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Influence of Food-Simulating Liquids on the Microhardness and Surface Roughness of Tooth-Coloured Restorative Materials

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KEYWORDS

Tooth-coloured restorative material, microhardness, surface roughness, food-simulating liquids

ABSTRACT

The effects of food-simulating liquids (FSLs) on the microhardness and surface roughness: Luna (LN, conventional nanohybrid), Aura Bulk Fill (AB, bulk-fill composite), and Stela Automix (SA, self-cured composite) were evaluated. The materials were exposed to air as control, artificial saliva and three FSLs: 50% ethanol-water solution, 0.02N citric acid, and heptane-over different time intervals to compare their performance. Microhardness and surface roughness were measured at baseline, seven days, and 30 days after immersion. Two-way ANOVA revealed significant interactions between FSLs and materials for both microhardness and surface roughness ($p<0.001$). All materials showed a decrease in microhardness and an increase in surface roughness over time, except when exposed to air. LN exhibited the highest microhardness and lowest surface roughness, while SA demonstrated the lowest microhardness and the highest surface roughness in all FSLs. SA's surface roughness decreased in citric acid, potentially due to its lower filler content, which may result in a less durable surface. Ethanol and citric acid had the most detrimental effects on the microhardness of all materials, while heptane caused the most significant surface roughness changes in SA. These results highlight the material-specific responses to FSLs, with important implications for material selection and restoration longevity in clinical practice.

INTRODUCTION

Direct tooth-coloured restorative materials (TCRMs) have become indispensable in contemporary dentistry due to their superior aesthetics, mechanical durability, and versatility in both anterior and posterior restorations. Advances in resin chemistry, filler technology, and bioactive components have been aimed at improving clinical longevity and patient outcomes [1]. The expanding range of commercially available TCRMs reflects an ongoing effort by manufacturers to meet evolving clinical demands [2].

Despite their favourable mechanical properties, TCRMs are susceptible to degradation in certain chemical environments, particularly when exposed to food ingredients and organic acids [3, 4]. Chemical dissolution, even in the absence of external mechanical forces, can also weaken their strength [5]. To evaluate how dietary substances may degrade TCRMs, the United States Food and Drug Administration (FDA) advises testing with food-simulating liquids (FSLs) that replicate common oral exposures [6]. These include citric acid and ethanol solutions to mimic foods like fruits, vegetables, candies, and alcoholic beverages, while heptane simulates greasy foods such as oils, butter, and fatty meats. Distilled water and artificial saliva are used to replicate the oral environment [3, 7].

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Surface roughness plays a key role in plaque retention on dental materials. In vitro studies have shown that plaque formation and bacterial adhesion on restorations are closely linked to surface roughness, with a threshold of 0.2 µm being critical for minimizing bacterial attachment [8, 9].

Hardness is another important property of TCRMs, directly influencing their durability and performance. It reflects a material's resistance to indentation, which in turn affects the longevity of dental restorations [10]. Materials with higher hardness are better able to withstand both mechanical and chemical stresses, while those with lower hardness are more likely to fail under load. This can reduce their effectiveness, shorten their lifespan, and increase the risk of caries.

Although many studies have examined the hardness and surface roughness of traditional TCRMs, limited data exist on the influence of dietary factors on newer materials such as Stela (SDI, Bayswater, Australia). Marketed as a "true amalgam alternative," Stela is a self-curing composite formulated with BPA-free resin monomers, Ion Glass™ (a bioactive hybrid glass), and surface-modified silica nanoparticles. According to the manufacturer, it offers high mechanical strength, ease of handling, and consistent performance regardless of technique variability. Its unique self-curing chemistry, lower filler content, and bioactive components distinguish it from conventional light-cured composites, making it clinically relevant to investigate how it withstands chemical challenges such as those simulated by food-simulating liquids.

This study aimed to determine how immersion in FSLs influences the microhardness and surface roughness of selected TCRMs and to compare their performance over defined time intervals. The null hypotheses were: (a) Immersion in FSLs does not affect the microhardness or surface roughness of TCRMs, and (b) There are no significant differences in microhardness or surface roughness between the tested materials, regardless of the conditioning medium or exposure time.

MATERIALS AND METHOD

A laboratory experimental study was conducted to evaluate three commercially available TCRMs: Luna (LN) (control), Aura Bulk Fill (AB), and Stela Automix (SA). The technical specifications and manufacturers of these materials are provided in Table 1.

