



Objective

The purpose of this study was to assess the flexural strength of different 3D-printed resin (3DP-R) denture base materials and the effect of different types of reline materials on their flexural strength.

Introduction

The population of edentulous patients has increased due to the improved life lifespan. Computer-aided design/computer-assisted manufacturing (CAD/CAM) technology in the field of dentistry has been evolving to overcome the limitations and lengthy processing of conventional techniques and provide an accessible treatment modality. CAD/CAM-fabricated complete dentures are associated with reduced clinical chair time, high retention, enhanced fit, and improved mechanical properties over conventionally fabricated complete dentures. Fabrication of digital removable complete dentures generally consists of scanning the definitive impression/final casts, recording maxillomandibular relationship, virtual design, and manufacturing of the definitive prosthesis using an additive or subtractive technique. With the advancements in technology, 3D-printed resin (3DP-R) has been developed to improve the flexural strength of denture base materials. Previous studies mentioned that 3D-printed resin has superior mechanical properties compared to heat-polymerized polymethyl methacrylate. Moreover, progressive resorption of the underlying alveolar ridge is a continuous process that results in loss of fit of the removable complete denture. When the loss of fit occurs, complete dentures are hard-relined to reestablish the fit and enhance the adaptation of the denture base to the underlying structure. Numerous resins and PMMA-based 3D printing materials have been developed since the advancement in 3D-printing technology, and their mechanical properties must be assessed to provide appropriate information for dental practitioners.

Materials and Methods

One hundred and forty strips, each 64×10×3.3 mm, were fabricated in accordance with ISO 20795-1 specifications from the respective materials; 30 were manufactured of each material being evaluated. HP-PMMA strips (Lucitone 199; Dentsply Prosthetics, York, PA) were prepared using the compression molding technique. A 64×10×3.3mm strip was virtually designed (Meshmixer, Autodesk, San Rafael, CA) and saved as a standard tessellation language (stl) file (Figure 1A). The stl file was used to manufacture strips of the various denture base materials using additive technique (Figure 1B), following the respective manufacturers' instructions (Table 1). Each group had thirty samples; ten were relined using ProBase Cold, ten were relined using Ufi Gel Hard C, and ten were not relined.

