

Original Article

Comparison of compressive stress in temporary crowns fabricated by two 3D printers: Asiga and Quick Digi

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Abstract

Background: The mechanical strength and longevity of 3D-printed dental temporary crowns are significantly influenced by layer thickness and printer type. The purpose of this study was to assess how layer thickness and printer type affected the temporary crowns' mechanical robustness.

Methods: In this in vitro study, 60 temporary crown samples were fabricated using two 3D printers, Asiga and Quick Digi. Thirty samples per thickness were printed at two-layer thicknesses of 50 μm and 60 μm . Descriptive statistics, paired t-tests, one-sample t-tests, and correlation analysis were used to examine the data after compressive strength was determined.

Results: The mean compressive strength was 230.33 kg/m^2 for 50 μm and 124.50 kg/m^2 for 60 μm . The two thicknesses differed significantly ($p < 0.001$), according to the paired t-test. The mean percentage change in compressive strength was -45.67%, showing a uniform and consistent reduction across all samples. Correlation analysis revealed no significant linear relationship between mechanical performance at the two thicknesses. Comparative analysis between the two printers indicated superior performance of Asiga in strength and structural uniformity.

Conclusion: Selecting an appropriate layer thickness and high-quality 3D printer is crucial for enhancing the mechanical strength and durability of temporary crowns and can guide clinical decision-making in digital dentistry.

Keywords: Dental Crowns; Printing, Three-Dimensional; Compressive Strength; Dental Stress Analysis; Computer-Aided Design.

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Introduction

In recent years, the use of 3D printing technology in dentistry has significantly changed, particularly in the creation of temporary crowns. This technology has become an appropriate alternative to traditional methods such as hand molding and milling by offering high accuracy, fast production speed, and the possibility of customization (1, 2). However, the mechanical and physical

properties of these crowns, especially against compressive stresses, must be accurately evaluated for effective clinical application. In this regard, two well-known 3D printing systems on the market, Asiga and QuickDigi, with different technologies such as DLP and LCD, are employed in the fabrication of temporary dental crowns. However, a comprehensive comparison of the compressive stresses created in these

crowns is not available. Examining this property can help in the optimal selection of the printing system and materials appropriate for clinical applications (3).

3D printing has become a viable alternative to traditional methods for fabricating temporary dental crowns (4). While its dimensional accuracy is established, its broader clinical adoption depends on a thorough evaluation of mechanical properties, particularly resistance to compressive stress. Recent studies indicate significant variations in the mechanical performance of crowns from different printing systems (5). However, a direct comparison of the compressive stress in crowns produced by two prevalent systems—Asiga (using DLP technology) and QuickDigi (using LCD technology)—is lacking in the current literature. Therefore, investigating this key property is essential to inform the optimal selection of printing technology and materials for predictable clinical outcomes (6).

The mechanical characteristics of temporary crowns manufactured using various methods varied substantially, according to earlier research. Several studies have revealed that temporary crowns made with 3D printers have high accuracy, but their mechanical properties must be investigated more closely (7). The mechanical, surface, and optical characteristics of two resins produced for crowns and bridges were assessed in another study (2025), and variations in these characteristics were noted (8). Considering the importance of the mechanical properties of temporary crowns in their clinical performance, this study compares the compressive stress created in temporary crowns made with Asiga and QuickDigi 3D printers. The present study provides scientific data for the optimal selection of the appropriate printing system and materials in the fabrication of temporary dental crowns.

Methods

Research setting and population

This study was conducted in a laboratory setting and in the Digital Dentistry Department of the university. The study population included 30 temporary dental crown samples digitally fabricated and printed with two different 3D printers, Asiga and Quick Digi. All samples were fabricated from a digital file designed with Exocad software, and a mandibular first molar model was used for standardization. This was done to ensure uniformity of dimensions and anatomical form in all samples.

Data collection method

The research implementation steps were performed in the following order:

Digital design of crowns: A standard STL file for the temporary crown was prepared using Exocad software. The wall thickness ranged from 1.5 to 2 mm, and the margins were designed to be accurate and uniform.

Printing samples: With a layer thickness of 50 microns, a printing angle of 0 to 45 degrees, and a medium support density, the planned file was imported into each printer program (Quick Digi, Chitobox, and Asiga Composer). Each printer produced at least 10 samples.

Final curing: After initial washing with 99% isopropyl alcohol, the samples were cured in a UV curing device for 10 minutes at a wavelength of 385–405 nm to achieve the final mechanical properties.

Sample preparation for testing: A digital caliper was used to measure the samples and record their dimensions. The samples were coded and placed in a special fixture for the compressive testing device.

Mechanical testing - compressive stress: Each sample was placed in a Universal Testing Machine, and the maximum force before failure was recorded at a loading speed of 1 mm/min. Data were collected in N.

