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RESEARCH AND EDUCATION

Mechanical properties and reliability of an additively manufactured resin incorporated with a commercially available ceramic composite concentrate

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ABSTRACT

Statement of problem. A ceramic composite concentrate that can be incorporated into resins used in additive manufacturing to improve their mechanical properties has been recently marketed. However, knowledge on whether this modification enhances the mechanical properties of such resins is lacking.

Purpose. The purpose of this in vitro study was to evaluate the mechanical properties and reliability of a dental resin used for additive manufacturing incorporated with a commercially available ceramic composite concentrate.

Material and methods. Specimens for flexural strength (17×4×1.5 mm, n=12), Vickers hardness (Ø10×1.5 mm, n=16), and fracture toughness (25×5×2.2 mm, n=15) tests were additively manufactured from an urethane acrylate-based resin with no fillers intended for definitive use (AM-D), a composite resin with ceramic fillers intended for definitive use (AM-DC), a resin with no fillers intended for interim use (AM-I), and the AM-I resin reinforced with a commercially available ceramic composite concentrate (AM-IR). The AM-IR resin was obtained by mechanically mixing 30 wt% of the ceramic composite concentrate with 70 wt% of the AM-I resin for 3 hours at 50 °C. Flexural strength and Vickers hardness data were analyzed with the Kruskal-Wallis and Dunn tests, while 1-way analysis of variance and the Tukey honestly significant difference tests were used for the fracture toughness data. Weibull modulus and characteristic strength were evaluated with the chi-squared test (α=.05).

Results. Resin type affected tested outcomes (P<.001). AM-DC and AM-IR had significantly higher flexural strength than the other groups (P≤.004). AM-DC also had the highest Vickers hardness among tested resins (P<.001). In terms of fracture toughness, AM-IR had the highest values followed by AM-DC (P≤.010). AM-IR had the highest Weibull modulus, and AM-DC had the highest characteristic strength among tested resins (P≤.019).

Conclusions. The resin modified with the ceramic composite concentrate had similar biaxial flexural strength to that of the composite resin with ceramic fillers intended for definitive use along with the highest Weibull modulus and fracture toughness. However, its Vickers hardness was similar to that of resins indicated for interim use. (J Prosthet Dent 2025;133:1089.e1-e7)

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Clinical Implications

The tested modified resin can be considered suitable for adhesively cemented single-unit restorations. In addition, crowns made of this resin may be more resistant to mechanical complications in the long-term than those made of other tested resins. However, the modified resin might be more prone to wear than the tested composite resin.

Interim prostheses play a crucial role in restoring function, esthetics, and occlusion, as well as protecting the pulp from thermal and mechanical stresses and preventing teeth from shifting until the definitive restorations are delivered.[1–4] Interim prostheses have been fabricated conventionally using direct or indirect techniques.[2,3] However, with the introduction of digital technologies, interim prostheses can be fabricated either using additive (AM) or subtractive (SM) manufacturing technologies.[5,6] The advantages of AM and SM include minimizing trauma to oral tissues by reducing monomer release and avoiding exothermic reactions, shortening chairside time, and enhancing fabrication accuracy.[5–8] In recent years, AM has become widely preferred because it allows for the unrestricted fabrication of complex geometries, minimizes nonreusable material waste, and enables the simultaneous production of multiple restorations at a lower cost.[9–11] AM interim prostheses can be fabricated from resins intended for interim use or from those intended for definitive use, which are also approved for long-term interim applications.[5,12] Interim intended resins are mostly methacrylate-based,[4,5] while resins intended for definitive use are typically urethane acrylate-based or composite resins reinforced with inorganic fillers such as glass-filler reinforced composite resin or interpenetrating network composite resins.[11,12]

