

Comparative Analysis Of Two Specialized 3d Resins Tailored For Prosthodontic Applications: An In Vitro Study

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ABSTRACT

Introduction: Three-dimensional (3D) printing has become an increasingly popular manufacturing tool in the medical world. Three-dimensional printing allows dentists to create high-precision models of teeth and jaw structure, and enables them to develop customized tools for patient's treatment.

Aim & Objectives: To compare the mechanical properties (compression and tensile moduli) of two commercially available 3D-printable resins (Elegoo and Anycubic) used in dentistry.

Material And Methodology: Two 3D-printable resins, namely Elegoo and Anycubic were tested to evaluate their properties and Universal Testing Machine was used for testing their mechanical properties. Both are biocompatible materials, but with different properties.

Result: The compressive and tensile strength of Anycubic resin was significantly higher than Elegoo resin.

Conclusion: Anycubic 3D resin material is more adequate for use in prosthodontic applications as compare to Elegoo 3D resin material, Anycubic 3D resin could be used more as a stiff material

Keywords: 3D printing in dentistry; dental materials; tensile; compression; resins; prosthodontics

1. INTRODUCTION

Three-dimensional (3D) printing has become an increasingly popular manufacturing tool in the medical world.¹ 3D printing is commonly applied in dentistry to fabricate a variety of dental parts. The introduction of 3D printing in dentistry has its origin in prosthodontics.²

In recent years the use of digital technology is gaining tremendous recognition³ due to the high precision of 3D-printed elements, their good biocompatibility, and their high stability in quantity and quality, they are used in all branches of dentistry.² This window of opportunity has led to the development of a range of materials for a multitude for medicine and dentistry.⁴

The 3D-printing method, an additive method, exhibits some advantages and is considered economical compared to the subtractive method.⁵ Additive manufacturing (AM) is the most recent form of prototyping Computer Aided Designed (CAD) files in Dentistry.⁶ AM is economical because it does not involve the wear or waste of raw materials, and AM enables the simultaneous manufacture of multiple products.⁷

3D printing technology is emerging as a new technology⁸ that is finding more and more use in the world today.⁹ Several different resins are used in prosthetic dental medicine, according to their composition and method of processing for the purposes of removable prosthetics.¹⁰

This in vitro study aimed to provide a comparative analysis of two specialized 3D printing resins developed specifically for prosthodontic applications. By evaluating their mechanical properties, this research seeks to guide practitioners in selecting the most suitable resin for enhanced prosthodontic outcomes.

AIM

To compare the mechanical properties (compression and tensile moduli) of two commercially available 3D-printable resins (Elegoo and Anycubic) used in dentistry.

OBJECTIVES

1. To check the mechanical properties (compression and tensile moduli) of 3D-printable resins (Elegoo).
2. To check the mechanical properties (compression and tensile moduli) of 3D-printable resins (Anycubic).
3. To compare the mechanical properties (compression and tensile moduli) of two commercially available 3D-printable resins (Elegoo and Anycubic).

2. MATERIAL AND METHODOLOGY

Materials

Two 3D-printable resins, namely Elegoo and Anycubic were tested to evaluate their properties and Universal Testing Machine was used for testing their mechanical properties. Both are biocompatible materials, but with different properties.

Sample Size

40 Sample of 3D resins 20 each of Elegoo and Anycubic. According to ISO standards, the minimum number of probes in this kind of research should be five. Therefore, 10 specimens of each material will be taken for tensile and compressive strength each of compressive and tensile strength.

3. STUDY PROCEDURE

Preparation of Specimens

The samples were prepared according to the ISO standards. Two types of blocks were used to measure the selected properties: a rectangular block, according to the ISO 604:2003 standard for the compression test that is 10 mm × 10 mm × 4 mm, and a dumbbell-shaped block (type 1BA), according to the ISO 527-1:2019(E) standard for the tensile test that is length: 75 mm, end width: 10 mm, thickness: 2 mm. (Fig. 1 & 2)

Material blocks were printed using a Elegoo 3D printer. The samples were prepared according to the appropriate ISO standards and instructions of the manufacturer. The printer is self-adjustable, and the settings were adjusted during the placement of the resin cartridge with a built-in chip. (Fig. 3)

Compression Test

The width and height of the samples were measured at five points by using a digital caliper. The mean values were then calculated. The compression test was performed by using a Universal Testing Machine at a speed of 1 mm/min.