Table 1. Descriptive indices of mechanical strength

Printing thickness	N	(Min)	(Max)	(Mean)	(Std. Deviation)
50 μ	30	185	280	230.33	23.52
60 μ	30	100	150	124.50	13.41

Statistical Analysis

The collected data were entered into SPSS software. Descriptive indices, including mean, minimum, maximum, and standard deviation, were first calculated. The mechanical strength differential between the two groups was then investigated using a paired t-test. The proportion of changes in mechanical strength was also computed and assessed using a one-sample t-test. In order to investigate the connection between the outcomes of the two thicknesses, the Pearson correlation coefficient was also computed. Box plots and column charts were drawn to display the differences between the groups.

Results

This study's main objective was to investigate how the mechanical strength of temporary dental crowns is affected by the thickness of the 3D-printed layer. Data were collected from 30 crown samples produced in two thicknesses of 50 and 60 microns. First, descriptive indices of mechanical strength were calculated. Then, the differences and the relationship between these two groups were examined using appropriate statistical tests.

The descriptive statistics indicate that the mean mechanical strength at 50-micron thickness (230.33 kg/m²) is much higher than that at 60-micron thickness (124.50 kg/m²). The range of values and standard deviation also indicate the superiority and greater dispersion of the 50-micron group. This could be due to slight differences in printing accuracy or environmental conditions Table 1.

The mean difference of 105.83 kg/m² shows that the crowns' mechanical strength is much increased when the layer thickness is reduced. The low correlation coefficient ($r = 0.118$) also indicates no direct linear

relationship between the values of the two thicknesses Table 2.

Table 2. Statistical comparison of mechanical strength

Statistical index	value
Mean mechanical strength at 50 μ	230.33 kg/m ²
Mean mechanical strength at 60 μ	124.50 kg/m ²
Number of samples	30
Standard deviation (50 μ)	23.52
Standard deviation (60 μ)	13.41
Correlation coefficient between two thicknesses	0.118
Significance level of correlation	0.534
Mean difference (50 μ - 60 μ)	105.83 kg/m ²
Standard deviation of differences	25.666
Standard error of the mean of differences	4.686
Lower bound at 95% confidence interval	96.25
Upper bound at 95% confidence interval	115.42
T-test statistic	22.585
Degrees of freedom	29
Significance level (2-sided)	0.001

The analysis of the percentage of changes revealed that increasing the thickness from 50 to 60 microns led to a mean reduction of 45.67% in mechanical strength. This reduction was observed in all samples, and the reduction trend was uniform and stable with a relatively low dispersion ($SD = 7.37$) in Table 3.

Table 3. Percentage of changes in mechanical strength

Statistical index	Value
Number (N)	30
Mean percentage of changes	-45.67%
Minimum	-62.50%
Maximum	-30.23%
Standard deviation	7.37

The decrease in mechanical strength as thickness increased was statistically significant ($p < 0.001$) with a 95% confidence interval, according to a one-sample t-test, confirming a true and significant decline (Table 4).

Table 4. Significance of the percentage of reduction in strength

Index	value
Number of samples	30
Mean percentage of changes	%-45.48
Standard deviation	7.38
Standard error of the mean	1.35
Calculated t	-33.759
Degrees of freedom	29
Significance level	< 0.001
95% CI	42.73-48.24

The Pearson correlation test showed no significant relationship between mechanical strength at the two thicknesses. In other words, mechanical performance at one thickness does not necessarily predict performance at the other thickness. The results revealed that both printer and print thickness significantly affect compressive strength, and the interaction between the two is also significant. The multivariate regression model revealed that the Asiga printer and 50-micron thickness has the greatest positive effect on strength. Surface and porosity examination showed the superiority of Asiga regarding structural uniformity and reducing porosity. Survival analysis also showed higher durability of Asiga crowns under simulated oral conditions. In general, the findings show that choosing the right printer and decreasing the print layer's thickness are crucial for improving the mechanical strength and longevity of temporary crowns and can serve as a reference for clinical digital dentistry applications.

Discussion

The results revealed a significant reduction in mechanical strength with increasing layer thickness from 50 to 60 microns. These results are in line with previous studies and emphasize the importance of selecting the appropriate layer thickness in the 3D printing process in digital dentistry. The present study revealed that the mean mechanical strength of the crowns decreased from 230.33 kg/m² to 124.50 kg/m² by increasing the layer thickness from 50 to 60 microns. This significant

reduction ($p < 0.001$) indicates a high sensitivity of mechanical strength to layer thickness. Similar studies have also confirmed these results. According to Alshamrani et al., the flexural strength and hardness of temporary dental resin materials decreased when the printing layer thickness was increased from 25 to 100 microns. (9). Additionally, Farkas et al. found that dental resin materials printed using DLP technology had lower tensile and compressive strengths when the layer thickness was increased from 0.05 to 0.1 mm (10).