Table 1 Technical profiles and manufacturers of the materials evaluated.

Materials	Manufacturer	Classification and method of curing	Resin	Filler types	Filler size	Filler content % by weight/ volume	Shade
Luna (LN) [control]	SDI, Bayswater, Australia	Universal nanohybrid composite (Light-cured)	DUDMA, TEGDMA, Bis-EMA	Strontium glass	40nm - 1.5µm	76/ 56	A2
Aura Bulk Fill (AB)	SDI, Bayswater, Australia	Bulk fill nanohybrid composite (Light-cured)	UDMA, Bis-EMA, Bis-GMA, TEGDMA	Amorphous silicon dioxide, barium, aluminum, glass, prepolymerized filler	-	72.7/ 81	Universal shade (BKF)
Stela Automix (SA)	SDI, Bayswater, Australia	Self-cure composite	DUDMA, GDMA, 10-MDP	Fluoro-alumino-silicate glass	2µm - 8µm (mean:4µm)	61.2/ 36.4	Universal shade
				Barium-alumino-borosilicate glass	2µm - 5µm (mean:2.8µm)		

DUDMA= Diurethane dimethacrylate; TEGDMA= Triethylene glycol dimethacrylate; Bis-EMA= Bisphenol A ethoxylate dimethacrylate ; BisGMA= bisphenol A glycidyl methacrylate; UDMA= urethane dimethacrylate; GDMA= Glycerol dimethacrylate; 10-MDP= 10-methacryloyloxydecyl dihydrogen phosphate.
*(Abbreviation) depicts the code for study materials

The sample size was determined following the methodology of Lee et al. [7], who assessed the effect of resin coatings on the surface roughness and microhardness of high-viscosity glass ionomer cement. Using G*Power software (version 3.1.9.73), the required sample size for a two-way ANOVA was calculated based on an effect size of 0.52, an alpha level of 0.05, and 95% power. The design involved 15 experimental conditions—derived from the combination of three restorative materials (LN, AB, and SA) and five immersion media (air, artificial saliva, ethanol, citric acid, and heptane). This calculation indicated a minimum of nine specimens per condition, giving a total of 135 specimens. To allow for potential specimen loss or defects, 150 circular specimens (10 mm × 2 mm) were fabricated using a custom plastic mould and equally divided into three material groups: LN (n = 50), AB (n = 50), and SA (n = 50). Each material group was then randomly allocated to the five immersion media, with 10 specimens per medium.

For LN, the composite was packed into the mould in a single increment and compressed between mylar strips and a 1 mm glass slide on both sides. Finger pressure was applied to ensure proper adaptation, and excess material was extruded to achieve a flat surface. The specimens were polymerized using a calibrated Demi Ultra LED Curing Light (Kerr, Orange, USA), with an output irradiance of 1200 mW/cm^2 and a wavelength range of 440–480 nm. Two overlapping 20 second irradiations were applied through the glass slide. After the glass slides were removed, the bottom surface was cured for an additional 20 seconds. The same procedure was followed for the AB specimens.

For the SA composite, the automix tip was attached to the syringe, and the first 3 mm of paste was discarded to ensure thorough mixing. The material was then loaded into the mould in a single increment, and both sides were compressed with mylar strips and a glass slide for proper adaptation. Excess material was extruded to achieve a flat surface, and the specimens were allowed to polymerize completely for 4 minutes. After polymerization, each specimen was thoroughly examined for voids or defects, and any unsatisfactory specimens were replaced.

The specimens were finished and polished using Sof-Lex™ discs (3M ESPE, USA), starting with coarse discs and progressing to medium, fine, and superfine discs. Each disc was applied in a clockwise circular motion for 20 seconds under dry conditions. All procedures were performed by a single operator to minimize inter-operator variability and bias.

Before baseline testing, the finished specimens for each material were randomly assigned to five groups of ten specimens (n=10). The specimens were then stored in closed containers in an incubator (Memmert Incubator, IN-460, Schwabach, Germany) at 37°C and 80% humidity for 24 hours. After baseline testing, each group was conditioned in air as control, artificial saliva [11], and three FSLs for up to 30 days at 37°C: 50% ethanol-water solution, 0.02N citric acid, or heptane. To minimize evaporation and exposure to air, the containers were sealed, and the conditioning mediums were replaced every seven days. This was done to maintain consistent conditions, as FSLs can change in composition over time and potentially influence the results. The pH of artificial saliva was monitored using a digital pH meter (Eutech pH2700, Singapore) and adjusted to 6.8 with diluted hydrochloric acid to match the pH of natural saliva.

