Effects of 3D Printing Build Parameters on Mechanical Properties of Dental Models Using DLP and SLA Technology

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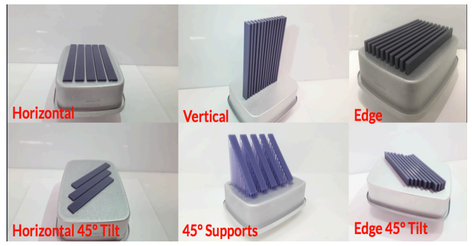
INTRODUCTION:

- 3D printing has recently been applied to dentistry to reduce the time of manufacturing crowns, surgical guides, and night guards.
- Dental models must tolerate the stress during surgery, overnight use, and long term use.
- The building parameters can affect the mechanical properties of 3D printed dental models thus this study aims to investigate two common printing methods in digital dentistry: digital light processing (DLP) and stereolithography (SLA).

Specimen



1. Material: Dental Model (SprintRay)
2. Model: ASTM D790 (Flex) & ASTM D638-14 V (Tensile)
3. Layer Thickness: 20 µm,50 µm,100 µm

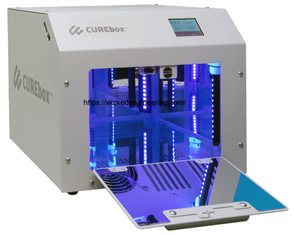
1. Material: Diacrylate monomer, BAPO photoinitiator, Mayzo OB+ photoabsoriber
2. Model: 50 x 5 x 0.3 (L x W x H) mm rectangular CAD model
3. Layer Thickness: 100 µm

Printing

1. Resin mixing (1 minute)
2. 3D Printer: MoonRay
3. Digital Light Processing (405 nm)

1. Resin mixing (10 minutes)
2. 3D printer: FormsLab 2
3. Stereolithography (405 nm)

Post Curing



1. UV Light Curing (30 minutes, 30°C)
2. CUREbox (Wicked Engineering)
3. Wavelength: 405 nm

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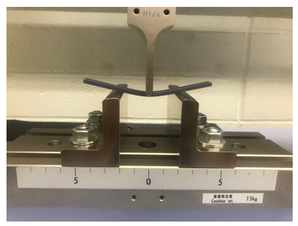
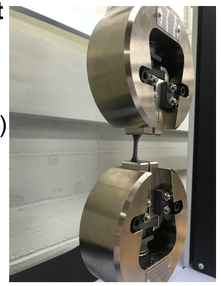
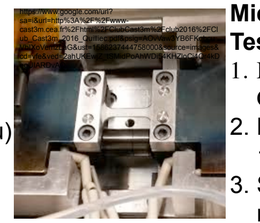
Experimental Analyses



Flexural Test
1. Universal Testing Machine (Shimadzu)
2. Span Length: 16:1 mm
3. Speed: 1 mm/min



Tensile Test
1. Universal Testing Machine (Shimadzu)
2. Load Cell: 1 kN
3. Speed: 1 mm/min



Microtensile Test
1. MTEST Quattro
2. Load Cell: 1 kN
3. Speed: 1 mm/min

RESULTS:

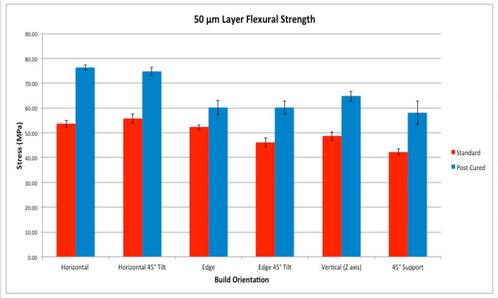


Figure 1. This figure illustrates that post curing increases the maximum flexural strength.

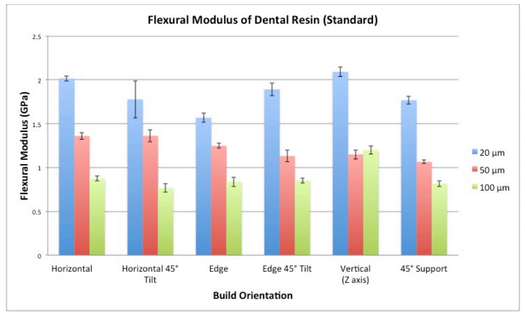


Figure 2. This figure illustrates that a smaller layer thickness increases the maximum flexural modulus.

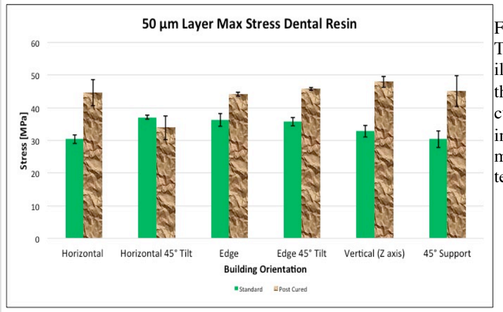


Figure 3. This figure illustrates that post curing increases the maximum tensile stress.

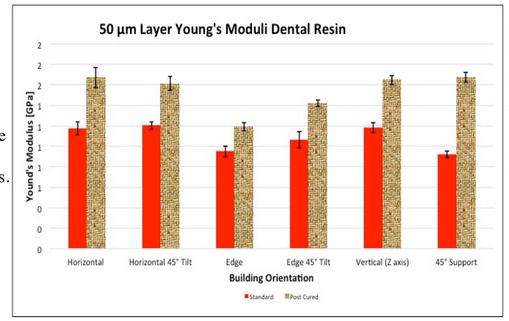


Figure 4. This figure illustrates that post curing increases the Young's Modulus.

CONCLUSION/FUTURE WORK:

- Smaller layer thickness yields stronger flexural properties.
- Parts made by DLP exhibit anisotropic flexural properties.
- Similar strength is observed in tensile properties regardless of printing orientation.
- Post curing increases the flexural strength and tensile strength of the model regardless of printing orientation.
- For future work dynamic mechanical analysis (DMA) will be performed to characterize crosslink density as a possible explanation for the anisotropic properties observed.

REFERENCES:

[1] J. W. Stansbury and M. J. Idacavage, "3D printing with polymers: Challenges among expanding options and opportunities," *Dent. Mater.*, vol. 32, no. 1, pp. 54–64, Jan. 2016, doi: 10.1016/j.dental.2015.09.018.

[2] J. Jockusch and M. Özcan, "Additive manufacturing of dental polymers: An overview on processes, materials and applications," *Dent. Mater. J.*, 2020, doi: 10.4012/dmj.2019-123.

[3] K. V. Wong and A. Hernandez, "A Review of Additive Manufacturing," *ISRN Mech. Eng.*, vol. 2012, pp. 1–10, 2012, doi: 10.5402/2012/208760.

[4] E. Aznarte, C. Ayranci, and A. J. Qureshi, "DIGITAL LIGHT PROCESSING (DLP): ANISOTROPIC TENSILE CONSIDERATIONS," p. 13.

[5] M. Monzón, Z. Ortega, A. Hernández, R. Paz, and F. Ortega, "Anisotropy of Photopolymer Parts Made by Digital Light Processing," *Materials*, vol. 10, no. 1, p. 64, Jan. 2017, doi: 10.3390/ma10010064.

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