Tensile Test

The width and height of the samples were measured at five points by using a digital caliper. The mean values were then calculated. The tensile test was performed using a Universal Testing Machine at a constant crosshead speed of 5 mm/min.

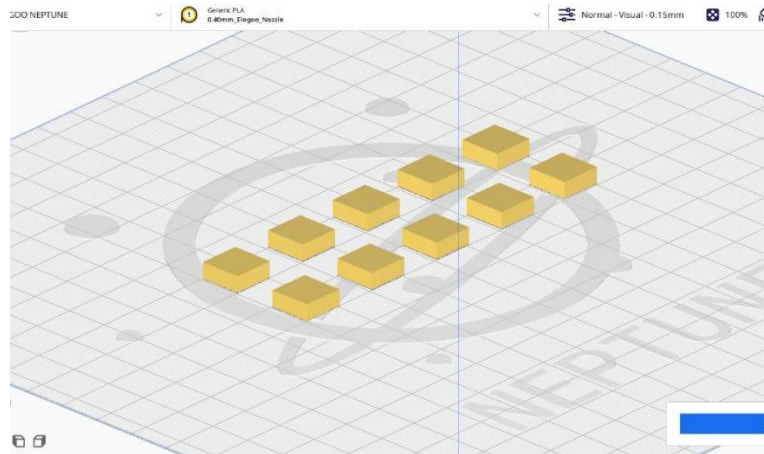


Fig 1. STL file of Rectangular Block for Compression Test (10 mm x 10mm x 4mm)

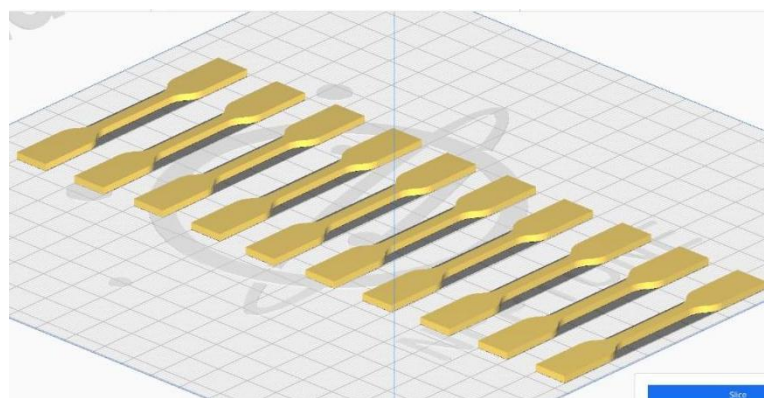


Fig 2. STL file of Dumbbell Block for Tensile Test (75 mm, 10mm end width, 2mm thickness)