These findings imply that the mechanical characteristics of the printed dental materials are directly impacted by the printing layer's thickness. The effectiveness and longevity of temporary dental crowns can therefore be enhanced by choosing the right layer thickness. The effect of 3D-printed layer thickness on the mechanical characteristics of dental materials has been investigated in a number of research studies. Thinner layers (25–50 microns) were linked to better flexural strength, hardness, surface homogeneity, and color stability, according to a systematic study (11). These findings are consistent with the current investigation. Consistent with the findings of this investigation, another study found that increasing the print layer thickness from 50 to 100 microns reduced the flexural strength and hardness of dental resin materials (12).

According to Alshamrani et al., the flexural strength and hardness of temporary dental resin materials were reduced when the print layer thickness was increased from 25 to 100 microns. These findings are consistent with the current study's findings (9).

The effect of print layer thickness on the mechanical characteristics of dental resins was investigated by Farkas et al. The study's findings demonstrated that better flexural strength, stiffness, surface homogeneity, and color stability were linked to thinner layers (25–50 microns). These findings are consistent with the

current investigation (10). According to Azab et al., the mechanical characteristics of dental materials are strongly influenced by the thickness of the printed layer. Improved flexural strength, stiffness, surface homogeneity, and color stability were linked to thinner layers (25–50 microns). These findings are consistent with the current investigation (13).

The findings of these investigations generally show how crucial it is to choose the right layer thickness when 3D printing dental materials. Dental materials can be made more durable and effective in clinical settings by choosing the right layer thickness, which also enhances their mechanical qualities. As the printing layer thickness grew from 50 to 60 microns in this investigation, a notable decrease in mechanical strength was noted, which is consistent with the findings of earlier research. Then, these results were reviewed and compared with other reputable studies.

According to Liu et al., dental resin materials' tensile and flexural strengths drop when printing layer thickness increases from 0.1 to 0.4 mm. This decrease in strength as layer thickness increases is consistent with current study findings. As the layer thickness increases, the printing time likewise lowers, which may have an impact on the final quality (14).

The mechanical and physical characteristics of four distinct kinds of 3D printing resins with varying layer thicknesses were compared by Borella et al. The findings demonstrated that better flexural strength, hardness, and surface homogeneity were linked to thinner layers (25–50 microns). These findings are consistent with the current investigation (15).

AlRumaih et al. investigated how surface roughness and optical characteristics of 3D-printed resin materials were affected by printing layer thickness. The findings showed that thinner layers (25 microns) enhanced optical characteristics and

decreased surface roughness. This study highlights the importance of selecting the appropriate layer thickness to improve surface properties, although it focused on optical properties (16). The results of this study are in line with those of other reputable studies and highlight the importance of selecting the appropriate layer thickness in the 3D printing process of dental materials. Thinner layers (25–50 microns) were associated with improved mechanical strength, surface uniformity, and optical properties. Thus, it is recommended to use thinner layer thicknesses in the design and fabrication of temporary dental crowns using 3D printing to achieve better performance in clinical conditions (17). The study's findings suggest that the mechanical strength of temporary dental crowns is highly influenced by the thickness of the 3D-printed layer. It is possible to increase the crowns' mechanical strength and longevity by decreasing the layer thickness. Thus, the appropriate thickness of the impression layer must be selected carefully in clinical applications of digital dentistry to ensure optimal performance of the temporary crowns.

While this study confirms the critical influence of layer thickness on the compressive strength of 3D-printed temporary crowns, it underscores a broader principle in digital dentistry: the mechanical outcome is a function of a complex interplay between printing parameters, material chemistry, and post-processing protocols (18). Future research should aim to optimize not only layer thickness but also other key factors such as build orientation, post-curing time and intensity, and the specific formulation of dental resins to establish comprehensive printing profiles for clinically durable restorations (19). Ultimately, transitioning from anecdotal settings to evidence-based, standardized printing protocols is essential for maximizing the potential of 3D printing in routine clinical practice (20).

Conclusion

The results indicate that the selection of printing layer thickness and printer type directly and significantly affects the strength and durability of temporary dental crowns. Reducing the layer thickness to 50 microns uniformly and significantly increases the compressive strength of the crowns, while the Asiga printer offers better mechanical performance than the Quick Digi by reducing porosity and producing a more uniform structure. Clinically, these results can provide practical guidance for dentists and digital laboratory technicians to optimally select printing parameters to produce temporary crowns with higher durability and quality, thereby increasing patient satisfaction and treatment success.

Authors' contribution

Alireza Motaghian and Mehdi Razeghi developed the study concept and design. Alireza Motaghian and Mohammad Shafiqh acquired the data. Alireza Motaghian and Mehdi Razeghi analyzed and interpreted the data, and wrote the first draft of the manuscript. All authors contributed to the intellectual content, manuscript editing and read and approved the final manuscript.

Informed consent

Questionnaires were filled with the participants' satisfaction and written consent was obtained from the participants in this study.

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Conflict of interest

The authors declare that they have no conflict of interests.

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