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Evaluation of Different Materials and Techniques Used for Repairing of Digital Denture Base

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ABSTRACT

Aim: to assess the effect of different materials and techniques of surface treatment on the flexural strength of repaired 3D-printed denture base. **Subjects and Methods:** A total of 150 specimens were printed on a 3D printer in a rectangular shape in dimensions 65×10×2mm. The flexural specimens were 10 groups (n=15). Each specimen was sectioned in the middle into two halves. Group 1 (control), the first three groups repaired with 3D denture base resin using surface treatment of Monomer, Sandblasting, and a combination of both respectively. The second three groups repaired with heat-polymerized polymethyl methacrylate (HPA) using surface treatment of Monomer, Sandblasting, and a combination of both respectively. And last three groups repaired with Auto-polymerized polymethyl methacrylate (APA) using surface treatment of Monomer, Sandblasting, and a combination of both respectively. The flexural strength was measured using a universal testing machine. Statistical analysis was done using one-way ANOVA test and Tukey's post-hoc test (α=.05). **Results:** The groups repaired with 3D denture base resin was significantly the highest mean flexural strength. Mechanical surface treatment was significantly the highest mean flexural strength in every repaired material. **Conclusions:** The 3D denture base resin is the material of choice for repairing fractured 3D dentures followed by (HPA) and then (APA). Mechanical surface treatment is recommended for repairing 3D dentures.

KEYWORDS

3D-printed acrylic resin denture bases, Denture repair, Surface treatment, Flexural strength, Polymethyl methacrylate

INTRODUCTION

Edentulism is the condition of being edentulous or lacking natural teeth. Adequate dentition is critical for overall health and quality of life. Patients with edentulism have a wide range of physical variations and medical conditions(1). One of the most essential demands for patients to restore aesthetics and function is the replacement of missing teeth which leads to an improvement in life quality as oral health improves(2). For medical and financial reasons, conventional complete and partial dentures are still preferred as a treatment option for edentulous patients(3). Dentures can now be fabricated using computer-aided design and computer-aided manufacturing (CAD/CAM) or additive technologies

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(3D printing) in conjunction with traditional heat curing and self-curing acrylic resin, these technologies have shown promise in providing a promising solution for some denture fabrication challenges[4].

Digital light processing (DLP) stands out among 3D printing technologies for dental applications due to its speed and high resolution[5]. To date, chair-side computer-aided technology has been used to fabricate entire dentures, simplifying laboratory procedures, and reducing the number of patient visits[6]. Furthermore, previous case reports demonstrated that the DLP printed denture base can more accurately fit the patient's alveolar bone and mucosa, resulting in better retention and stability[7]. When compared to the heat-cured denture base, the denture base made with additive manufacturing has a higher retentive force, most likely due to better border sealing and more uniform pressurization[8]. The conventional methyl methacrylate (MMA) is similar in some ways to the 3D printed material denture base, with the denture base material used for DLP which is typically made up of multiple polymers of methacrylate or acrylate monomers and oligomers. Although manufacturers may disclose certain fundamental mechanical parameters, many other aspects of the new materials' performance are unknown. So, there is a need for more research into this novel material, and one of the aspects that should be studied is reparability, as repairing an old denture is more efficient and cost-effective than making new ones[8]. Denture fracture is one of the most prevalent difficulties with complete dentures, owing to the complicated intraoral forces caused by mastication[9]. It is estimated that denture base fractures account for one-third of all complications, particularly for maxillary complete dentures[9].

Bonding the two fractured portions using resins is a standard procedure for denture repair. Previous research has revealed that repaired dentures are prone to fracturing repeatedly at the interface junction between the repair material and the damaged surface[10]. As a result, adequate strength at the bonded contact is required for long-term success following repair. Previous studies have carefully investigated the repair of common denture base materials. Surface treatments, among other considerations, may play an important role in enhancing the bonding contact[11]. Chemical etching using MMA monomer might greatly improve bond strength[10]. The fundamental process is that the monomer may disintegrate the surface of PMMA, resulting in more superficial pits and fissures that are advantageous for bonding[12].Mechanical roughening of the cracked surface, on the other hand, can improve bond strength by expanding the effective bonding area for mechanical retention, such as grinding with burs and sandblasting[13].