Table 1. Materials, Manufacturer, Wavelength and Fabrication Techniques

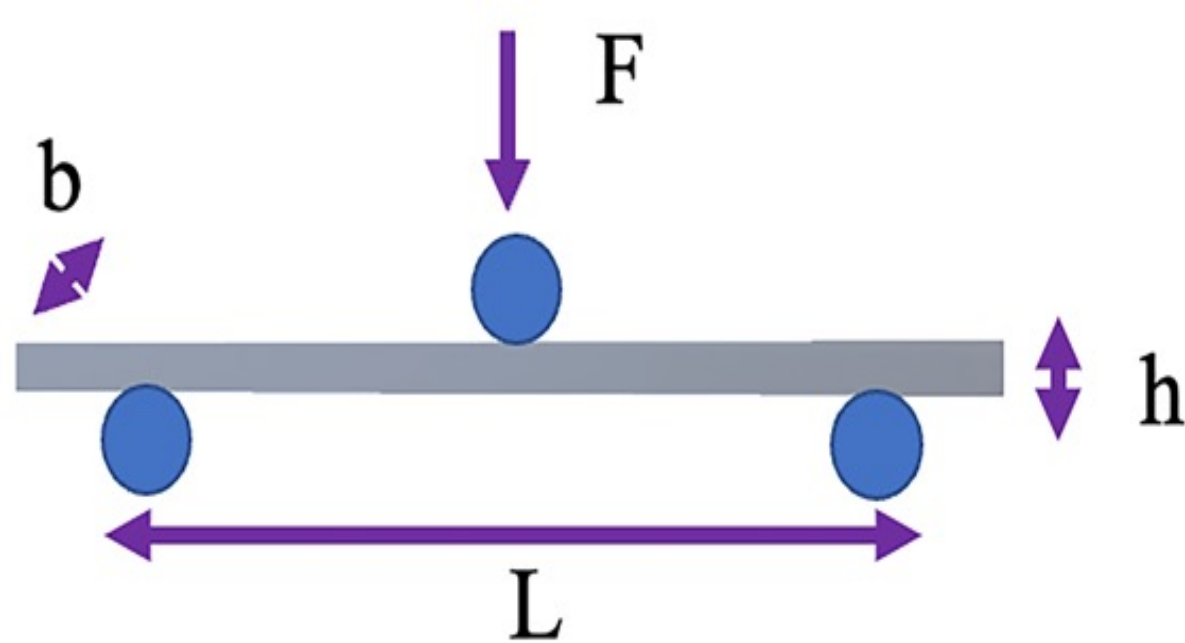
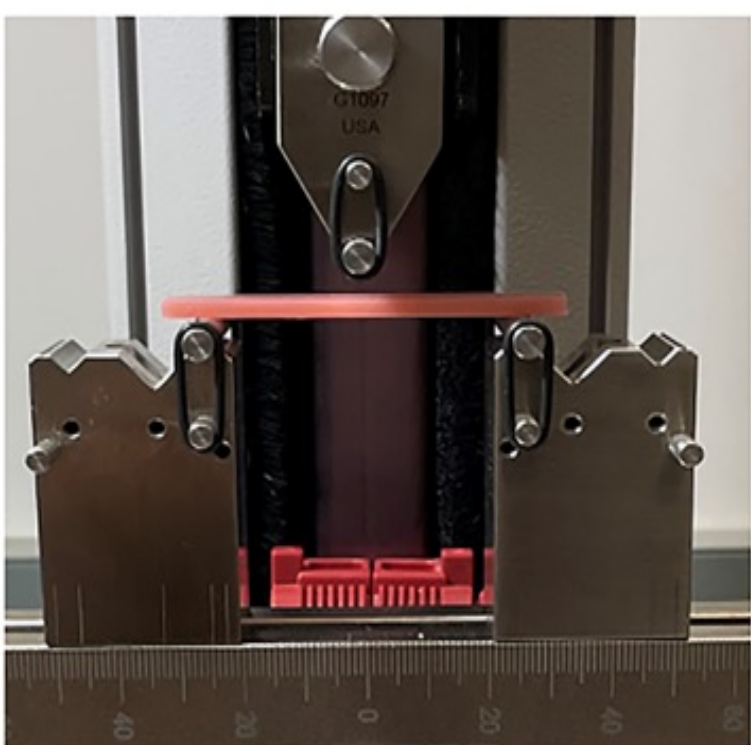
Materials	Manufacturer	Type	Fabrication
Lucitone 199	 Dentsply Prosthetics, York, PA	PMMA	Conventional Compress heat-polymerized 
Detax Freeprint Denture	 Detax GmbH & Co. KG, Ettlingen, Germany	Resin Wavelength: 385	3D-printed using Asiga Max UV 3D printer with post-processing by Dreve PCU LED N ² and cured in a Nitrogen vacuum for 30 mins 
Asiga DentaBase	 ASIGA, Alexandra, Australia	Resin Wavelength: 385 & 405	3D-printed using Straumann CARES P30 printer; with post-processing by Straumann P-cure cured for 20 mins 
Dreve Fotodent Denture	 Dreve Dentamid GmbH, Unna, Germany	Resin Wavelength: 385	3D-printed using Straumann CARES P30 printer; with post-processing by Straumann P-cure cured for 20 mins 

Table 2. Reline Materials used in current study

Chairside Reline	Lab Reline
 Ufi Gel Hard C	 ProBase Cold

Each group had thirty samples; ten were relined using ProBase Cold, ten were relined using chairside Ufi Gel Hard C, and ten were not relined.

Flexural strength of each group was assessed with a universal testing machine at a cross-head speed of 5.0mm/minute to test 3-point flexural strength.

