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Comparative Analysis of 3D Printed Denture Resins with Traditional Denture Materials at the Micro Level

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ABSTRACT

The aim of this experiment was to evaluate and identify compression strength between traditionally manufactured acrylic dentures and additive manufacturing resin dentures. Specifically, the dentures produced by Uhler Dental, its Reveal line were compared against samples produced on the Formlabs Form 2 SLA, Stereolithography, 3D printer using their Denture Teeth A2 resin to test compression strength to assure they are compatible with the occlusal forces in the oral cavity. Using the ZwickRoell tensile testing machine, it appeared that the acrylic dentures were half as strong as the resin dentures. Then we went ahead to and did a comparative analysis under a microscope to see the micro-properties such as the isotropic uniformity in the resin, layer adhesion, and the microstructure of the two different materials; in general, these two materials appear that resin denture teeth have lesser mean percent porosity values than the acrylic denture teeth. After doing both the compression test and a micro level analysis under the microscope we have determined that the resin denture has the proper strengths and properties to handle the occlusal forces in a human oral cavity.

MATERIALS AND METHODS

-Extensive Literature Research Conducted on denture material and their properties
-Critical Understanding of microstructure of denture materials.
-Keywords: Denture materials, acrylic teeth, 3D printing
-Research Experts Consulted: Professor Gaffar Gailani

INTRODUCTION

The ideal denture base material should possess several key physical attributes. Some of these properties include biocompatibility, good esthetics, high bond strength with available denture teeth, radiopacity, ease of repair, and should possess adequate physical and mechanical properties. The denture base must be strong enough to allow the prosthesis to withstand functional and parafunctional masticatory forces. In addition, because these prostheses are removable, shock induced fracture resistance, possibly due to patient abuse, is desirable. Many different materials have been used for denture bases. Historically materials such as bone, wood, ivory, and vulcanized rubber were utilized; now many new materials are in the market whether they are traditionally manufactured acrylic dentures or additive manufactured resin dentures.

However, there are significant differences in the mechanical properties among denture materials based on their molecular structures. Usually, it is known that the causes of denture fractures are more often related to design errors of the resins rather than problems with their mechanical properties.

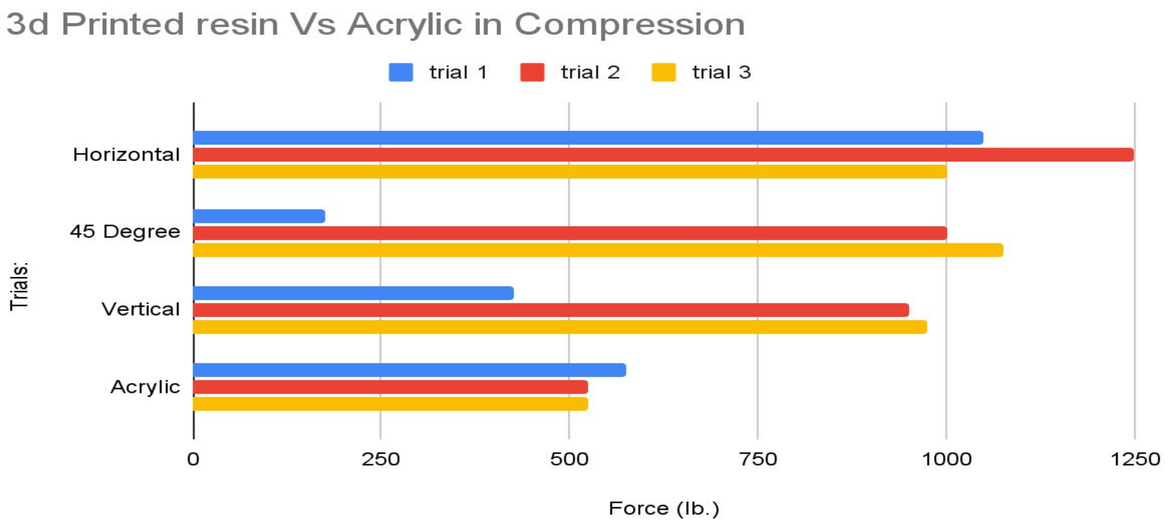
It is determined that denture failures can occur in excessively thin areas or weakened flanges around frenal notches. Midline fractures of denture base resins are especially troublesome, leading some to recommend selectively increasing the bulk of material in regions subject to deformation and fractures. Regardless of how the failure occurred, due to excessive thickness or thinness of the denture it is important to keep in mind of their mechanical strength that decreases the potential for fracture making the use of a stronger acrylic resin very important. Hence, these factors have led manufacturers to develop higher strength denture base materials is why we were determined to test the strengths of the traditionally manufactured acrylic dentures or additive manufactured resin dentures.

