar Free Light) (3M™, St. Paul, MN, USA) of 1,000 mW/cm2 strength and light-cured for 40 seconds(Almatrafi et al., 2024). After removal of the discs from the mold, they were polished using a SHOFU super snap mini kit according to the manufacturer's instructions. The discs were stored in distilled water at 37º C for 24 hours prior to subjecting the samples for surface roughness and gloss retention analysis.

## Brushing simulation

The prepared samples were mounted on the brushing simulator (ZM3.8 SD Mechatronik)(fig.1) and subjected to 10000 cycles ( 5000 cycles were performed in the linear X axis, 5000 cycles in the linear Y axis) for a time period of 3 hours which is equivalent to approximately one year of brushing.

**Surface roughness analysis:**Prior to the brushing simulation and post brushing simulation, the surface roughness was analysedusing a Stylus profilometer - Mitutoyo SJ 310. The profilometer has a 2μm tip/60°angle, which is dynamic in action and moves physically on the surface of the material to obtain the surface roughness values (Ra).

**Gloss retention analysis:**The gloss meter (3nh gloss meter) with a square measurement area of 15 × 10 mm and a 60° geometry was used to measure the intensity of the reflected light beam after striking the surface and compares the measured value to a reference value which is expressed in gloss units (GU). The sample was covered with an opaque plastic mold during measurement, in order to eliminate the exposure to ambient light and for maintaining the exact position of the sample for repeated measurements.

**Statistical analysis:**Paired T test was performed using SPSS software (version 23) to determine the p value for the surface roughness and gloss values for both the composites before and after simulated brushing.p value was set at 0.05.



**Figure 1:** ZM3.8 SD Mechatronik brushing simulator with composite samples.

# Results

## Surface roughness

The overall surface roughness values for both the composites were decreased post brushing simulation(table.1). The mean values before and after brushing for Ivoclar were 0.117 and 0.601 and for KEDO, they were 0.129 and 0.579 respectively. Ivoclar composite elicited improved wear resistance in terms of surface roughness when compared to KEDO. A statistically significant difference (p<0.05) was present when comparing ivoclar (p=0.206) and KEDO (P=0.0308)

**Table.1:** mean surface roughness (Ra) values and P-value of Ivoclar and KEDO composites before and after simulated brushing.

| Sample | Mean Ra value pre and post brushing | P-value |
| --- | --- | --- |
| Ivoclar | 0.117 0.601 | 0.0206 |
| KEDO | 0.129 0.579 | 0.0308 |

## Gloss retention

The gloss retention values of all the samples were found to drastically decrease post brushing simulation. (table.2). The mean gloss values before and after simulated brushing were 55.02 and 11.1 for Ivoclar and 54.97 and 14.42 for KEDO. There was enhanced gloss retention among KEDO composite when compared to Ivoclar composite. The P values obtained were 0.0000311 for Ivoclar and 0.0000814 for KEDO composite, which was statistically significant.

**Table.2:** mean gloss values and P-values of Ivoclar and KEDO composites before and after simulated brushing.

| Sample number | Mean values pre and post brushing | P-value |
| --- | --- | --- |
| Ivoclar | 55.02 11.10 | 0.0000311 |
| KEDO | 54.97 14.42 | 0.0000814 |