Microhardness and surface roughness were measured at baseline (pre-immersion) and again at seven and 30 days post-immersion. Prior to each measurement, specimens were blotted dry, and after testing, they were returned to their closed containers in the incubator. The Vickers Hardness Number (VHN) was measured using a diamond pyramid penetrator with a 136° angle, applying a 1.961N load for 10 seconds with a microhardness tester (Shimadzu HMV-G, Kyoto, Japan). Three random, equally spaced locations on the upper surface of each specimen were tested, and the average of the three VHN values (kg/mm^2) was used as the representative value for each specimen.

Surface roughness (Ra) was measured using the Infinite Focus Optical 3D Measurement G4e machine (Alicona Imaging GmbH, Raaba, Austria) at 20× magnification, with lateral and vertical resolutions of 2.93 µm and 325.66 nm, respectively. Measurements were taken at five different locations on each specimen, and the average Ra was calculated using the IFM version 3.5 software (Alicona Imaging GmbH).

Data were analysed using the Statistical Package for the Social Sciences (SPSS) software (version 27, SPSS Inc., Chicago, IL, USA). Normality was assessed using the Kolmogorov–Smirnov test ($n \geq 50$) for a normal distribution. All measurements, except baseline readings, were normally distributed ($p<0.05$). For baseline readings, normality was assessed using a z-test for skewness and kurtosis, with a z-value ≤3.29 indicating normal distribution [12]. Parametric analyses were then performed. Two-way repeated measures ANOVA assessed interactions between materials and mediums, while one-way ANOVA with post hoc Tukey's HSD tests compared the different materials and mediums. Repeated measures ANOVA and paired t-tests were used for pairwise comparisons. All statistical analyses were performed with a significance level of $\alpha = 0.05$.

RESULTS

Microhardness

The mean and standard deviation of the VHN for the three TCRMs at different time intervals are presented in Table 2. Two-way ANOVA revealed a significant interaction between FSL immersion and test materials (p<0.001) concerning microhardness. The paired t-test analysis for all materials, showed a statistically significant time effect in microhardness across all three time points (p<0.001). Comparisons of hardness values showed that LN exhibited the highest wear resistance, followed by AB, with SA showing the lowest hardness values. All materials demonstrated a decrease in hardness over time in all media, except for air.

Table 2 Mean (SD) microhardness values (VHN) of the TCRMs in different FSLs.

Material	Medium	Mean VHN		
		Baseline	7 days	30 days
Luna (LN)	Air	68.07 (2.17)	65.92 (2.33)	65.26 (2.53)
	Artificial Saliva	61.37 (2.66)	60.92 (4.12)	59.48 (3.85)
	Ethanol	58.97 (3.68)	51.69 (3.75)	48.13 (1.54)
	Citric Acid	56.99 (2.22)	53.58 (2.98)	51.50 (3.74)
	Heptane	58.75 (2.62)	49.74 (2.99)	47.07 (2.40)
Aura Bulk Fill (AB)	Air	52.72 (2.28)	54.26 (0.79)	51.46 (0.94)
	Artificial Saliva	51.16 (1.15)	45.40 (1.83)	45.99 (1.44)
	Ethanol	47.74 (2.30)	43.27 (2.28)	40.53 (1.42)
	Citric Acid	53.30 (1.31)	50.54 (3.24)	48.38 (2.42)
	Heptane	51.72 (1.43)	46.51 (1.79)	45.36 (1.81)
Stela Automix (SA)	Air	42.48 (3.68)	45.44 (2.41)	43.43 (0.97)
	Artificial Saliva	40.88 (0.95)	37.75 (2.94)	32.87 (2.25)
	Ethanol	45.96 (1.91)	33.60 (3.38)	29.93 (2.69)
	Citric Acid	41.85 (1.29)	32.02 (1.63)	31.57 (2.96)
	Heptane	41.16 (1.18)	42.72 (1.18)	40.42 (1.38)

