



Effects of print orientation and post-curing time on the mechanical properties of a permanent restorative material used for additive manufacturing

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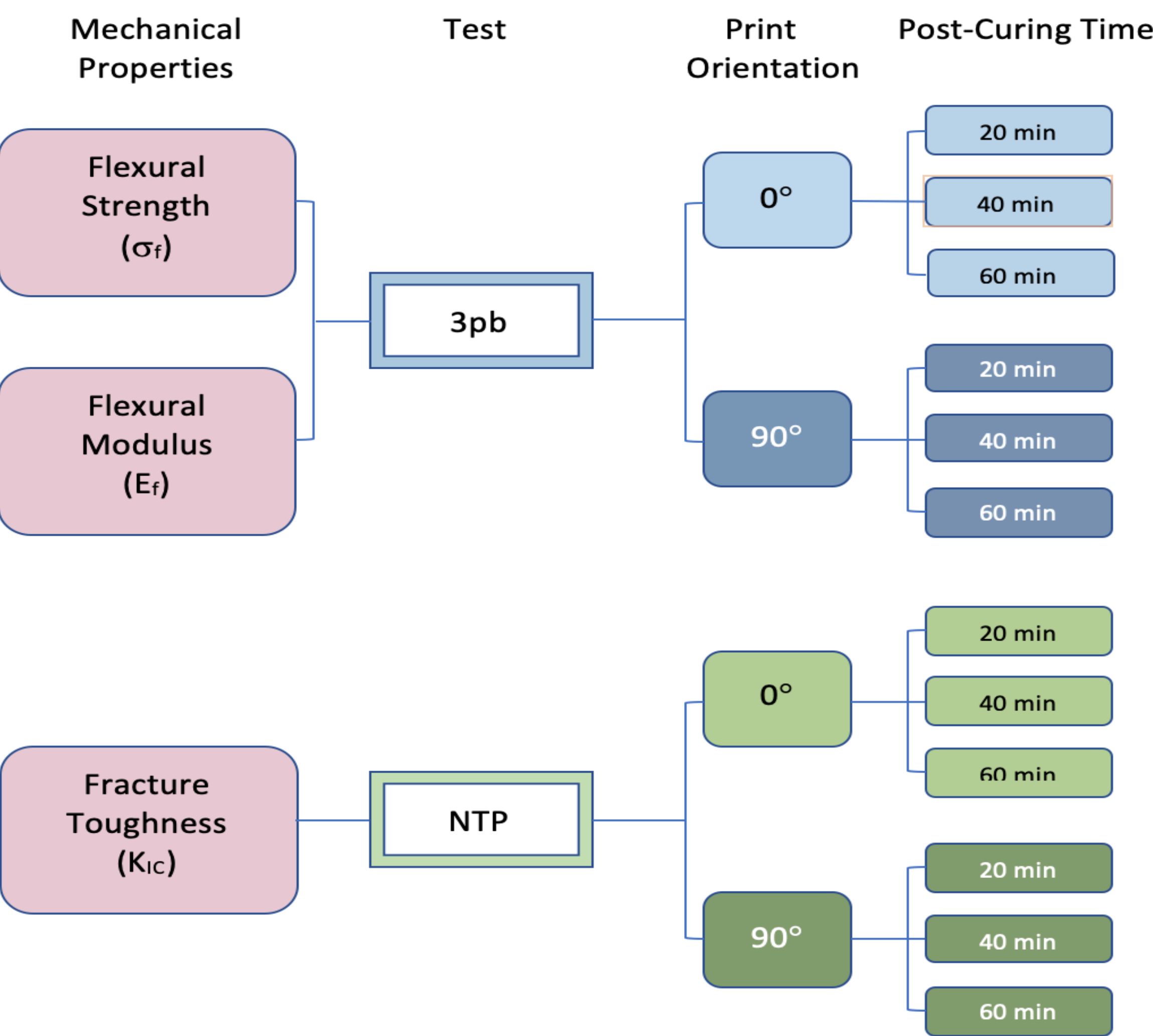
Objectives

The aim of this study was to determine the effects of varying post-curing time and print orientation on the flexural strength (σ_f), flexural modulus (E_f), and fracture toughness (K_{IC}) of a commercially available 3D printed resin used for permanent restorations.