RESULTS

This experiment used the tinius olsen tensile tester which is an analog testing machine that provinces either compressive or tensile forces on an object until the point of failure. for this experiment each sample was crushed under a compressive load to the point of failure, while paying attention to the forces equal to the maximum experienced by the human jaw under normal circumstances.

The results of the tensile testing experiment show that the the horizontally printed samples scored roughly 1000 lbf each trial. the 45° samples were showed to have similar strength with one sample scoring lower than average by a wide margin. the vertical samples were shown to have similar results to the 45^0 samples having one outlier and the rest hovering just below 1000 lbf. the acrylic scored consistently around the 500 lbs mark with was roughly half the average of the 3d printed samples.

The average bite force of an adult human is roughly 170 lbf which each of the samples was able to suppress to some degree. The first test from the 45 degree samples was unable to meet this minimum.



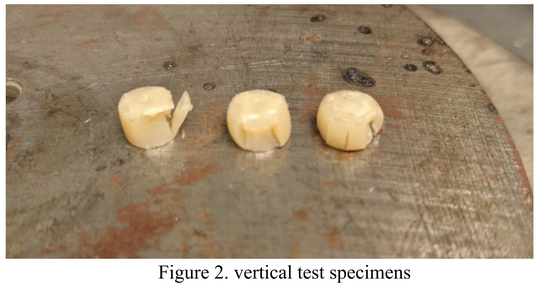


Figure 2. vertical test specimens

Figure 3. Acrylic test specimens

Figure 4. 45 degree Test specimens

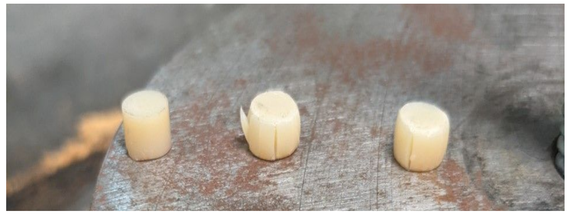


Figure 5. Horizontally printed specimens

DISCUSSION

- In this experiment it was shown how the 3d printed samples were able to outperform the acrylic samples. the first trial of the horizontal samples was surprising it successfully surpassed the amount of force produced by the human mouth. the following tests yielded the same results was promising.
- Then the 45^0 samples started with a very low result which is unknown in origin, however the remaining tests provided comparable results to the horizontal specimens.
- The vertical specimens showed results slightly lower than the 45^0 specimens, and as well reproduces a similar error to the 45^0 samples.
- The last test group of the acrylic samples consistently produced half of the same force amount as the 3d printed samples.

CONCLUSION

This work was able to demonstrate that overall 3d printed resin regardless of orientation outperforms the original acrylic. however these results do not accurately show the effectiveness of the acrylic due to a number of limiting factors, such as the quantity of samples for both material types, as well as limiting the scope of acrylic samples tested to just molars, as opposed to canine teeth which deflect force differently.

Further study will see the sample quantity for all datasets increased to gather a clearer picture of the performance of both; as well as using a more modern tensile testing machine to gather more accurate data digitally.

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