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Original Article

Evaluation of surface roughness of resin materials with different contents

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Abstract

Aim: The aim of this study is to compare the roughness level of the surfaces of polymerized temporary acrylic resin, standard 3D resin, temporary 3D resin materials with polished and unpolished conditions.
Methodology: Thirty samples of 1 cm diameter and 5 mm height cylinders of temporary 3D resin (Alias C & B Temp, Dokuz Kimya, İstanbul, Türkiye) and standard 3D resin (Alias Sharp & Rigid, Dokuz Kimya, Dokuz Kimya, İstanbul, Türkiye) were produced with 3D printer (Photon Mono X, Anycubic). Residual resins were cleaned in Wash & Cure Plus (Anycubic) device using isopropyl alcohol and kept under UV light for 10 minutes in the same device to fully polymerize. Self-curing temporary acrylic resin (Imident, Imicryl, Konya, Türkiye) was prepared according to the manufacturer's instructions and 30 samples were prepared by transferring them to moulds of the same size. Half of the samples in each material were polished for 90 seconds with the same dentist using polishing paste (Universal Polishing Paste, Ivoclar Vivadent) (n=15). The surface of each sample was measured three times with a 120˚ angle difference using a profilometer (SJ-201, Mitutoyo, Kanagawa, Japan) and the average was taken. Levene test, t test, two-way ANOVA and Tukey test were used for statistical analysis. A p-value less than 0.05 was accepted for statistical significance.
Results: Roughness values 1.9173±0.25078 Ra in the Unpolished Temporary 3D Resin group, 0.2807±0.13317 Ra in the Polished Temporary 3D Resin group, 0.7760±0.17175 Ra in the Unpolished Standard 3B Resin group, 0 in the Polished Standard 3D Resin group It was found to be 0.1887±0.08340 Ra, 2.4827±0.79651 Ra in the Unpolished Cold Acryl group, and 0.6307±0.22118 Ra in the Polished Cold Acryl group.
Conclusion: The roughness of 3D printed materials is lower than that of conventional temporary acrylic resin and polishing significantly reduced roughness in all groups.

Keywords: Surface roughness, acrylic resin, 3D resin, 3D print

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Introduction

3D printing is the process of printing a 3D object designed in a virtual environment in solid form. Devices that perform the printing process are also called 3D printers. In 3D printing, the joining process is usually done by adding layer upon layer (1). The popularity of SLA, one of the three-dimensional printing techniques, is increasing in dentistry due to its use of resins. The popularity of SLA, one of the three-dimensional printing techniques, is increasing in dentistry due to its use of resins. In this system, a tray is immersed to the bottom of a transparent container containing the photopolymerizable resin. A curing light is given from below to form the first layer of the layered digital model. The screed lifts one layer and curing light is given again to form the second layer. This process continues until all layers of the model have been created (2). SLA has been used in the manufacture of patient-specific models, surgical guides, custom maxillofacial implants and prostheses, denture bases, clear aligners, mouth guards, temporary restorations, and ceramic restorations (3).

Roughness is an important parameter for temporary crowns and bridges. Rough dental materials are easier to discolour, accumulate more biofilm, cause more inflammation in the surrounding tissues and wear more (4).

Our hypothesis in this study is that the roughness of acrylic resin traditionally used in temporary crowns and bridges, temporary 3D printer resin and standard 3D printer resin are not different.

Materials and Methods

A hollow cylindrical mould with an inner diameter of 1 cm and a height of 5 mm was placed on the glass surface and a white chemical curing temporary acrylic resin (Imident, Imicryl™) prepared according to the manufacturer's instructions was placed in this hollow. The top of the mould was covered with glass and a smooth surface was formed. After curing, the excess was carefully trimmed with a scalpel and the sample was removed from the mold. A total of 30 samples were obtained.

For the samples to be produced with a 3D printer, the digital model with a diameter of 1 cm and a height of 5 mm was designed with 3D Builder (Microsoft, US) software. The model file was imported into the slicer software (Chitubox™, Guangdong, China) and the production parameters were entered according to the instructions of the manufacturer of the 3D resins (layer thickness=0.05 mm, bottom exposure=30 seconds, normal exposure 2.5 seconds, off time=0.5 seconds, bottom layers=4, z lift distance=6 mm, z lift speed= 4 mm/s, z retract speed= 4 mm/s). The model file prepared for production was transferred to the 3D printer (Anycubic™) with a USB memory and physical production was carried out. In order to remove residual resin on the surface of the printed samples, the samples were washed with isopropyl alcohol for 2 minutes using a Wash & Cure Plus device (Anycubic™), then gently dried with a paper towel. For the samples to fully cure, they were exposed to UV light for 10 minutes in the same device in the curing mode. Thirty samples were produced for both temporary 3D resin (Alias C & B Temp™) and standard 3D resin (Alias C & B Temp™).

Half of the samples in each material were polished for 90 seconds with the same dentist using polishing paste (Universal Polishing Paste, Ivoclar Vivadent™) with wool polishing wheel (n=15). The polished samples were washed with water and gently dried with a paper towel. Then, the surface of each sample was measured three times with a 120° angle difference using a profilometer (SJ-201, Mitutoyo™) and the average was taken.