MATERIALS AND METHODS

1. Preparation of the specimens:

The test specimen was designed as a rectangle shape using computer-aided design software (solid works,Dassault Systèmes SolidWorks Corp,France). A total of 150 specimens were printed vertically with 100 µm layer in thickness (z-direction angulated 90◦ to the printing direction) by a DLP 3D printer (Rasdent SP, Rapid Shape, Raspart, Netherlands) using a denture base material (FREEPRINT denture, Detax, Ettlingen, Germany).150 specimens with dimensions of 65mm × 10mm × 2mm according to ISO standard (20795-1:2013) for flexural strength test. The specimens measured by digital caliper for dimensions checking. According to the manufacturer's instructions. Post-processing was done by cleaning the test specimens in isopropanol > 98% with an ultrasonic cleaner (GT Sonic, China) for 2: 3 minutes. and post-curing in a light chamber (Huge Dental Material Co., Ltd,China)for 10 min.

The 150 prepared aged specimens were randomly divided into ten groups, 15 specimens per group (N=15) for flexural strength test.

2. Specimens grouping:

Group 1 (control)None repaired and without any surface treatment specimens of 3D printing denture base material.

The next three groups (Group 2,3 and 4) repaired with 3D denture base resin using surface treatment of Monomer coating, Sandblasting, and a combination of both respectively.

The second three groups (Group 5,6 and 7) repaired with heat-polymerized polymethyl methacrylate (HPA) using surface treatment of Monomer coating, Sandblasting, and a combination of both respectively.

The last three groups (Group 8,9 and 10) repaired with Auto-polymerized polymethyl methacrylate (APA) using surface treatment of Monomer coating, Sandblasting, and a combination of both respectively.

To ensure the standardization of the cutting process, for flexural specimens, a customized silicon putty rubber base mold done by taking impression of intact specimen. Each specimen was marked by a pen in the middle of it to mark the section line and a dovetail in standardized shape and size was created to each side of the repairing area not apposing to each other and copied to other specimens by a carbon paper. The specimens were sectioned in the middle into two halves using a thin diamond fissure bur under water coolant creating 1mm-gap for repair. The sectioned specimen's edge of one half was shaped into a bevel contour.

3. Repair Procedures:

To ensure the standardization of the repair process, each specimen was fixed by using the customized silicon putty rubber base mold. Figure (1).

- ***Surface treatment procedure:***

For Chemical treatment groups:

The repair site edges from both segments were initially wetted with monomer liquid of methyl metha acrylate (MMA) applied for 3 min using a micro brush Monomer coating.

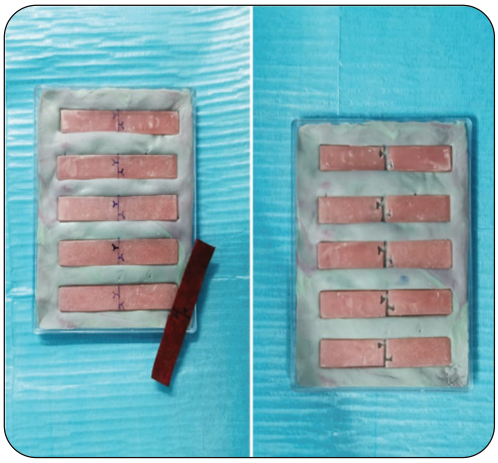

Fig. (1) Specimens, were fixed, marked, then cut into two equal halves

For Mechanical treatment groups

The repair site edges from both segments were pretreated with 125 µm alumina oxide air abrasion under 0.2 Mpa pressure at distance 10 mm for 10 s sandblasting.

Combination treatment groups:

The repair site edges from both segments were first pretreated with s sandblasting. Then wetted with monomer liquid of MMA.