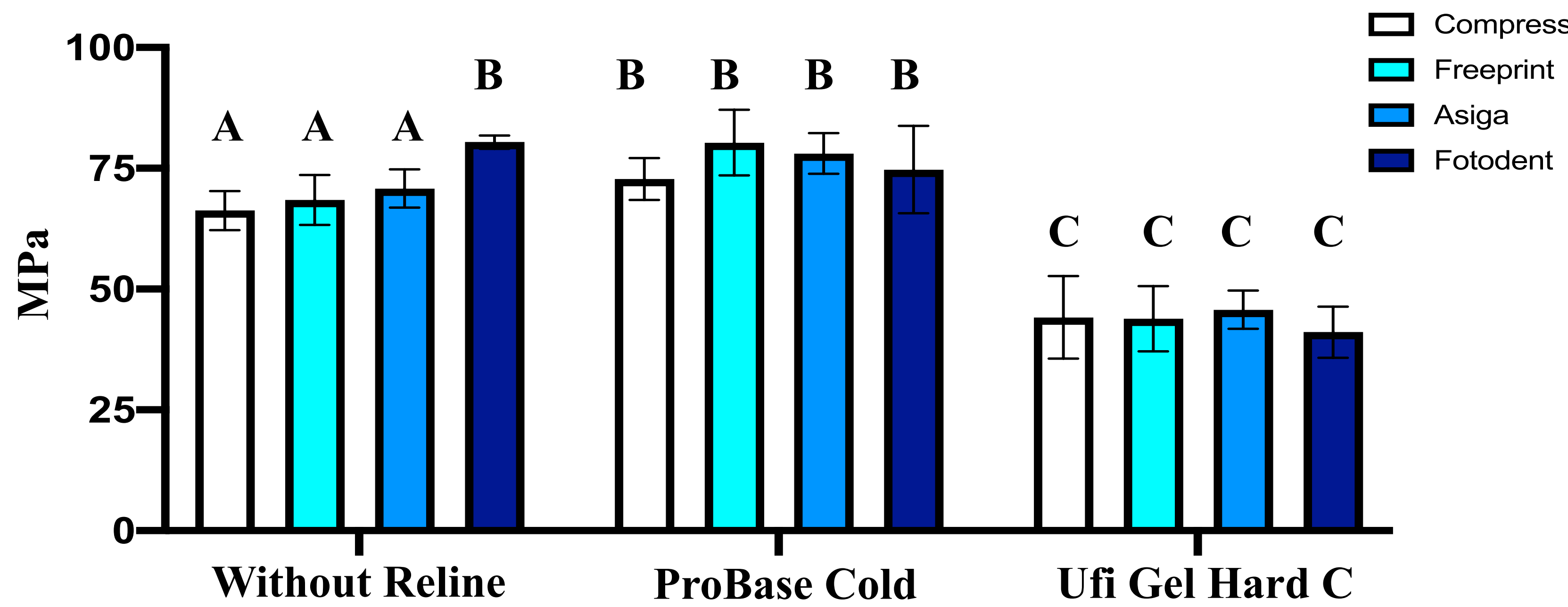


$FS = 3 FL/2bh^2$
F is the maximum force exerted on the test specimen (N),
L is the distance between the specimen supports (50 mm)
b is the specimen width (10 mm)
h is the specimen thickness (3.3 mm)

Figure 1: Schematic for 3-point flexural strength test

Statistic Analysis: Two-way ANOVA and Tukey's multiple comparison tests were used to compare the average flexural strength at a significance level of 0.5.

Results



Matching uppercase letters denote no significant differences between groups ($p < 0.05$).

Figure 2: Flexural strength

Table 4. Two-way ANOVA Result

Source of Variation	% of variation	F (DFn, DFd)	P Value
Interaction	4.245	F (6, 108) = 6.58	<0.0001
Row Factor/ Materials	83.01	F (2, 108) = 386.0	<0.0001
Column Factor/ Reline	1.134	F (3, 108) = 3.515	0.0177

Conclusions

- 3DP-R base materials have an acceptable flexural strength value of more than 65MPa, whether or not they are hard-relined except when it is relined with Ufi Gel Hard.
- PorBase Cold reline increase the flexural strength of 3DP-R base material.
- 3D-printed resin has superior flexural strength value compared to heat-polymerized polymethyl methacrylate.

References

- Kattadiyil MT, AlHelal A, Goodacre BJ: Clinical complications and quality assessments with computer-engineered complete dentures: A systematic review. J Prosthet Dent 2017;117:721-728
- Tallgren A: The continuing reduction of the residual alveolar ridges in complete denture wearers: a mixed-longitudinal study covering 25 years. J Prosthet Dent 2003;89:427-435