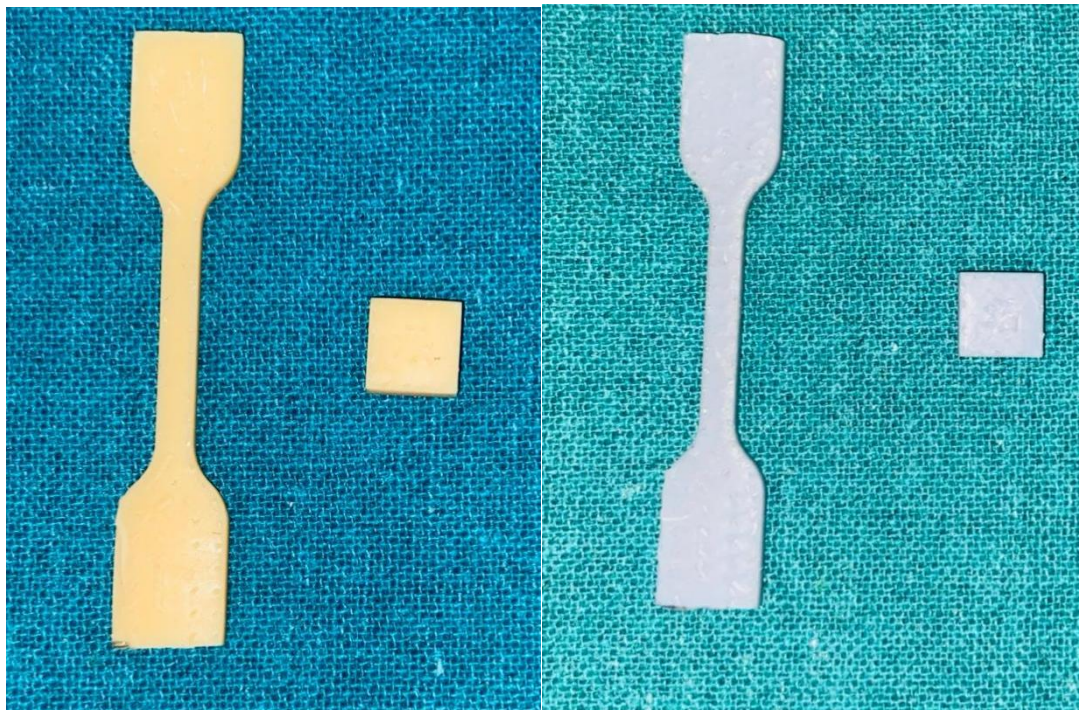


Fig 3. 3D- Printed Elegoo Block and 3D- Printed Any cubic Block for Testing

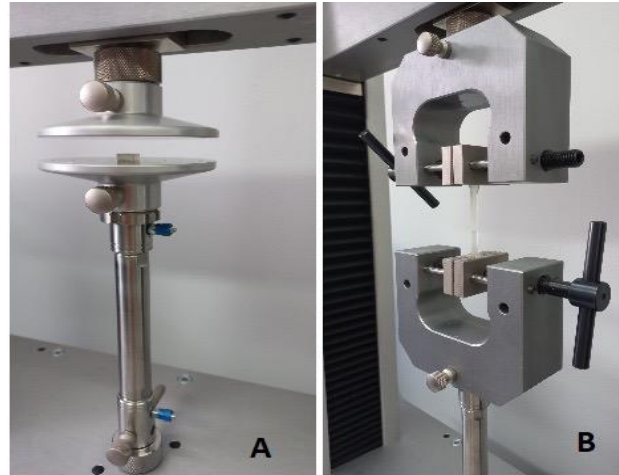
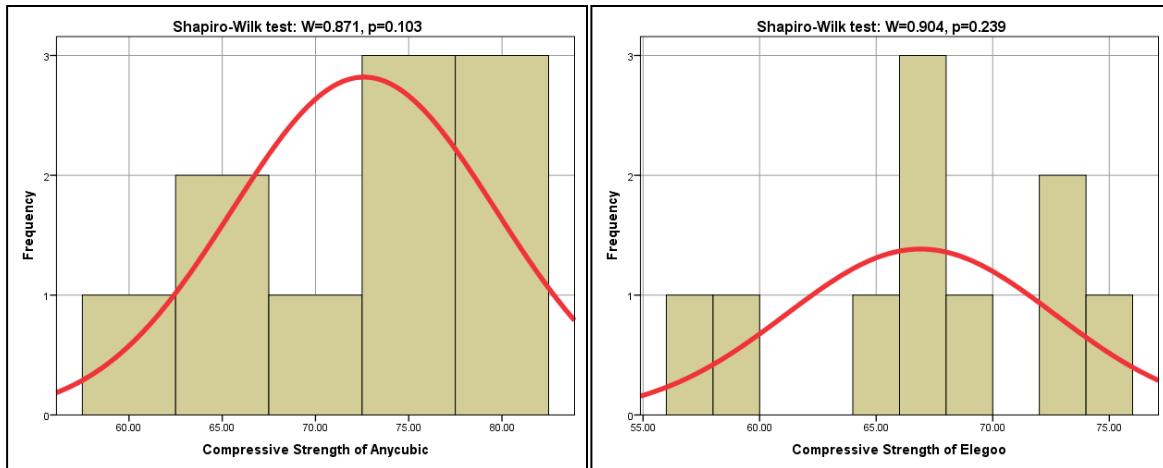