Null Hypotheses

1. Post-curing time does not affect E_f , σ_f or K_{IC} of the 3D printed resin used for definitive restorations.
2. The print orientation does not affect E_f , σ_f or K_{IC} of the 3D printed resin used for definitive restorations.

Experimental Design



Materials and Methods

Material	Composition (Wt %)	Manufacturer
 SprintRay Crown™	Matrix components: ≥ 50 - $< 75\%$ Bis-EMA Fillers: 30 – 50% silanized dental glass Photo initiator: $< 2.5\%$ TPO, MBF	SprintRay

Bis-EMA = bis-ethoxylated bisphenol-A dimethacrylate, TPO = diphenyl (2,4,6-trimethylbenzoyl) phosphine oxide, MBF = methyl benzoylformate

3 Point-Bending Test (3pb)

For each group, 20 bars [(25 x 2 x 2) mm] were 3D printed and stored in distilled water at 37 °C for 24 h. The width and height of each specimen was measured prior to loading in a universal testing machine (Shimadzu) at a crosshead speed of 1mm/min until fracture.

$$\sigma_f = \frac{3Fl}{2bh^2}$$

F = fracture load, l = distance between supports, b = specimen width
h = specimen height, d = deflection

$$E_f = \frac{Fl^3}{4bh^3d}$$

Notchless Triangular Prism (NTP) Specimen K_{IC} Test

For each group, 20 NTP specimens [(6.3 x 6.3 x 6.3 x 14) mm] were 3D printed and stored in distilled water at 37 °C for 24 h. A flawless edge was identified under a light microscope and a ~0.1 mm defect was created with a 200 μ m thick surgical blade to help crack initiation. A universal testing machine (Instron 4301) was used to load the test assembly in tension at a crosshead speed of 0.1 mm/min until fracture or crack arrest.

$$K_{IC} = Y_{min}^* \frac{P_{max}}{DW^{1/2}}$$

Y_{min}^* = dimensionless stress intensity coefficient factor minimum,
D = specimen diameter, W = specimen length

Statistical Analysis

One-way Anova was performed to test significance for each mechanical property (E_f , σ_f , K_{IC}) according to post-curing time and print orientation, followed by a post-hoc Scheffe test. The collected data was plotted using SPSS statistics software ($\alpha = 0.05$).