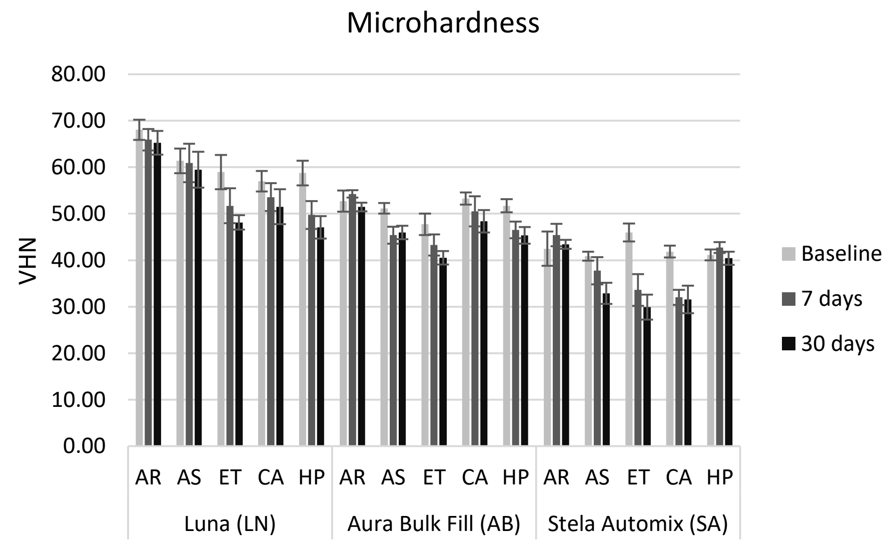

Figure 1 Bar graph showing change of microhardness (VHN) of each material in different medium over time.

As shown in Table 3, LN consistently had the highest microhardness values across all mediums at both seven and 30 days. In contrast, SA exhibited the lowest microhardness values in all mediums at both time points. Significant differences (p<0.05) were observed between materials at both time intervals, except for the comparison between LN and AB in citric acid and heptane at both seven and 30 days.

Further comparison of FSLs for each material revealed significant differences in microhardness after both seven and 30 days (Table 4). None of the materials showed significant changes in microhardness after immersion in artificial saliva. For LN, no significant difference in microhardness reduction was observed between heptane, ethanol, and citric acid at seven days. However, after 30 days, specimens immersed in heptane showed significantly lower microhardness compared to those immersed in citric acid. For AB and SA, ethanol resulted in significantly lower microhardness values than heptane at both seven and 30 days. Table 4 summarizes the comparison of mean microhardness values between mediums at both time points.

Table 3 Comparison of microhardness between materials for each medium at two-time intervals.

Mediums	**Comparison Between Materials**	
	7 days	**30 days**
Air	LN > AB > SA	LN > AB > SA
Artificial Saliva	LN > AB > SA	LN > AB > SA
Ethanol	LN > AB > SA	LN > AB > SA
Citric Acid	LN, AB > SA	LN, AB > SA
Heptane	LN, AB > SA	LN, AB > SA

Abbreviations: LN, Luna (control); AB, Aura Bulk Fill; SA, Stela Automix.
> indicates statistical significance. Results of one-way ANOVA and post-hoc Tukey test (p<0.05).

Table 4 Comparison of microhardness between mediums for each material at two-time intervals.

Mediums	**Comparison Between Mediums**	
	7 days	**30 days**
Luna (LN)	AR > AS > CA, ET, HP	AR > AS > CA, ET, HP CA > HP
Aura Bulk Fill (AB)	AR > CA > HP, AS, ET HP > ET	AR > CA > AS, HP > ET
Stela Automix (SA)	AR, HP > AS > ET, CA AR > CA	AR > HP > AS, CA, ET AS > ET

Abbreviations: AR, Air (control); AS, Artificial Saliva; ET, Ethanol; CA, Citric Acid; HP, Heptane.
> indicates statistical significance. Results of one-way ANOVA and post-hoc Tukey test (p<0.05).

Surface Roughness

The mean surface roughness (Ra) values and standard deviations for the investigated TCRMs after immersion in different FSLs at various time intervals are shown in Table 5. Two-way ANOVA revealed a statistically significant interaction between FSLs immersion and test materials (p<0.001) regarding surface roughness. However, the paired t-test analysis for all materials, showed the effect of time across all three time points was not statistically significant (p=0.057) in surface roughness.

The comparison of materials for each medium at both time intervals, as shown in Table 6, revealed that SA exhibited the highest Ra values in all mediums, except for air and citric acid after both 7 and 30 days. In contrast, LN showed the lowest Ra values in all media, except for air and citric acid, at both time points.