Flexural strength, fracture toughness, and microhardness are important mechanical properties that have been reported to determine integrity, resistance to crack propagation and fracture, and resistance to wear, respectively.[2,12–17] Reliability, as assessed through Weibull analysis, is another important factor in evaluating a restorative material for long-term intraoral use and in providing 2 key outcomes as the Weibull modulus and characteristic strength. The Weibull modulus reflects the variability in the material's strength; a higher modulus indicates greater predictability, as failures are likely to occur within a narrower stress range. Characteristic strength represents the stress level at which 63.2% of tested specimens fail. A higher characteristic strength suggests the material can endure greater stress before reaching the point where failures start to become more frequent.[18] Irrespective of material and fabrication technology, interim prostheses should have sufficient mechanical properties to sustain occlusal forces during clinical use.[12,16,19] Particularly for long-term interim prostheses, long-span or cantilevered prostheses, or for patients with parafunctional habits such as bruxism, a high mechanical strength is required.[20–22] Hence, efforts have been made to improve the longevity and mechanical strength of the resins indicated for interim restorations,[4,23] including by incorporating organic or inorganic nanosized fillers.[4,24] Consequently, different nanoparticles have been used to reinforce polymethyl methacrylate or composite resins, and favorable mechanical, physical, and biological properties have been reported.[4,24–31] Along with the recent advancement of materials, nanosized ceramic fillers have been introduced to reinforce AM resins.[4,25,32] In addition, a biocompatible ceramic composite concentrate with nanoparticles, designed for incorporation into AM resins, has recently become available.[33,34] These ceramic nanofillers have also been preferred because of their ease of use in AM processes.[25,35–39] Improved mechanical properties[4] and antimicrobial capability[25] have been reported when AM acrylate ester-based interim intended resin has been reinforced with zirconia nanoparticles. In addition, adding 5 wt% glass fillers and 10 wt% to 20 wt% zirconia nanoparticles has been reported to improve the flexural strength and biocompatibility of the AM methacrylate-based resin intended for interim use.[26] Hence, zirconia nanoparticle reinforcement has been reported as a promising option for long-term interim restorations.[4,40] Previous studies have focused on the custom addition of particles to resins to enhance their mechanical properties.[4,13,14,26,27,30,31,37] However, the authors are unaware of a study that evaluated the effect of adding commercially available ceramic composite concentrate to an AM resin to improve its mechanical properties. A recent study on the fabrication trueness and fit of crowns in a resin incorporated with this ceramic composite concentrate reported deviations comparable with those of a resin with no fillers for interim restorations and a ceramic-filled resin intended for definitive restorations, with clinically acceptable internal gap values.[33] Thus, elaborating the knowledge on this ceramic composite concentrate with a study on whether the incorporated resin's mechanical properties would be comparable with that of resins intended for interim or definitive restorations may facilitate its clinical implementation. Therefore, the purpose of this in vitro study was to evaluate the flexural strength, reliability, Vickers microhardness, and fracture toughness of a resin incorporated with a ceramic composite concentrate by comparing it with a resin with no fillers indicated for interim use, a resin with no fillers indicated for definitive use, and a ceramic-filled resin indicated for definitive use. The null hypotheses were that the resin type would not affect the flexural strength, reliability, Vickers microhardness, or fracture toughness of the tested resins.

MATERIAL AND METHODS

A design software program (Meshmixer v3.5.474; Autodesk Inc) was used to design bar-shaped specimens for flexural strength (17×4×1.5 mm) and fracture toughness (25×5×2.2 mm) testing and disk-shaped specimens for Vickers hardness (Ø10×1.5 mm) testing in accordance with the International Organization for Standardization (ISO) 6872:2024 standard.[41] These design files were imported into the nesting software program (Composer v2.0; Asiga) of a 3-dimensional (3D) printer (MAX UV; Asiga) with digital light processing technology. Each design file was positioned horizontally on the build platform in a separate printing job. After automatically generating supports for each design, the bar-shaped specimens for the flexural strength test were duplicated to place 12 and those for the fracture toughness test were duplicated to place 15 specimens on the build platform, while for the Vickers hardness test, the design was duplicated to place 16 specimens on the build platform. The number of specimens in each group was determined after a power analysis by using the results of pilot tests with 4 specimens for each outcome (95% power, 8.8 minimum effect size, and α=.05).