- ***Repairing with different materials:***

i. 3D printing denture base resin repair:

The specimens were fixed in a customized silicon putty rubber base mold. 3D denture base resin was drawn up into a light-protected syringe from the 3D material (FREEPRINT) and applied into the sectioned site .Polymerization was performed layer-by-layer (each layer < 2 mm) using a light-emitting diode curing device (1200 mW/cm^2, LED 55N Cordless, TPC, USA) for 60 s. After polymerization, UV-post-cured for 10 min in a light oven (Huge Dental Material Co., Ltd, China) according to the manufacturer's Instructions. Then finished and polished. Figure (2).

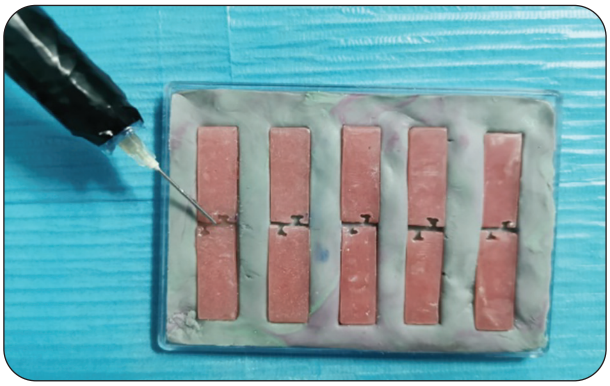

Fig. (2) Applying the 3D denture base material into the sectioned

ii. Heat-polymerized polymethyl methacrylate resin repair:

The conventional dental compression molding technique using gypsum investment was applied to prepare specimens mold in the flask. The intact specimens were painted with separating medium, flasked in dental stone and removed from the flask after setting of the dental stone leaving mold spaces having the same dimensions of the specimens. Following the manufacturer's instructions, The PMMA, (Acro stone dental manufacture, England), powder and monomer liquid and the polymer to monomer ratio is 2.5:1 by weight; the material was mixed until reaching the dough stage. The resin was packed at the dough stage into the sectioned site very well, flasked and placed under compression for 30 min at room temperature. Subsequently, it was heat-cured in a short-cycle water bath for 30 min at 100 C0. Post heat-curing, the denture flasks were allowed to cool down to room temperature, then finished and polished. Figure (3)

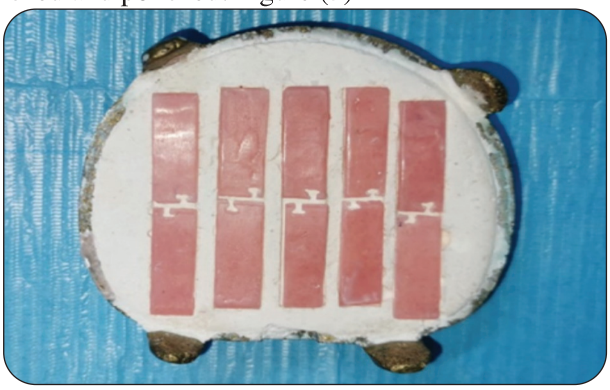

Fig. (3) Flasking the sectioned specimens

iii. Auto polymerized polymethyl methacrylate resin repair:

Following the manufacturer's directions, the auto-polymerizing acrylic resin was mixed and applied to the repair location in a free-flowing state. (APA) resin was used to fill the gaps. Given the shrinkage after polymerization and to assure safe finishing and polishing, the gaps were slightly overfilled, and bench polymerized for 2 hours at room temperature before being finished and polished.

The dimension of each specimen in each group were measured using digital caliper to account for changes in the specimen's dimensions during polishing, and the repair site was washed with water and cleaned with an ultrasonic cleaner for 10 minutes in accordance with the manufacturer's instructions.

4. Flexural strength test:

A universal testing device (Model 3345; Instron Industrial Products, Norwood, A, USA) was used for the flexural test, with the crosshead speed set to 1 mm/min. The maximum load necessary to fracture the samples was measured after the load was applied in the middle of the repair site. Figure (4)

5. Statistical Analysis:

The obtained data were evaluated with ANOVA and Tukey's post-hoc test using SPSS 19 (IBM Corporation, Armonk, NY, USA) at the significance level p = 0.05.