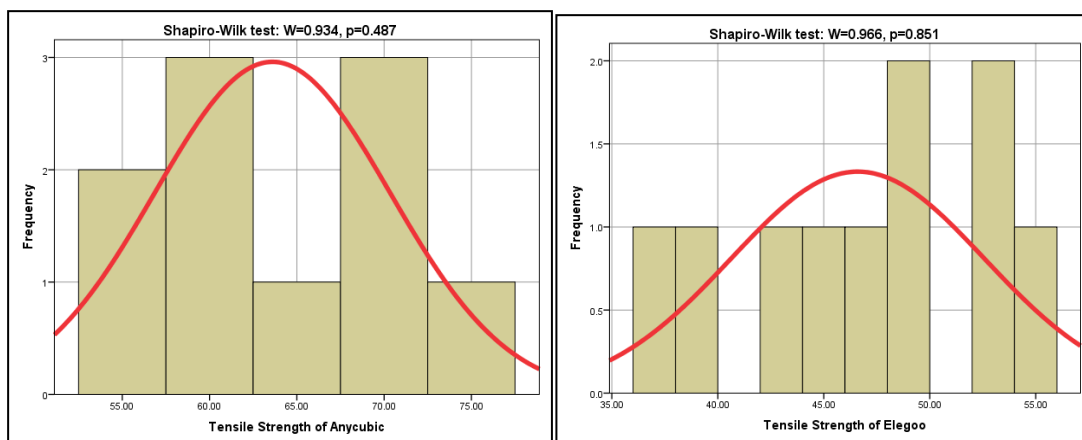
Fig 4: A) Compression Test performed in UTS B) Tensile Test performed in UTS

Statistical Analysis

Shapiro-Wilk test was used to determine the appropriate statistical test to be used based on the distribution of the data. Independent t test is used for the statistical analysis. The p value ≤ 0.05 is considered statistically significant. (Graph 1 & 2)



Graph 1. Shapiro-Wilk test showed that the data of the compressive strength of Anycubic & Elegoo respectively was following normal distribution.



Graph 2. Shapiro-Wilk test showed that the data of the tensile strength of Anycubic & Elegoo respectively was following normal distribution

4. RESULTS

The compressive strength of the two groups, Anycubic and Elegoo, was compared using an independent t-test (Table 1). The results revealed that the compressive strength was significantly greater in the Anycubic group (72.60 ± 7.07 MPa) compared to the Elegoo group (66.90 ± 5.76 MPa), with a p-value of 0.044 (Graph 3).

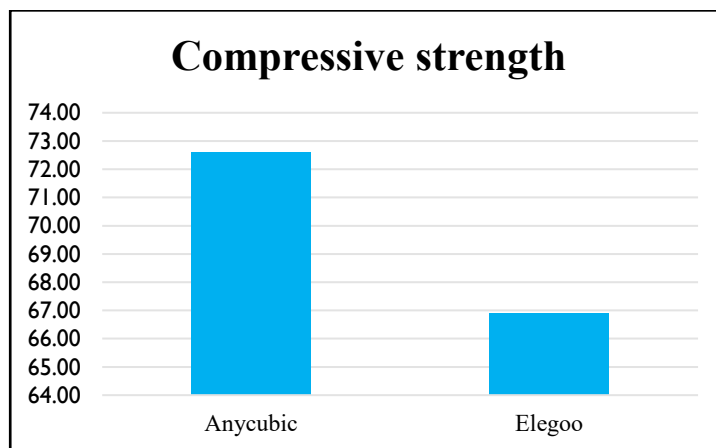
Similarly, the tensile strength of the two groups was analyzed using an independent t-test (Table 2). The Anycubic group demonstrated a significantly higher tensile strength (63.60 ± 6.74 MPa) compared to the Elegoo group (46.60 ± 5.99 MPa), with a p-value of <0.001 (Graph 4).

Table 1. Comparison of compressive strength between the groups using independent t test

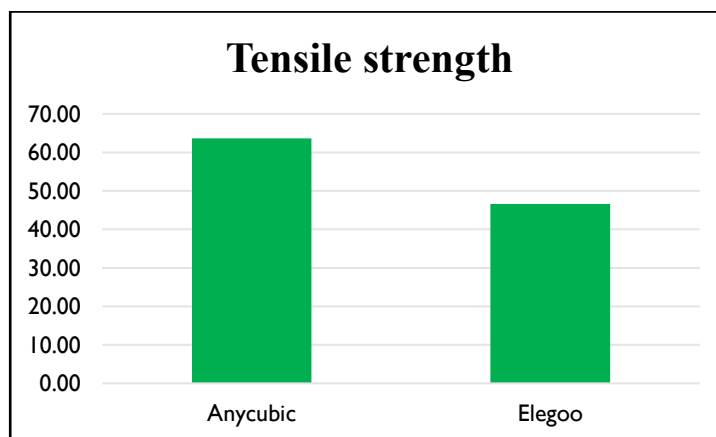
Parameter	Group	Minimum	Maximum	Mean	SD	P value
Compressive strength	Anycubic	60.00	80.00	72.60	7.07	0.044
	Elegoo	57.00	74.00	66.90	5.76	