Specimens for each test were fabricated by using an AM urethane acrylate-based resin with no fillers intended for definitive use (AM-D) (Tera Harz TC-80DP; Graphy Inc), an AM composite resin with ceramic fillers intended for definitive use (AM-DC) (Crowntec; Saremco), an AM resin intended for interim use (AM-I) (FreePrint Temp; Detax), and the same AM resin intended for interim use reinforced with a commercially available ceramic composite concentrate (AM-IR) (3D-ADD CCA1; 3DResyns). The AM-IR resin was prepared by mixing the AM-I resin with the ceramic composite concentrate with a ratio of 70 wt% of resin to 30 wt% of concentrate for 3 hours at 50 °C (MR 3001; Heidolph).[33] This mixture was prepared in a glass beaker without any light exposure during the process. Table 1 lists detailed information on the AM resins tested in the present study. All specimens were prepared by using the previously prepared nesting files with a standardized layer thickness of 50 µm. After fabrication, the AM-D specimens were ultrasonically cleaned in 96% ethanol for 45 seconds and further cleaned with 96% ethanol-soaked cloths, the AM-DC specimens were only cleaned with 96% ethanol-soaked cloths, and the AM-I and AM-IR specimens were ultrasonically cleaned in 98% isopropanol for 6 minutes (3 minutes of precleaning and an additional 3 minutes of main cleaning) (Fig. 1). After the specimens had been dried, all supports were removed under magnification loupes (EyeMag Pro ×3.5; Carl Zeiss) with a tungsten carbide bur (CX78M; Jota AG), and a xenon polymerization device (Otoflash G171; NK Optik) was used to polymerize all specimens under nitrogen gas atmosphere (2000 flashes × 2). All AM-IR specimens were fabricated on the same day the resin was prepared.

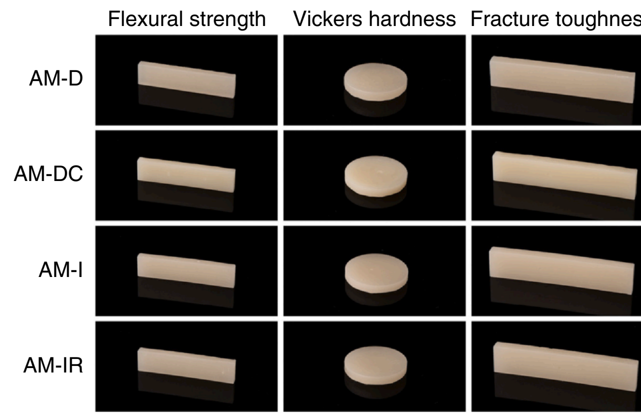

Figure 1. Representative specimens from each group for tested outcomes. AM-D, Additively manufactured urethane acrylate-based resin with no fillers intended for definitive use; AM-DC, Additively manufactured composite resin with ceramic fillers intended for definitive use; AM-I, Additively manufactured resin intended for interim use; AM-IR, Additively manufactured resin modified with ceramic composite concentrate.

Table 1. Resins tested

Resin	Abbreviation	Type	Chemical Composition
Tera Harz TC–80DP – A1	AM-D	Additively manufactured urethane acrylate-based resin with no fillers intended for definitive use	Urethane acrylate oligomer, bisphenol A ethoxylated dimethacrylate, 2-HEMA, diphenyl (2,4,6-trimethylbenzoyl) phosphine oxide, and additives
Crowntec – A1	AM-DC	Additively manufactured composite resin with ceramic fillers intended for definitive use	Esterification products of 4,4′-isopropylidiphenol, ethoxylated and 2-methylprop–2enoic acid, silanized dental glass, pyrogenic silica, initiators
FreePrint Temp – A1	AM-I	Additively manufactured resin with no fillers intended for interim use	Isopropylidenediphenol peg dimethacrylate, 7,7,9(or 7,9,9)-trimethyl–4,13-dioxo–3,14-dioxa–5,12-diazahexadecane–1,16-diyl bismethacrylate, 1,6-hexanediol dimethacrylate, 2-hydroxyethyl methacrylate, diphenyl(2,4,6-trimethylbenzoyl)phosphine oxide, Hydroxy propyl methacrylate, phenyl bis(2,4,6-trimethylbenzoyl)-phosphine oxide
FreePrint Temp – A1+3D-ADD CCA1	AM-IR	Additively manufactured resin intended for interim use reinforced with ceramic composite concentrate	Composition of ceramic composite concentrate is not disclosed