Statistical analysis

Statistical analyses were performed using SPSS software V21.0 (IBM SPSS Inc., Armonk, NY, USA). The homogeneity of the obtained data was evaluated with Levene's test, t test was used to compare the polished and unpolished groups of the same material, and two-way analysis of variance and Tukey test were applied to compare the materials. A *p*-value less than 0.05 was accepted for statistical significance.

Results

The descriptive statistics of the roughness data obtained from the groups as a result of the test are shown in Table 1.

The t test was used to compare the polished and unpolished conditions of the materials and, as can be expected, a significant difference was found in terms of roughness ($p < 0.05$). Although temporary acrylic resin was the roughest material, it was the material whose roughness could be reduced the most by polishing (Table 2).

Table 1. Roughness data of groups

Material	Polishing	n	Mean	Standard Deviation	Standard Error	95% Confidence Interval		Min.	Max.
						Lower Bound	Upper Bound		
Temporary 3D Resin	No	15	1,9173	,25078	,06475	1,7785	2,0562	1,62	2,39
	Yes	15	0,2807	,13317	,03439	,2069	,3544	,14	,58
Standard 3D Resin	No	15	0,7760	,17175	,04434	,6809	,8711	,53	1,13
	Yes	15	0,1887	,08340	,02153	,1425	,2349	,10	,38
Temporary Acrylic Resin	No	15	2,4827	,79651	,20566	2,0416	2,9238	1,49	4,00
	Yes	15	0,6307	,22118	,05711	,5082	,7532	,34	,99

Table 2. Results of t-test

	t	df	p	Mean Difference	Standard Error Mean	95% Confidence Interval	
						Lower Bound	Upper Bound
Temporary 3D Resin vs. Temporary 3D Resin with polishing	22,324	21,314	,000	1,63667*	,07332	1,48434	1,78900
Standard 3D Resin vs. Standard 3D Resin with polishing	11,914	28	,000	,58733*	,04930	,48635	,68831
Temporary Acrylic Resin vs. Temporary Acrylic Resin with polishing	8,677	16,146	,000	1,85200*	,21344	1,39986	2,30414

According to the results of the two-way ANOVA test (Table 3), a significant difference was found between the roughness of all materials, including the polished and unpolished groups. In the unpolished groups, the roughest material was temporary acrylic resin, while the smoothest material was standard 3D resin. This ranking did not change in the polished groups either ($p < 0.05$).

Table 3: Multiple comparisons

		Mean Difference (I-J)	Standar Error	p	95% Confidence Interval	
					Lower Bound	Lower Bound
Temporary 3D Resin	Standard 3D Resin	0,6167*	0,09431	0,000	0,3917	0,8417
	Temporary Acrylic Resin	-0,4577*	0,09431	0,000	-0,6827	-0,2327
Standard 3D Resin	Temporary 3D Resin	-0,6167*	0,09431	0,000	-0,8417	-0,3917
	Temporary Acrylic Resin	-1,0743*	0,09431	0,000	-1,2993	-0,8493
Temporary Acrylic Resin	Temporary 3D Resin	0,4577*	0,09431	0,000	0,2327	0,6827
	Standard 3D Resin	1,0743*	0,09431	0,000	0,8493	1,2993

Discussion

According to the findings we obtained, our hypothesis is that the roughness of acrylic resin traditionally used in temporary crowns and bridges, temporary 3D printer resin and standard 3D printer resin are not different was rejected. There is a significant difference between temporary acrylic resin, 3D temporary resin and standard 3D resin.

Although temporary prostheses are clinically used for a shorter period, they are at least as important as permanent prostheses when considering the health of teeth and surrounding tissues. Improperly prepared temporary dentures will endanger the health of both the prepared teeth and periodontal tissues, and as a result, will adversely affect the success of the permanent prosthesis. For this reason, due care should be taken for the construction of temporary prostheses and appropriate materials and techniques should be used in their preparation (5). Although polishing is an important step in the preparation of temporary prostheses, unfortunately it can sometimes be skipped. Therefore, in our study, we compared the polished and unpolished conditions of the temporary prothesis materials.

The most important difference between standard 3D resin and temporary 3D resin is biocompatibility. Biocompatible is an umbrella term for materials specifically engineered to interact with living tissues without causing an immunological response (6). Although standard 3d resin is not suitable for temporary prosthesis production, it was included in our study to give an insight in comparison with temporary 3d resin. In our study, the surface of the standard 3D resin was found to be smoother than the temporary 3D resin.

In the case of 3D printers, an initial hardening of the resin occurs in the resin vat during the manufacturing process, by the light emitted from the printer screen; however, a post-curing step is required to promote the complementary polymerization of the objects and enhance the mechanical properties of the material. Since the properties of most 3d printing materials do not improve after 10 minutes of post-curing (7), the post-curing time was set as 10 minutes in our study.

The dimensional accuracy (8), water absorption, flexural strength, and biocompatibility of 3D-printed temporary prostheses have been reported to be clinically acceptable (9). In our study, it was found that its roughness was better than temporary acrylic resins. 3D-printed temporary prostheses are a relatively new concept and most studies, including this one, are in vitro. Therefore, the results of this and other studies should be interpreted taking into account the limitations of in vitro studies.

Conclusions

The roughness of 3D printed materials is lower than that of conventional temporary acrylic resin and polishing significantly reduced roughness in all groups.

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