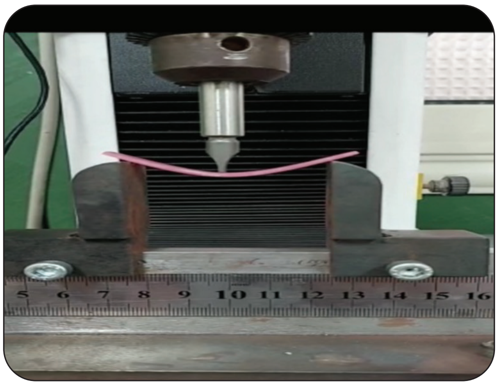

Fig. (4) Flexural strength Test Setup

RESULTS

Descriptive statistics of flexure strength test results; mean values, standard deviation (SD) measured in mega-Pascal (MPa) for Different types of repairing materials and different surface treatment are summarized in table (1) and graphically drawn in figure (5).

Table (1) *Descriptive statistics of flexure strength for Different types of repairing materials and different surface treatment*

Group	Surface Treatment	Mean	SD	Statistics p value
3D denture base resin	(G.2)	269.1	±31.2	p=0.00005 (p<0.05)
	(G.3)	650.3	±25.1	
	(G.4)	356.3	±27.1	
HPA	(G .5)	189.5	±15.1	p=0.00007 (p<0.05)
	(G .6)	429.2	±24.4	
	(G .7)	263.7	±15.2	
APA	(G .8)	156.2	±16.5	p=0.00027 (p<0.05)
	(G .9)	255.5	±16.9	
	(G .10)	219.1	±13.9	
Control	No treatment	783.7	±27.6	

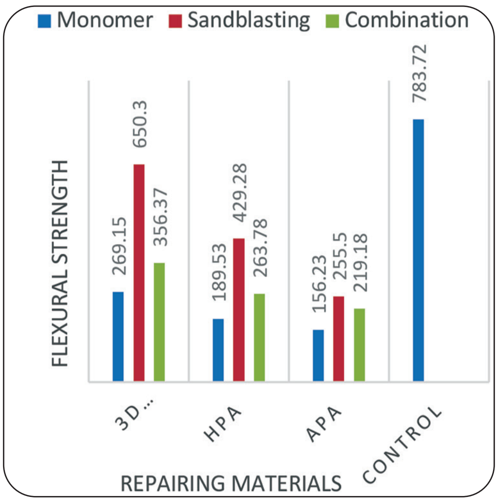

Fig. (5) Column chart showing flexure strength mean values for Different types of repairing materials with different surface treatment compared to control group

I. Result of Repairing material

i. 3D denture base resin

The highest mean value was recorded for control group; (783.72 MPa) followed by (Group 3) mechanical surface treatment sandblasting with mean value (650.30 MPa) then (Group 4) combination treatment with mean value (356.37 MPa) and the lowest is (Group 2) treated with chemical surface treatment monomer coating with mean value (269.15 MPa). There was highly statistically significant difference between control group and 3D denture base resin Groups as the significant value was p=0.0000 (p<0.05) as indicated by ANOVA test.

In Pair-wise Tukey's post-hoc multiple comparisons test showed there was highly significant difference between control group and 3D denture base resin Groups (Groups2, 3& 4) Monomer, sandblasting, and combination respectively, with p= (0.0000, 0.007 &0.0000) respectively. Also, there was highly significant difference between (Group 3) Sandblasting and (Groups 2, 4) Monomer and combination respectively, with p= (0.0000 and 0.0000) respectively, but There is no statistically significant difference between (Group 2) Monomer coating and (Group 4) combination treatment. As the p= 0.131.

ii. Heat Polymerized Acrylic resin:

The highest mean value was recorded for control group; (783.72 MPa) followed by (Group 6) mechanical surface treatment sandblasting with mean value (429.28 MPa) then (Group 7) combination treatment with mean value (263.78 MPa) and the lowest is (Group 5) treated with chemical surface treatment monomer coating with mean value (269.15 MPa). There was highly statistically significant difference between control group and Heat Polymerized Acrylic resin (HPA) Groups as the significant value was p=0.000 (p<0.05) as indicated by ANOVA test.