The flexural strength of the specimens was measured using a 3-point bend test with a universal test machine (zwickiline z1.0 TN; Zwick-Roell). The specimens' dimensions were measured before the test. The specimens were mounted on the vertical supports of the specimen holder apparatus of the universal testing device with a 12-mm span. A vertical load was applied to the center of the specimens with a 1 mm/minute crosshead speed.[41] The load was applied until the specimens fractured, and the maximum load at fracture was recorded. The flexural strength (σ) was calculated in MPa by using the flexural strength formula: $\sigma=3Fd/2wh^2$, where F (N) is the maximum load at fracture, d (mm) is the span length, w (mm) is the measured width of the specimen, and h (mm) is the measured thickness of the specimen.[2,12]

The Vickers hardness of the specimens was measured by applying 490.3 mN for 30 seconds at 10 different sites that were 0.5 mm apart from each other by using a Vickers hardness tester (Fischerscope HM2000; Helmut-Fischer). The values were then averaged.[4]

For the fracture toughness test, a notch of 2.5 mm was prepared in the center of the specimens designated for fracture toughness. The specimens were tested by using the same 3-point bend test machine (zwickiline z1.0 TN; Zwick-Roell) with a 20-mm span and 0.5 mm/minute crosshead speed.[40,42] The recorded maximum force was used to determine the fracture toughness (K_{Ic}) according to the following formula[42]:

$$KIC = \frac{F}{B\sqrt{H}} \times \frac{L}{H} \times \frac{3\sqrt{a}}{2(1-a)^{1.5}}\gamma,$$

where F is the maximum load applied at the fracture point, B is the width of the prepared specimen, H is the thickness of the as-prepared specimen, L is the length of the support span, α is the ratio of the notch depth to specimen height, and γ is the geometric shape factor.

The Kolmogorov-Smirnov test was used to evaluate the distribution of data, and the fracture toughness data showed a normal distribution, whereas the flexural strength and Vickers hardness data did not. Therefore, Kruskal-Wallis and Dunn tests were used for flexural strength and Vickers hardness data, while 1-way analysis of variance and the Tukey honestly significant difference tests were used to analyze the fracture toughness data. All analyses were performed using a statistical analysis software program (IBM SPSS Statistics, v23; IBM Corp) (α=.05). The Weibull analysis was performed by using the maximum likelihood estimation method (Minitab Software V.17; Minitab), and the Weibull moduli and characteristic strength values were further analyzed with the chi-squared test.

Table 3. Mean (95% confidence intervals) Weibull modulus and characteristic strength (MPa) values of test groups

	Weibull Modulus	Characteristic Strength
AM-D	6.9^{a}(4.6–10.5)	85.9^{a}(78.8–93.7)
AM-DC	14.5^{b}(9.4–22.3)	124.5^{d}(119.5–129.8)
AM-I	10.5^{ab}(6.6–16.6)	91.3^{b}(86.3–96.7)
AM-IR	30.6^{c}(19.6–47.5)	115.6^{c}(113.4–117.9)

Different superscript lowercase letters indicate significant differences among test groups (P<.05)

RESULTS

Resin type significantly affected the flexural strength (P<.001), fracture toughness (P<.001), and Vickers surface hardness (P<.001) values. When the flexural strength values were considered, AM-DC and AM-IR had statistically similar values (P>.05) that were higher than those of the remaining groups (P≤.004). The difference between AM-I and AM-D was not significant (P>.05) (Table 2). AM-IR had the highest Weibull modulus among tested resins, while AM-DC had the highest characteristic strength (P≤.019) (Table 3, Fig. 2).