# Discussion

The findings of this study highlights the significant impact of brushing on the surface roughness and gloss of both Ivoclar Te-Econom Plus and KEDO E MAX composites. The results revealed that brushing simulation led to a statistically significant increase in surface roughness and a decrease in gloss for both materials, emphasizing the abrasive effects of daily oral hygiene practices on dental restorations. Prior to brushing simulation, Ivoclar exhibited a increased initial surface roughness (mean 0.177 µm) compared to KEDO E MAX (mean 0.129 µm) showcasing the variation in polishability and surface topography of the different brands of composites. Following brushing simulation, surface roughness increased significantly for both composites, with Ivoclar showing a remarkable difference in the rougness values (mean post-brushing roughness 0.601 µm) compared to KEDO E MAX (mean 0.579 µm). Similarly, gloss retention values for both materials decreased markedly post brushing, with Ivoclar’s mean gloss drastically decreasing from 55.02 GU to 11.1 GU, and KEDO E MAX from 54.97 GU to 14.42 GU. Despite the substantial reduction in gloss for both materials, KEDO E MAX showed slightly improved gloss retention values than Ivoclar.In spite of the aging process, toothbrushing remains a key factor in the long-term wear of composite materials, which can affect their aesthetic appeal[(“Surface Roughness and Gloss Alteration of Polished Resin Composites with Various Filler Types after Simulated Toothbrush Abrasion,” 2023)](https://paperpile.com/c/6FCELo/Yg0D). Toothbrushing abrasion is a significant factor in the wear of non-stress-bearing dental surfaces[(Turssi et al., 2001)](https://paperpile.com/c/6FCELo/ufDr). Numerous studies have confirmed that toothbrushing can lead to a marked increase in surface roughness[(“Effects of Toothbrushing on Surface Characteristics of Microhybrid and Nanofilled Resin Composites Following Different Finishing and Polishing Procedures,” 2020; Kamonkhantikul et al., 2014)](https://paperpile.com/c/6FCELo/K6Gf+8zvE). The morphology, size distribution, and bonding of filler particles within the resin matrix are very important in influencing this outcome[(Suzuki et al., 2009)](https://paperpile.com/c/6FCELo/cA58). Ivoclar’s composite, which displayed higher initial roughness, may have contained larger or less securely bound filler particles that were more susceptible to displacement or exposure during brushing. Conversely, the nano-hybrid structure of KEDO E MAX, though initially smoother, may have permitted a more uniform distribution of wear across the surface, leading to a consistent increase in roughness. [(Ramakrishnan et al., 2023; Shenoy & Maiti, 2023; J. S. Sindhu et al., 2023)](https://paperpile.com/c/6FCELo/jXICh+GOzmd+RKTb9)Gloss is a crucial aesthetic parameter, and in this study, both composites experienced a significant reduction in gloss following brushing simulation. While Chiang et al. found a strong relationship between surface gloss and perceived texture,[(“Polishing Mechanism of Light-Initiated Dental Composite: Geometric Optics Approach,” 2016)](https://paperpile.com/c/6FCELo/O8LN) other factors such as filler size, load, and distribution also influenced the appearance of surfaces[(“Influence of Filler Charge on Gloss of Composite Materials before and after in Vitro Toothbrushing,” 2013)](https://paperpile.com/c/6FCELo/tbT3). The greater reflectivity of filler particles might explain this phenomenon. Previous studies have reported a positive correlation between smaller filler size and higher surface gloss in composite materials[(“Surface Roughness and Gloss of Polished Nanofilled and Nanohybrid Resin Composites,” 2021; Waheeb et al., 2012)](https://paperpile.com/c/6FCELo/pjuw+ZkNK). The superior gloss retention observed in KEDO E MAX may be due to its nano-hybrid composition, which potentially allows for a more uniform wear pattern and less pronounced surface irregularities compared to the conventional filler structure in Ivoclar.[(Kasabwala et al., 2021; Rajeshkumar & Lakshmi, 2021; Varghese et al., 2023)](https://paperpile.com/c/6FCELo/v3gYC+sDNgJ+Qnr65)Clinically, these results translate the need to consider both the mechanical and aesthetic properties of composite resins when selecting materials for restorations.[(Keerthana & Ramesh, 2021; Murugesan, 2021; Tiwari & Jain, 2021)](https://paperpile.com/c/6FCELo/RixVY+IWpD0+3i57i)[(Keerthana & Ramesh, 2021; Murugesan, 2021; Subramanian et al., 2021; Tiwari & Jain, 2021)](https://paperpile.com/c/6FCELo/RixVY+IWpD0+3i57i+mSOgf) Dentists should be aware that while some composites may offer superior initial aesthetics, their long-term performance under daily wear conditions, such as brushing, may differ significantly. [(G. & Ganapathy, 2022; Kumar & Ramesh, 2021)](https://paperpile.com/c/6FCELo/l0ddn+BAxMa)) Regular maintenance and polishing may be necessary to extend the aesthetic and functional lifespan of composite restorations, particularly for materials that demonstrate a significant increase in roughness or decrease in gloss over time. [(*Evaluation Composite Restoration Posterior Teeth Proanthocyanidin Pretreatment Liner Using Fédération Dentaire Internationale Criteria: Split-Mouth Randomized Controlled Trial*, n.d.; Pranati et al., 2021; Sakthi, 2021)](https://paperpile.com/c/6FCELo/smKwf+0WGsr+w1qUN))This study’s limitations include the fact that the simulation may not fully replicate the complex dynamics of *in vivo* brushing, where factors such as toothpaste composition, brushing force, and technique can vary. Future research should address these variables and consider longer simulation periods to better replicate clinical conditions. Additionally, further investigation into other properties, such as color stability and wear resistance over extended periods, would provide a more comprehensive understanding of the long-term performance of these composites.

# Conclusion

This study demonstrates that simulated brushing significantly affects the surface roughness and gloss of both Ivoclar Te-Econom Plus and KEDO E MAX composites. While both materials showed increased roughness and reduced gloss, KEDO E MAX exhibited slightly improved gloss retention. These findings highlight the need to consider both aesthetic and mechanical properties when selecting composite resins for dental restorations. Regular maintenance may be necessary to extend the lifespan of these materials. Further research is recommended to better replicate clinical conditions and evaluate long-term performance.

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