Table 2. Comparison of compressive strength between the groups using independent t test

Parameter	Group	Minimum	Maximum	Mean	SD	P value
Tensile strength	Anycubic	55.00	75.00	63.60	6.74	<0.001
	Elegoo	37.00	55.00	46.60	5.99	



Graph 3. The compressive strength was significantly greater in Anycubic (72.60 ± 7.07 Mpa) than in Elegoo (66.90 ± 5.76 Mpa) ($p=0.044$)



Graph 4. The tensile strength was significantly greater in Anycubic (63.60 ± 6.74 Mpa) than in Elegoo (46.60 ± 5.99 Mpa) ($p<0.001$)

5. DISCUSSION

This study evaluates the mechanical properties of 3D resins, Elegoo and Anycubic, by comparing their compressive and tensile strength for potential applications in prosthodontics.

The adoption of computer-aided design and computer-aided manufacturing (CAD-CAM) has significantly impacted dentistry.^{7,11} CAD-CAM prostheses have advantage¹² and can be fabricated by either additive manufacturing (AM) or subtractive manufacturing (SM), but 3D printing (an AM method) provides significant advantages over SM methods.⁷ Different 3D printers and materials have been used in dentistry, including selective laser sintering (SLS), thermal inkjet (TIJ), and fused deposition modelling (FDM).¹³

Currently, due to the large variety of 3D printers, post-processing units, and resin systems, there is a wide range of operating procedures with respect to processing and post-processing of materials for dental applications.

Recent advances in three-dimensional (3D) printing have introduced new materials that can be utilized for dental restorations.⁸ 3D printers enable the fabrication of temporary dental restorations, surgical guides, interocclusal appliances.⁶ 3D printing techniques do not produce casts and are often based on scans, reducing the possibility of the distortion of dental impressions.²

Various studies conducted by different authors have found that the properties of 3D resin materials surpass those of conventional materials, as stated by Pablo J et al.⁴ reported that among the tested resins, permanent bridges fabricated from 3D resins exhibited superior mechanical properties. Afnan Fouzan Alfouzan et al.³ found that 3D-printed denture resins demonstrated minimal colour changes compared to conventional heat-polymerized PMMA. Mariya Dimitrova et al.¹⁰ observed that 3D-printed resins had superior surface roughness but lower hardness values than heat-cured acrylic resins (PMMA). Additionally, Mihaela Pantea et al.¹⁴ concluded that 3D-printed interim resins outperformed conventional resins in both compression and flexural tests.

Several studies in the literature support comparisons among different 3D resins. Paradowska-Stolarz et al.¹ reported that BioMed Amber resin exhibited greater resistance to both compression and tensile forces, indicating its ability to endure higher stress during stretching, pulling, or pushing compared to IBT resin. Similarly, Anna Paradowska-Stolarz et al.⁹ found that BioMed Amber demonstrated superior compressive strength, while Dental LT Clear performed better in tensile tests. In our present study, we observed that Anycubic resin exhibited greater resistance compared to Elegoo 3D resin.

Based on the findings of this study and existing literature, it is evident that 3D-printed resins exhibit promising mechanical properties, making them a viable alternative to conventional materials in prosthodontic applications. The variations in compressive and tensile strength among different 3D resins highlight the importance of selecting the appropriate material based on clinical requirements. With continuous advancements in additive manufacturing, 3D-printed resins hold significant potential for improving the efficiency and effectiveness of prosthodontic treatments.

6. LIMITATIONS

The current study has some limitations. The number of samples was small ($n = 10$), although it still meets ISO standards. Additional tests, such as flexural characterization of the materials, water sorption, translucency and solubility could also be considered. This test could be considered to widen the scope of future research.

7. CONCLUSION

Three dimensional printing has started entering esthetic dentistry and playing a major role, because the technique is used for manufacturing prosthetic restorations made from different materials, and the production time is significantly reduced compared to the conventional heat-cured polymerization process.

Anycubic 3D resin material is more adequate for use in prosthodontic applications as compare to Elegoo 3D resin material, Anycubic 3D resin could be used more as a stiff material; for example, as a surgical guide in implant and mini-implant placement.

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Conflicts of interest

There are no conflicts of interest.

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