In Pair-wise Tukey's post-hoc multiple comparisons test showed there was highly significant difference between control group and Heat Polymerized Acrylic resin (HPA) Groups (Groups 5, 6&7) Monomer, sandblasting and combination respectively, with p= 0.0000 for each, Also there was highly significant difference between (Group 6) Sandblasting and (Groups 5, 7) Monomer and combination respectively, with p=(0.0000 , 0.0001) respectively, but There is no statistically significant difference between (Group 5) Monomer coating and (Group 7) combination treatment. As p= 0.061.

iii. Auto Polymerized Acrylic resin:

The highest mean value was recorded for control group; (783.72 MPa) followed by (Group 9) mechanical surface treatment sandblasting with mean value (255.50 MPa) then (Group 10) combination treatment with mean value (219.18 MPa) And the lowest is (Group 8) treated with chemical surface treatment monomer coating with mean value (156.23 MPa). There was highly statistically significant difference between control group and Auto Polymerized Acrylic resin (APA) Groups as the significant value was p=0.0000 ($p<0.05$) as indicated by ANOVA test.

In Pair-wise Tukey's post-hoc multiple comparisons test showed there was highly significant difference between control group and Auto Polymerized Acrylic resin (APA) Groups (Groups 8, 9&10) Monomer, sandblasting and combination respectively, with p=0.0000 for each, Also there was significant difference between (Group 9) Sandblasting and (Group 8) Monomer coating with P=0.04, but There is no statistically significant difference between (Group 10) combination treatment and (Groups 8&9) Monomer and sandblasting treatment respectively, as the p= 0.114 & 0.555 respectively.

II. Result of surface treatment:

Descriptive statistics mean values of Surface treatment of different repairing materials graphically drawn in figure (6).

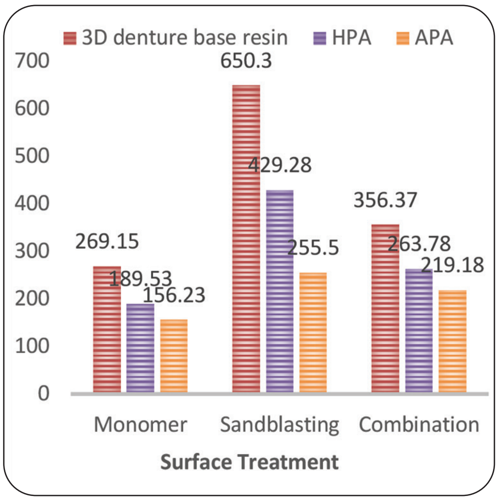

Fig. (6) Column chart showing flexure strength mean values for Different types of surface treatment of repairing materials

i. Chemical surface treatment (Monomer coating)

There was statistically significant difference between 3D denture base resin, HPA and APA repairing materials as the significant value p= 0.00268 (p0.05<) as indicated by ANOVA test.

In Pair-wise Tukey's post-hoc multiple comparisons test showed there was significant difference between (Group 2) for 3D denture base resin and (Groups 5&8) for HPA &APA respectively with P=0.039 &0.002 respectively, but There is no statistically significant difference between (Group 5) for HPA and (Group 8) for APA as p=0.543.

ii. Mechanical surface treatment (Sandblasting)

There was highly statistically significant difference between Different types of repaired materials as the significant value p= 0.0000 (p0.05<) as indicated by ANOVA test.

In Pair-wise Tukey's post-hoc test showed there was significant difference between 3D denture base resin and HPA and APA repairing materials as P= 0.0000 for both. And there was significant difference between HPA & APA repairing materials as p=0.0000.

iii. Combination of surface treatment (Sandblasting and Monomer coating):

There was statistically significant difference between Different types of repaired materials as the significant value p= 0.00005 (p0.05<) as indicated by ANOVA test.