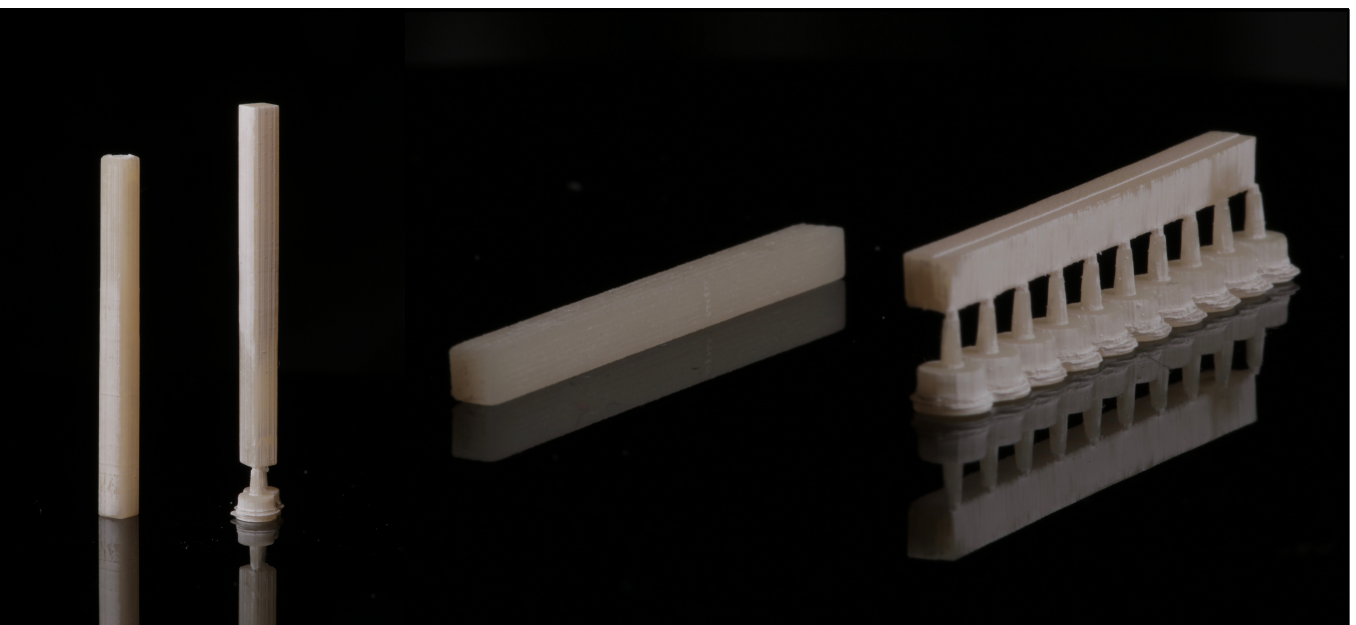


Figure 1: 3PB 3D printed specimens without and with supports (left bars at a 90° print orientation, right bars at a 0° print orientation).



Figure 2: NTP 3D printed specimens without and with supports (left prisms at a 90° print orientation, right prisms at a 0° print orientation).