As illustrated in Table 7, comparisons between mediums for each material revealed significant differences in surface roughness after both seven and 30 days. Post-hoc Tukey's test analysis showed that the mean Ra for LN after immersion in citric acid was significantly higher than that for heptane at both seven and 30 days. For SA, Ra in heptane was significantly higher than in citric acid at both time points. For AB, increased Ra was observed in ethanol, followed by citric acid, air, and heptane, with significantly lower Ra in artificial saliva after seven days. After 30 days, Ra in citric acid and heptane was significantly higher than in artificial saliva.

Table 5 Mean (SD) surface roughness values (Ra, µm) of the TCRMs in different FSLs.

Material	Medium	Mean Ra (SD)		
		Baseline	7 days	30 days
Luna (LN)	Air	0.175 (0.016)	0.180 (0.011)	0.191 (0.011)
	Artificial Saliva	0.160 (0.020)	0.156 (0.018)	0.148 (0.014)
	Ethanol	0.167 (0.020)	0.173 (0.025)	0.163 (0.028)
	Citric Acid	0.171 (0.025)	0.173 (0.016)	0.182 (0.009)
	Heptane	0.156 (0.023)	0.150 (0.017)	0.145 (0.022)
Aura Bulk Fill (AB)	Air	0.175 (0.037)	0.175 (0.017)	0.177 (0.027)
	Artificial Saliva	0.115 (0.020)	0.144 (0.012)	0.149 (0.025)
	Ethanol	0.159 (0.026)	0.184 (0.021)	0.170 (0.013)
	Citric Acid	0.166 (0.011)	0.182 (0.008)	0.188 (0.014)
	Heptane	0.157 (0.017)	0.168 (0.025)	0.181 (0.030)
Stela Automix (SA)	Air	0.165 (0.011)	0.160 (0.006)	0.162 (0.007)
	Artificial Saliva	0.167 (0.012)	0.160 (0.010)	0.166 (0.020)
	Ethanol	0.173 (0.015)	0.175 (0.013)	0.182 (0.010)
	Citric Acid	0.176 (0.012)	0.161 (0.011)	0.150 (0.004)
	Heptane	0.178 (0.011)	0.184 (0.014)	0.191 (0.011)

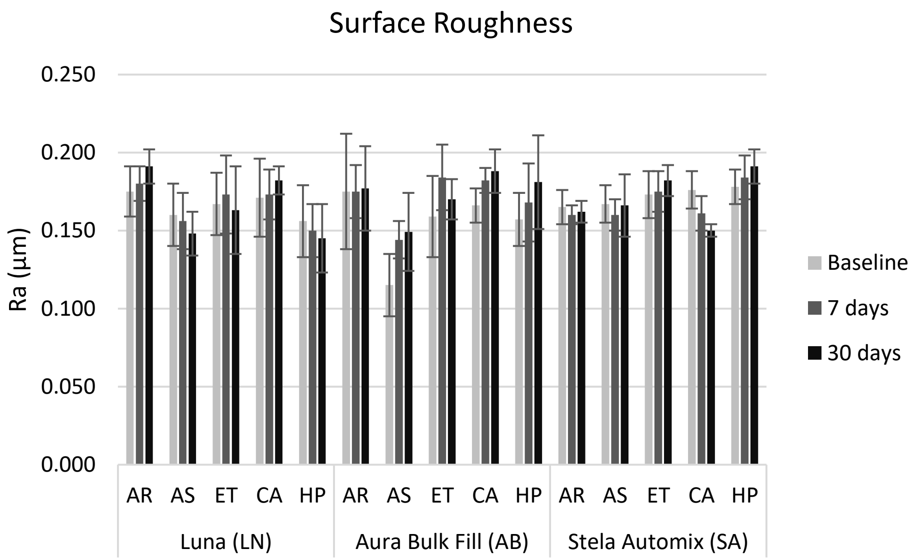

Figure 2 Bar graph showing change of surface roughness, Ra (µm) of each material in different medium over time.

Table 6 Comparison of surface roughness between materials for each medium at two-time intervals.