In Pair-wise Tukey's post-hoc test showed there was significant difference between 3D denture base resin and HPA and APA repairing materials as p=0.005&0.0000 respectively. And there was no statistically significant difference between HPA & APA repairing materials as p=0.256.

DISCUSSION

Currently, digital dentistry is making it easier to receive dental treatments. 3-D printing technology makes it possible to fabricate complex dental lab work with incredible accuracy, RPD frameworks, and complete dentures. However, more research is still needed to determine how well these new dental materials perform[14].

There have been several studies that have examined the mechanical strengths of 3-D printing materials and suggested strategies to enhance their qualities. One of the problems with 3-D printing materials is their poor mechanical strength compared to the definitive materials[15, 16]. Another issue is reparability; the protocols and materials that may be used to fix 3-D printed denture bases are not well documented in the literature. Even if the materials offer benefits over the conventional materials, this uncertainty may limit the usage of 3-D printed resins[17].

The current study used the traditional method of denture repair, bonding with monomer resin, and demonstrated its feasibility. Furthermore, the effects of surface treatment on flexural strength were examined. To limit the amount of repair material and, as a result, minimize polymerization shrinkage, the repair site dimension was kept evenly at 1 mm[18].

The selection of the appropriate repair material is critical. As a result, we chose this novel 3D denture base resin as a repair material in this study due to its likeness to the original specimen material, as its precise constituents are typically kept secret because to commercial interests.

The denture base material used for DLP is often made of multiple polymers of methacrylate or acrylate monomers and oligomers, which is comparable to the standard methyl methacrylate (MMA) in certain ways. Considering this, HPA and APA resins, which are in line with a recent study, would be the alternative repair material[19, 20].

The ultimate objective of denture repair is to achieve a strong, long-lasting connection between the repair material and denture base resin that, ideally, matches the strength of the original[21].

In order to investigate prospective procedures for the repair of printed denture bases, the flexural strength of various repair materials bound to 3-D printed resin was compared to that of fully undamaged 3-D printed resin (control specimens) in this study. The specimens were constructed to be the same size in all groups, and the testing groups' repairs followed the usual techniques outlined in the manufacturer's instructions.

The purpose of this study was to determine the repair ability of 3D printed digital denture base material by measuring the flexural strength between 3D printed denture base and various types of repairing materials based on (1) the type of repairing materials resin and (2) different surface treatments. The null hypotheses were that (I) no difference in flexural strength exists according on the kind of repairing materials resin and (ii) no difference in flexural strength exists based on different surface treatments. Both null hypotheses were rejected since the 3D denture base group had the greatest mean value in Flexural strength across all repairing materials. And, of all surface treatment processes, mechanical surface treatment (sandblasting) has the greatest mean value in Flexural strength.

As a control, group 1 was used to contrast the various repair materials. The outcomes shown a statistically significant difference in the mean value of flexural strength between the control and all test groups (Groups 2:10). This showed that the repair materials couldn't achieve the same strength as the control group made via 3D printing. A repaired denture foundation would not be as strong as an intact denture base, regardless of the material used. Because of this, the bonding of the repair ingredients to the 3-D printed resin cannot be employed as a long-term repair or to replace the remake of a severely cracked denture.

According to the current study, 3D denture groups, independent of surface treatment, had the greatest mean value in Flexural strength compared to other methyl methacrylate groups. This difference could be attributed to (1) the viscosity of the 3D denture resins or (2) the layered structure of the 3D printed resin, as well as the association and similarity between the original specimen material and repaired material, resulting in a strong chemical bond even without any surface treatment, which is consistent with data obtained in previous studies[19,22].