When the Vickers hardness was considered, AM-DC had the highest values among tested resins (P<.001). The remaining pairwise comparisons were not statistically significant (P≥.244). When the fracture toughness was considered, AM-IR had the highest values (P≤.002), followed by AM-DC (P≤.010). The difference between AM-I and AM-D was not significant (P=.993) (Table 2).

DISCUSSION

The AM-IR resin had a higher flexural strength than the tested resins with no fillers and also had the highest

Table 2. Descriptive statistics of flexural strength (MPa), Vickers microhardness (HV), and fracture toughness (MPam$^{1/2}$) of test groups

	Flexural Strength		Vickers Microhardness		Fracture Toughness	
	Mean ±Standard Deviation (95% Confidence Intervals)	Median (Min-Max)	Mean ±Standard Deviation (95% Confidence Intervals)	Median (Min-Max)	Mean ±Standard Deviation (95% Confidence Intervals)	Median (Min-Max)
AM-D	80.6 ±12.4 (72.7–88.5)	78.9^{a} (63.2–106.2)	16.8 ±2.2 (15.6–18.0)	17.1^{a} (12.2–21.2)	0.58 ±0.08^{a} (0.53–0.62)	0.57 (0.45–0.68)
AM-DC	120.3 ±3.6 (114.3–126.3)	120.7^{b} (107.1–136.5)	34.9 ±1.8 (33.7–35.8)	35.1^{b} (31.1–37.2)	0.72 ±0.10^{b} (0.66–0.77)	0.72 (0.57–0.92)
AM-I	86.9 ±10.8 (80.0–93.7)	88.4^{a} (67.7–101.6)	18.5 ±0.7 (18.1–18.8)	18.6^{a} (17.1–19.2)	0.59 ±0.16^{a} (0.50–0.68)	0.61 (0.05–0.79)
AM-IR	113.6 ±4.4 (110.8–116.4)	113.3^{b} (107.1–120.5)	18.6 ±1.7 (17.7–19.5)	18.3^{a} (16.6–23.0)	0.87 ±0.07^{c} (0.83–0.91)	0.90 (0.74–0.95)

Different superscript lowercase letters indicate significant differences among test groups (P<.05)

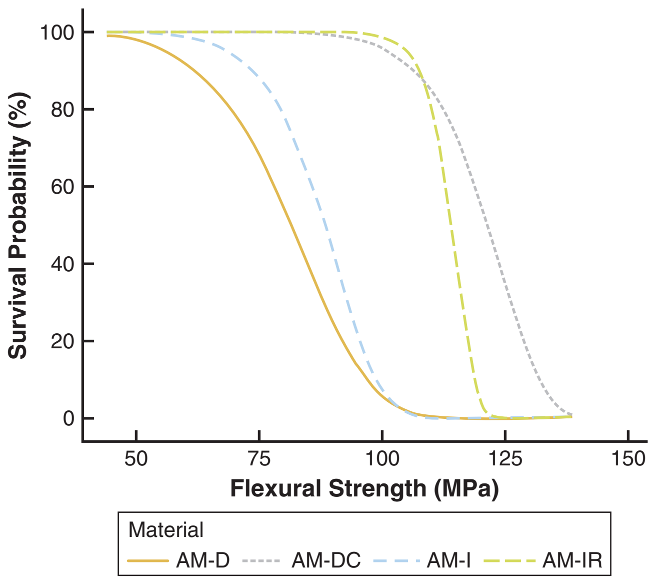

Figure 2. Survival probability (%) versus flexural strength (MPa) curves of tested resins. AM-D, Additively manufactured urethane acrylate-based resin with no fillers intended for definitive use; AM-DC, Additively manufactured composite resin with ceramic fillers intended for definitive use; AM-I, Additively manufactured resin intended for interim use; AM-IR, Additively manufactured resin modified with ceramic composite concentrate.