Mediums	Comparison Between Materials	
	7 days	30 days
Air (AR)	LN, AB > SA	LN, AB, SA
		LN > SA
Artificial Saliva (AS)	SA, LN, AB	SA, AB, LN
	SA > AB	
Ethanol (ET)	AB, SA, LN	SA, AB, LN
Citric Acid (CA)	AB, LN, SA	AB, LN > SA
	AB > SA	
Heptane (HP)	SA, AB, LN	SA, AB > LN
	SA > LN	

Abbreviations: LN, Luna (control); AB, Aura Bulk Fill; SA, Stela Automix.
> indicates statistical significance. Results of one-way ANOVA and post-hoc Tukey test ($p<0.05$)

Table 7 Comparison of surface roughness between mediums for each material at two-time intervals.

Materials	Comparison Between Mediums	
	7 days	30 days
Luna (LN)	AR, ET, CA, AS, HP	AR, CA, ET, AS, HP
	AR, ET, CA > HP	AR, CA > AS, HP
	AR > AS	AR > ET
Aura Bulk Fill (AB)	ET, CA, AR, HP > AS	CA, HP, AR, ET, AS
		CA, HP > AS
Stela Automix (SA)	HP, ET, CA, AS, AR	HP, ET > AS, AR, CA
	HP > CA, AS, AR	HP, ET > AS > CA

Abbreviations: AR, Air (control); AS, Artificial Saliva; ET, Ethanol; CA, Citric Acid; HP, Heptane.
> indicates statistical significance. Results of one-way ANOVA and post-hoc Tukey test ($p<0.05$).

DISCUSSION

This study examined the effects of food-simulating liquids (FSLs) on the microhardness and surface roughness of three tooth-coloured restorative materials (TCRMs) with different compositions and curing mechanisms: Luna (LN), a widely used high-strength nanohybrid composite; Aura Bulk Fill (AB), a bulk-fill formulation designed for greater curing depth and time efficiency; and Stela Automix (SA), a recently introduced self-curing composite containing bioactive glass and a lower filler content. Assessing these materials under identical chemical challenges allowed for direct comparison between conventional, bulk-fill, and self-cured systems, providing clinically relevant insight into their relative durability.

The study aimed to determine whether immersion in FSLs alters these surface properties and whether differences exist between materials regardless of the conditioning medium or exposure time. Results showed that both microhardness and surface roughness were significantly influenced by the material type, the immersion medium, and the duration of exposure, leading to partial rejection of the null hypotheses.

The conditioning media citric acid, ethanol, heptane, and artificial saliva were chosen to simulate common dietary challenges. Citric acid reflects exposure to acidic foods and beverages such as citrus fruits and carbonated drinks; ethanol represents alcoholic beverages; heptane models fatty foods; and artificial saliva serves as a baseline oral environment. Although continuous immersion may exaggerate real-world exposure, it provides a controlled method for assessing a material's chemical susceptibility. In practice, prolonged or repeated contact with such substances can occur in patients with poor oral hygiene, high dietary acid intake, or frequent alcohol consumption, especially in areas where plaque, calculus, or food particles accumulate along poorly finished restoration margins [3, 13]. The model does not replicate enzymatic activity in saliva, which may neutralise or lessen the effects of these chemicals [14], but it still offers useful insight into how TCRMs respond to controlled chemical challenges.

The Vickers microhardness test was used to evaluate the hardness of the composites, as it is more suitable for small, rounded specimens compared to the Knoop method, which is better for long, small specimens [15]. Hardness is closely linked to a material's compressive strength and its ability to resist dissolution and disintegration in the oral environment, all of which are key to long-term restoration stability and durability [16]. A material's hardness can also predict its wear resistance and potential to abrade opposing dental structures [14]. A decrease in surface hardness is typically associated with poor wear resistance, increased susceptibility to scratching, and ultimately, restoration failure [16, 17].

In this study, all materials demonstrated significant deterioration in microhardness over time in all FSLs, except air. This is likely due to the solvent solubility parameters of the FSLs, which can cause permanent deformation of the composite’s subsurface. The extent of the damage depends on the interfacial bonding between the organic matrix and fillers, as well as the degree of solvent penetration [18, 19]. LN exhibited the highest microhardness values across all mediums at both seven and 30 days, while SA consistently showed the lowest microhardness values. These findings are consistent with the known correlation between filler type and content and composite hardness [20]. AB had the highest filler volume (81%), while SA had the lowest (36.4%), which likely accounts for the observed differences in hardness. As SA's filler content falls within the range typical of flowable composites (37-53%), it may exhibit characteristics similar to those composites, which are generally weaker than conventional composites [21]. Despite AB having the highest filler content, LN had the highest microhardness. This may be due to LN’s smaller nanosized fillers (down to 40 nm), which improve strength, wear resistance, and reliability [22, 23].