Another important finding was that repairing with HPA resin showed higher flexural strength compared to APA in mechanical surface treatment, there was statistically significant between HPA groups and APA groups. This result may be explained by the fact that the bulk acrylic resin material possibly could have aided in better chemical bonding and adhesion. Initial low consistency resin mix, along with the presence of the monomer form the durable secondary semi-interpenetrating polymer networks[23]. Additional heat exposure during the repair process is also anticipated to help bulk acrylic resin continue to polymerize and help additional polymer penetrate the micro grooves to provide mechanical interlocking retention. However, the ANOVA (one way) showed that HPA groups treated with monomer and combination treatment and corresponding APA groups were not statistically significant at flexural and shear bond strength.

Although the sandblasting treatment's HPA repair strengths are promising, it is rarely used because of several undesirable aspects, including higher laboratory costs because a split gypsum mold must be made; risks of heat-induced deformation; lengthy polymerizing processes; and the patient's lack of a denture during the repairing procedure. APA is favored owing to its simple, rapid, and affordable laboratory process for repairing the cracked 3Ddenture basis. Because there was no statistically significant difference between HPA and APA in this study.

Also, the bond strength values of APA groups to 3D printed material were at the level of generally accepted adequate bonding values for prosthetic materials. Good bonding properties were expected to be based on free radical polymerization and this result match those observed in earlier study[20]. which conclude that the bond strength of auto polymerizing acrylic resin to 3D printed thermoset plates is higher when compared to thermoplastic plates and it is adequate for adjusting the splint by adding self-cure acrylic resin.

Some studies suggested using bonding agents containing methyl methacrylate (MMA) monomer, which significantly improved the bond strength compared to the non-pretreated group[24, 25].it was expected that MMA monomer treated groups may increase the bond strength both mechanically and chemically.

Contrary to expectations, the findings of the current study showed that, independent of the kind of repaired material, groups treated with monomers had the lowest mean values of flexural strength. This outcome might be explained by the fact of chemically wetting the 3D-printed denture base material with the MMA monomer did not produce any noticeable morphological changes on the surface. This showed that when compared to traditional denture base materials, 3D printed denture base materials have greater chemical resilience to MMA monomer. This finding might be explained by the examined 3D-printed denture base material's predominant composition of di-methacrylate monomers and oligomers (MMA-free composition).

To effectively etch the 3D printed denture base material, more aggressive organic solvents might be considered, such as acetone, chloroform, methylene chloride, and dichloromethane[(19)].

Palitsch et al.[(26)] reported that methyl methacrylate does not co-polymerize adequately with the bifunctional monomers of light curing denture base materials, and hence MMA is not an acceptable conditioning liquid. for 3D printed resin. This might also explain why monomer wetting groups have the lowest mean value in flexural and shear bond strength in various mending materials. And our findings are consistent with earlier research[(19,22,27)].

In each repaired material type, sand blasting treated groups had the greatest mean value in Flexural strength than any other surface treatment. This increase in bond strength may be attributable to enhanced surface roughening following sandblasting with aluminum oxide particles, which increased the surface area accessible for bonding where some mechanical interlocking may have occurred across the interface. Furthermore, the increased bonding strength might be attributed to the removal of a saturated surface layer through sandblasting with aluminum oxide particles, which exposed a subsurface layer with a greater free surface energy[(24)]. The freshly alumina-blasted resin surface has a greater free surface energy than the untreated surface, which might explain why roughening increases bonding[(28)]. These finding with sandblasting with aluminum oxide particles treatment were in accordance with this researcher[(22)]. and other very recent study which evaluate the effect of surface treatment on the Repair ability of a 3D printed denture base polymer[(19)].

However, compared to sandblasting alone, combination treatment was found to have a lower mean value for flexural and shear bond strength. This finding may be explained by the fact that monomer coating after sandblasting has weakened the bond by obstructing the micro groove, smoothing out the edges of the 3D denture base, and acting as a barrier against strong mechanical interlocking.

CONCLUSION

With the limitation of the present study, the research be deduced that, the 3D denture base resin is the first-choice material for repairing fractured 3D dentures followed by (HPA) and then (APA). Mechanical surface treatment (Sand blasting) is recommended for repairing 3D dentures. Monomer coating is not recommended for repairing 3D dentures. The bond strength of auto polymerizing acrylic resin to 3D printed is adequate for minimal adjusting and repairing 3D dentures by adding self-cure acrylic resin because its minimal cost and easy manipulation.