Weibull modulus and fracture toughness. However, it had lower Vickers hardness than the AM-DC resin, which also had the highest characteristic strength. Therefore, the null hypotheses that the resin type would not affect the flexural strength, reliability, Vickers microhardness, or fracture toughness of the tested resins were rejected.

The fabrication process of all specimens was standardized with the use of a single 3D printer and standardized print orientation and layer thickness. In addition, all specimens were postprocessed in line with respective manufacturers' recommendations. Even though the AM-IR resin does not have specified post-processing protocols, this resin was a homogeneous mixture of the AM-I resin with a ceramic concentrate that had a ratio in favor of the AM-I, justifying the postprocessing steps for the AM-IR. The significant differences among test groups appear to be related to the differences in chemical compositions and filler content.

Considering the ceramic content of some of the resin tested in the present study, particularly that of AM-IR, the specimens were prepared according to the ISO 6872:2024 standard for flexural strength tests.[41] The ISO 6872:2024 standard considers 100 MPa as the threshold flexural strength value for adhesively cemented anterior or posterior single restorations. In the present study, the AM-IR and AM-DC specimens had mean flexural strength values higher than 100 MPa, indicating that they are suitable for such indications. It should also be noted that the AM-IR specimens had the highest Weibull modulus and higher characteristic strength than the AM-I and AM-D specimens, while its difference from the AM-DC specimens was relatively small and potentially clinically negligible. Therefore, the AM-IR resin can be considered more reliable than the other resins tested, suggesting the AM-IR resin may be clinically successful. Since the AM-IR resin was prepared by mechanically mixing the AM-I resin with the tested ceramic composite concentrate, clinicians and dental laboratory technicians may extend the longevity of interim prostheses after an initial investment in equipment and the necessary learning curve while still achieving a cost-effective result compared with using the AM-DC resin, which is also indicated for interim use.[43] The flexural strength of ceramic-reinforced resins for AM has been a subject of interest with studies focusing on how barium silicate or zirconia addition affects this aspect.[4,13,14,26,30,31] The studies that focused only on barium silicate have reported increased flexural strength for resins incorporated with barium silicate when compared with resins without reinforcement.[13,30,31] In addition, parallel to the findings of the present study, one of those studies has shown that resins incorporated with 40 wt% and 50 wt% barium silicate had similar flexural strength to that of a commercially available resin with fillers intended for definitive use.[31] Aati et al[4] reported the enhancing effect of zirconia addition to the flexural strength of modified resins. This result was substantiated by Alshamrani et al, who[26] reported that zirconia or glass filler addition improved the flexural strength of resins significantly. The combination of barium silicate and zirconia in different ratios has also been tested in a recent study, and, regardless of the mixing ratio, filler reinforcement improved flexural strength values.[14]

Among the tested resins, AM-DC had the highest Vickers hardness, and the differences among other test groups were nonsignificant. This result may be related to AM-DC resin's high ceramic filler content that is between 30 wt% and 50 wt%, which potentially exceeds the 30 wt% ceramic content of the AM-IR resin. Considering that hardness is related to a material's resistance to surface wear, it can be hypothesized that restorations fabricated by using the AM-DC resin would be less susceptible to esthetic and mechanical complications related to wear induced by occlusal contacts and brushing. Two studies have also used the AM-D resin while testing the effect of filler incorporation on its Vickers hardness.[13,14] One of those studies focused on adding different ratios of barium silicate and zirconium silicate and reported increased hardness regardless of the filler ratio. In addition, the Vickers hardness was the highest among modified resins when the amount of zirconium silicate was 4 times that of the barium silicate by weight.[14] The other study showed that adding 20 wt %, 30 wt%, and 40 wt% barium silicate into the AM-D resin significantly increased its hardness.[13] Aati et al[4] tested the effect of zirconia nanoparticle addition on the hardness of a commercial resin and reported a positive correlation between Vickers hardness and filler content.