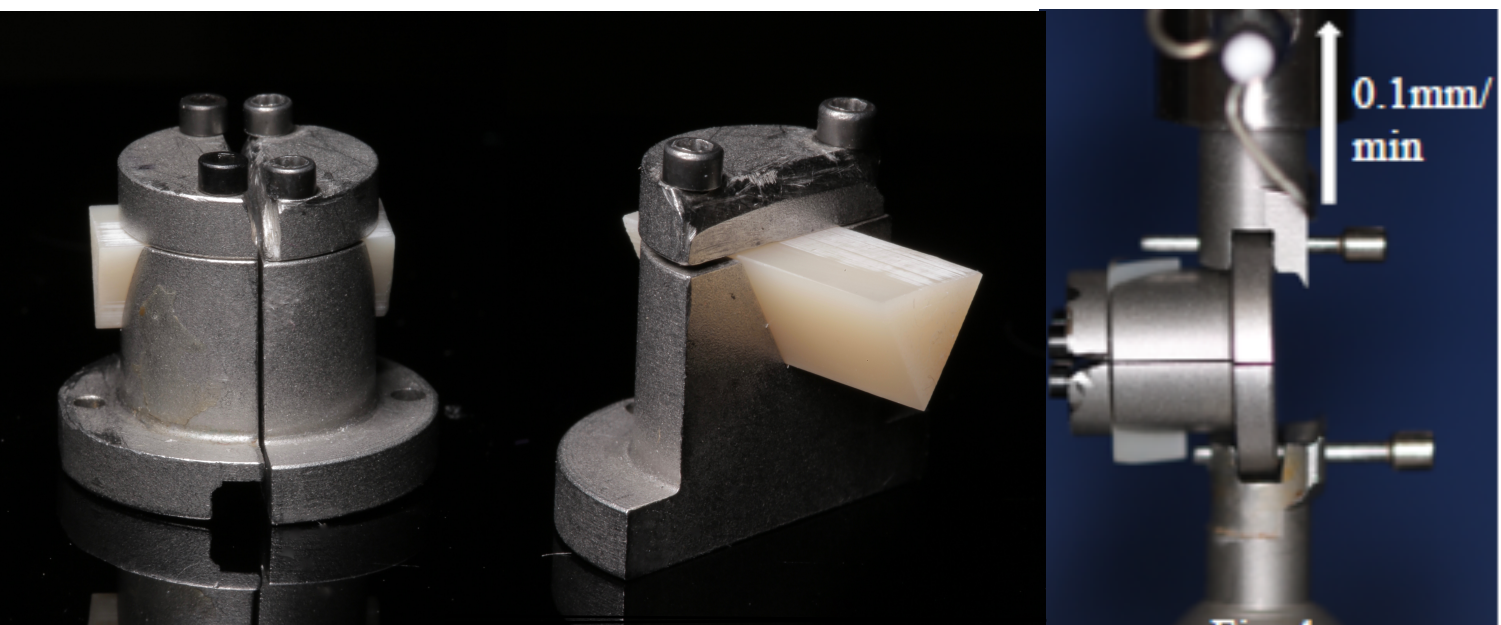
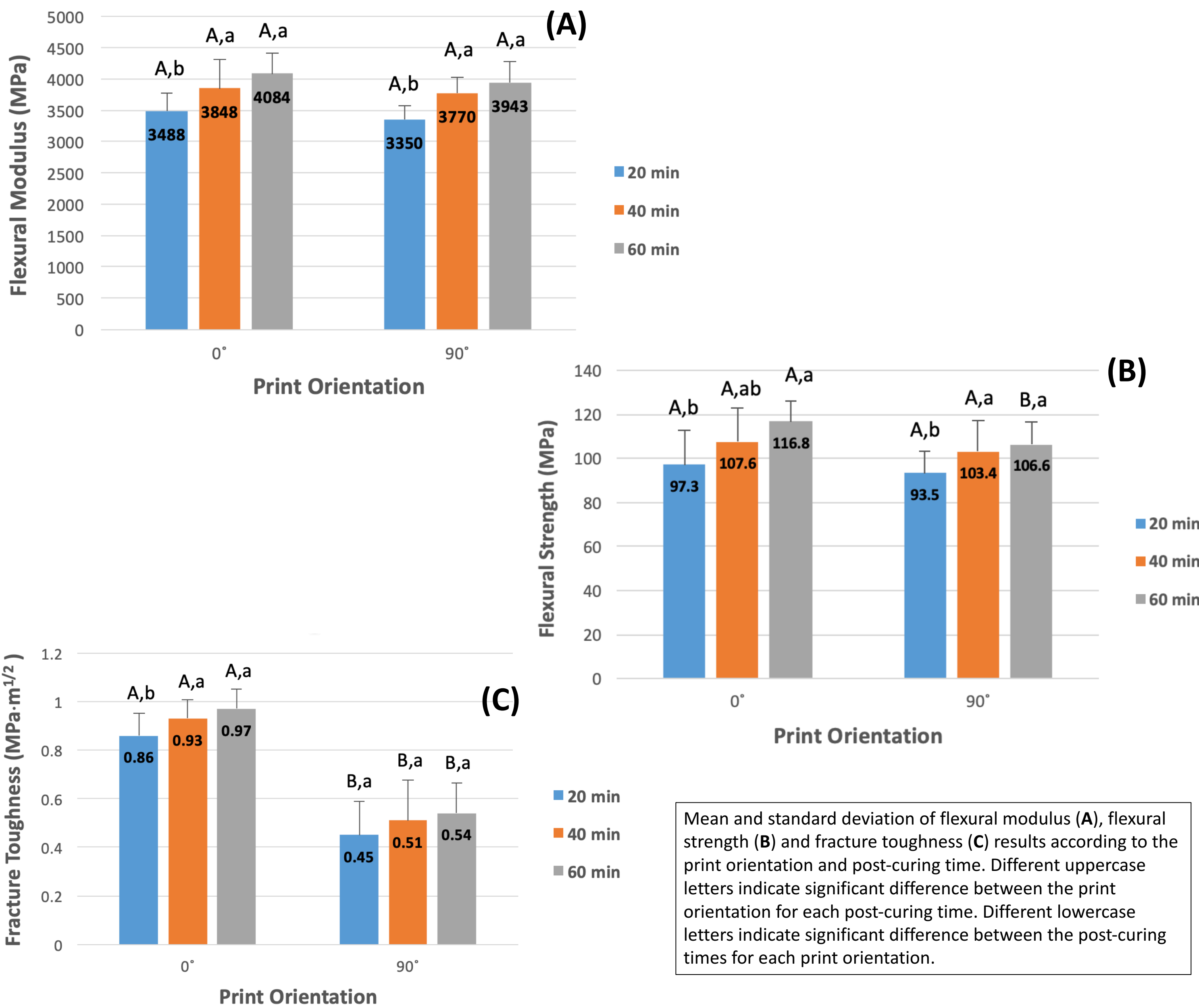


Figure 3: NTP specimen in holder (left), test assembly (centre), testing configuration (right).

Results



Conclusion

E_f , σ_f and K_{IC} of SprintRay Crown™ improved with increased curing time; however, this improvement was not significant beyond 40 minutes of curing in most cases. Specimens printed at a 0° orientation in relation to the print platform had significantly higher K_{IC} compared to the 90° orientation; however, there was no statistical difference between print orientations for E_f and σ_f .

References