A further study could assess the long-term effects of repairing 3D dentures and effect of aging on the bond strength.

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تقييم مواد وطرق مختلفة لإصلاح قاعدة اطقم الأسنان الرقمية

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الملخص:

الهدف: أُجريت هذه الدراسة لتقييم تأثير المواد المختلفة والمعالجة السطحية على قوة رابطة الانحناء والقص لقاعدة الأسنان المطبوعة ثلاثية الأبعاد بعد إصلاحها.

المواد والاساليب: تم طباعة ما مجموعه 150 عينة بواسطة طابعة ثلاثية الأبعاد باستخدام مادة قاعدة أطقم الأسنان في شكل مستطيل باستخدام برنامج تصميم بمساعدة الكمبيوتر بأبعاد 65 × 10 × 2 مم لاختبار قوة رابطة الانحناء. كانت عينات قوة رابطة الانحناء 10 مجموعات (ن = 15). تم تقسيم كل عينة في المنتصف إلى نصفين باستخدام قاطع رفيع من الماس تحت التبريد المائي. تم تشكيل حافة نصف العينة المجزأة في محيط مائل. المجموعة 1 الحاكمة. اول ثلاث مجموعات تم إصلاحهم براتنج قاعدة طقم الأسنان ثلاثي الأبعاد مع المعالجة السطحية باستخدام مونومر وتخشين رملي ومزيج من كليهما على التوالي. وثاني ثلاث مجموعات تم إصلاحهم باستخدام بوليميثيل ميثاكريلات المبلمر بالحرارة مع المعالجة السطحية باستخدام مونومر وتخشين رملي ومزيج من كليهما على التوالي. واخر ثلاث مجموعات تم اصلاحهم باستخدام البولي ميثيل ميثاكريلات المبلمر ذاتيا مع المعالجة السطحية باستخدام مونومر وتخشين رملي ومزيج من كليهما على التوالي. ثم قياس قوة الانحناء باستخدام آلة اختبار شاملة. تم إجراء التحليل الإحصائي باستخدام اختبار أحادي التباين ذا الاتجاه الواحد (أنوفا) واختبار توكي ما بعد انوفا (الفا =0.05).

النتائج: أظهرت المجموعة التي تم إصلاحها باستخدام راتنج قاعدة أطقم الأسنان ثلاثية الأبعاد أعلى متوسط لقوة الانحناء. كانت أعلى بكثير من المجموعات الأخرى التي تم إصلاحها باستخدام ميثيل ميثاكريلات التقليدي. أظهرت المعالجة الميكانيكية للسطح (التخشين الرملي) أعلى متوسط مقاومة لقوة الانحناء في كل مادة تم إصلاحها. المعالجة الكيميائية للأسطح (طلاء مونومر) لم تقو الرابطة وليست سائل تكييف مناسب لقاعدة أطقم الأسنان ثلاثية الأبعاد.

الخلاصة: أظهرت المواد الرقمية لقاعدة أطقم الأسنان المطبوعة ثلاثية الأبعاد نتيجة إصلاح ممتازة وقد تكون بديلاً جيدًا لمواد الاطقم التقليدية لغرض التحول الرقمي في صناعة الأسنان. الراتنج الرقمي لقاعدة اطقم الأسنان ثلاثي الأبعاد هو الخيار الأول لإصلاح أطقم الأسنان الرقمية ثلاثية الأبعاد يتبعها بوليميثيل ميثاكريلات المبلمر بالحرارة ثم البولي ميثيل ميثاكريلات المبلمر ذاتيا.

الكلمات المفتاحية: قواعد أطقم الأسنان المصنوعة من الراتنج الأكريليكي المطبوعة ثلاثية الأبعاد,أصلاح اطقم الأسنان, قوة الأنثناء, بوليميثيل ميثاكريلات