For LN, no significant difference in microhardness reduction was observed between heptane, ethanol, and citric acid at seven days. However, after 30 days, heptane caused a significantly lower microhardness value compared to citric acid, suggesting a stronger long-term solvent effect. For AB, citric acid appeared less detrimental than artificial saliva, ethanol, and heptane at both time points. Ethanol had the most significant negative impact on microhardness, likely because it facilitates the release of monomers, weakening the composite matrix over time. Studies have shown that ethanol can diffuse into composites, causing microcracking, which promotes further penetration and softening of the matrix [24]. Our results align with this mechanism, particularly for composites containing UDMA, Bis-EMA and TEGDMA, which show decreased hardness when exposed to ethanol [25].

For SA, both air and heptane exhibited the least detrimental effects on microhardness, with artificial saliva being less aggressive than ethanol and citric acid. Citric acid caused the greatest reduction in hardness, likely due to its acidic nature, which can erode the resin matrix and release unreacted monomers [26].

Surface roughness is a key factor in plaque retention and the long-term performance of dental restorations [27]. Bollen et al. [8] reported that a surface roughness threshold of 0.2 µm promotes plaque retention. In this study, all materials maintained surface roughness values below this threshold, suggesting that the FSLs tested did not significantly increase the roughness of the composites over time. This could be due to the chemical composition of the composites and the solvent properties of the FSLs, which may influence the interaction between the resin matrix and filler particles [20]. SA exhibited higher roughness values compared to LN and AB, especially when immersed in heptane, while LN showed higher roughness values in citric acid and lower roughness in heptane. These variations likely result from differences in resin matrix composition and setting reactions between the materials, as LN is light-cured, while SA is self-cured.

Citric acid had the most significant impact on surface roughness, particularly for LN and AB. This finding is consistent with other studies, which report that immersion in acidic solutions can increase surface roughness due to erosion, cracking, and the formation of surface irregularities [28, 29]. For SA, however, immersion in citric acid led to a decrease in roughness after 30 days, possibly due to the smoothing effect of acid on an initially uneven or poorly polished surface. This could also be related to the composite’s resistance to further surface degradation [30].

Although ethanol did not have the most significant effect on surface roughness, it is known to plasticize the polymer matrix, which can pull apart residual monomers and weaken the composite [30]. This suggests that alcohol-containing beverages could decrease the durability of dental restorations. It may be prudent for clinicians to consider the dietary habits of patients when selecting restorative materials, in order to improve the functional longevity of restorations [31].

The findings from this in vitro study indicate that FSLs can alter the microhardness and surface roughness of TCRMs. While these results provide valuable insight, the experimental conditions do not fully capture the complexity of the oral environment, where factors such as saliva dilution, pH fluctuations, enzymatic activity, and mechanical forces during mastication interact to influence material degradation [32]. The continuous immersion model used here may overestimate chemical effects compared to the intermittent exposure typical in vivo, and the absence of salivary enzymes or thermal cycling limits simulation of natural ageing processes. Furthermore, the flat disc specimens employed do not replicate the anatomical features of actual restorations, such as grooves, fissures, and irregular margins, which can affect fluid retention, plaque accumulation, and wear patterns. Despite these limitations, the study highlights the erosive potential of FSLs, particularly for newer self-cured composites like Stela, and underscores the need for future investigations using more clinically representative protocols, including thermocycling, pH cycling, and mechanical loading.

CONCLUSION

Within the limitations of this in vitro study, all FSLs except air significantly affected the microhardness and surface roughness of the tested restorative materials. Both properties were strongly influenced by material composition and the type of chemical exposure. Stela Automix (self-cured composite) showed the lowest microhardness and highest surface roughness across most media, indicating greater vulnerability to chemical degradation, although a reduction in roughness was noted in citric acid.

These findings highlight the value of choosing restorative materials with higher filler content and optimised filler–matrix bonding, such as Luna, for patients frequently exposed to acidic, alcoholic, or fatty substances. For newer self-cured systems like Stela Automix, use should be approached with caution until long-term clinical evidence confirms their resistance to chemical challenges in the oral environment. A clear understanding of how different materials respond to common dietary exposures enables clinicians to make evidence-based choices that enhance restoration longevity and performance, particularly in patients with high-risk dietary habits.

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DECLARATION OF INTEREST

Authors declare no conflict of interest.

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