The AM-IR resin had the highest fracture toughness, which may enable restorations made of this resin to be more resistant to crack propagation than those made of the other tested resins.[4,13] A similar interpretation may also be made for the AM-DC resin, as it had higher fracture toughness than the tested resins with no fillers. However, these hypotheses need to be confirmed with studies on the long-term mechanical behavior of tested resins. The effect of barium silicate and zirconia addition on the fracture toughness of ceramic-reinforced resins for AM has been previously tested.[4,13,14,27] Dönmez et al[13] reported increased toughness with the addition of barium silicate into the AM-D resin, while Won et al[27] reported a positive correlation between the barium silicate content and fracture toughness of modified resins. In a study on the effect of zirconia concentration (0 wt%, 1 wt%, 2 wt%, 3 wt%, 4 wt%, and 5 wt%) on fracture toughness, it was concluded that all reinforced resins had higher toughness than the resin with no fillers and that the fracture toughness showed a positive correlation with zirconia concentration up to 3 wt%.[4] In the only study on the combined effect of barium silicate and zirconia on the fracture toughness of a resin for AM, AM-D resin's fracture toughness increased significantly irrespective of the ratio between the barium silicate and zirconia.[14]

The mechanical properties of ceramic-reinforced resins for AM other than those tested in the present study have also been investigated previously.[4,13,14,27,31,37] In some of those studies, filler reinforcement led to a significant increase in flexural modulus, yield strength, ultimate strength, and Knoop hardness,[4,13,14,27,31] while another study concluded that filler addition did not affect the fracture resistance.[37] Nevertheless, increased filler concentration was also reported to impair the degree of conversion,[4] surface roughness,[13,14] transmittance,[13] flowability,[27] homogeneity,[27] translucency,[30] and nanoindentation properties[4] of modified resins. Therefore, future studies are needed to optimize the effect of adding filler to resins for AM.

Limitations of the present study included that the tested specimens had simple geometries that did not simulate actual clinical situations; nevertheless, each geometry was used considering the ISO standards for them to be suitable for the tests. With a more complex geometry in the shape of a crown or a fixed partial denture, the results may change. The standardized fabrication process was another limitation, and changing the 3D printer, build orientation, and layer thickness may affect the results. The present study did not involve a subtractively manufactured resin as the control group, although it aimed to evaluate the mechanical properties of a resin incorporated with a commercially available ceramic composite concentrate against resins with similar compositions without the effect of the manufacturing process. This could not have been possible if a subtractively manufactured resin group had been added. The absence of aging is also a limitation as previous studies have reported the detrimental effect of aging on the mechanical properties of resin-based materials.[4,12,17] Future studies should elaborate the findings of the present study by investigating how aging with different methods affects the AM-IR resin when tested outcomes along with other properties that could impact the longevity of a restoration such as fracture strength, surface roughness, stainability, translucency, and wear are considered. It would also be beneficial to compare the AM-IR resin with other commercially available resins with fillers and with resins incorporated with other fillers.

CONCLUSIONS

Based on the findings of this in vitro study, the following conclusions were drawn:

1. The modified resin and the resin containing ceramic fillers intended for definitive use may be suitable for adhesively cemented single-unit restorations because of their similar flexural strength values (P>.05), which exceeded the 100 MPa threshold set by ISO 6872:2024 standard. The modified resin may also be considered more reliable than the other resins in terms of mechanical stability, considering its higher Weibull modulus.
2. The modified resin and the resins with no fillers may exhibit similar wear resistance because of their comparable Vickers hardness (P≥.244).
3. The modified resin may have the highest resistance to crack propagation and related complications considering that it had the highest fracture toughness (P≤.002).

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Gabriela Panca Sabatini: Conceptualization, Methodology, Investigation. **Hyung-In Yoon:** Conceptualization, Writing - review and editing. **Gülce Çakmak:** Investigation, Writing - original draft. **Nadin Al-Haj Husain:** Formal analysis. **Burak Yilmaz:** Conceptualization, Writing - review and editing. **Mustafa Borga Donmez:** Writing - original draft, Writing - review and editing.

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