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The Effect of Expiration Date on Fracture Load and Printing Accuracy of 3D-Printed Crowns

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Objective

The aim of this study was to determine the effect of 3D-Printed resin expiration date and thermocycling on fracture load value and dimensional accuracy of 3D-printed interim crowns.

Introduction

With the increased integration of the digital workflow into common-day practice, increasing questions have rose regarding procedural steps, safety, and efficacy. Specifically, there is still a lack of knowledge regarding the importance of handling of resin materials, resin properties, rinse and cure techniques. This study aims to address a common problem in the field, is it necessary to throw away a recent expired container of 3D-Printer Resin? Is there potential for other uses?

Materials and Methods

Forty-eight crowns were manufactured using a resin material (P Pro Temporary Crown and Bridge; Straumann Inc.). (Figure 1) Twenty-four specimens were printed using a one-year expired resin material and 24 using an unexpired material. The marginal integrity of crowns was assessed visually on their assigned 3D-printed resin die by an experienced operator. Half of specimens from each group were subjected to thermocycling for 1,000 cycles between 5° and 55° Celsius with 15 seconds interval time. The marginal integrity of crowns was reassessed by the same operator after thermocycling. Crowns were then luted onto the assigned 3D-printed dies using a temporary cement (TempBond NE; Kerr Dental) under a constant load. The fracture strength of crowns was assessed after 24 hours of luting using a universal testing machine (Instron 33R4204; Illinois Tool Works Inc.). A stainless-steel sphere (r=5mm) was placed on the occlusal surface at the central pit. Then, the compressive load was applied to the long axis of the tooth at a crosshead speed of 5 mm/min until fracture occurred. (Figure 2).

A 3D-object was designed using a software (Fusion 360; Autodesk) with specific dimension. (Figure 3) Twenty-four 3D-object was fabricated using a resin (P pro Crown and Bridge; Straumann Inc) and a 3D-printing machine (P30; Straumann Inc); 12 specimens using a one-year expired material and 12 specimens using an unexpired material. Each group was then divided into 2 subgroups, 6 each. One subgroup went through thermocycling, and the other subgroup was evaluated without thermocycling. The subgroup with thermocycling went through 1000 cycles of 5 and 55 degrees centigrade with 15 seconds interval time. The specimens were then assessed by a coordinate measuring machine (DuraMax 5/5/5; Zeiss) to measure outer and inner diameter, cylinder height, base height, width, and length. (Figure 5)

Shapiro-Wilk test was used to assess the normality assumption. Two-way ANOVA followed by Tukey multiple comparisons post-hoc was used to assess the effect of expiration date and thermocycling processing on the fracture strength and dimensional stability of the interim 3D-printed material. All statistical analyses were used at a significance level of .05.

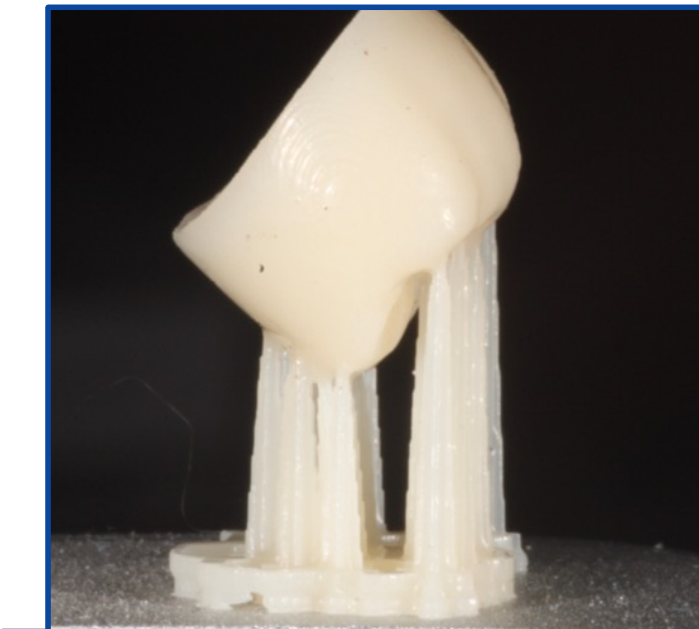


Fig. 1: 3D-Printed Crown Using Temporary Crown and Bridge Material

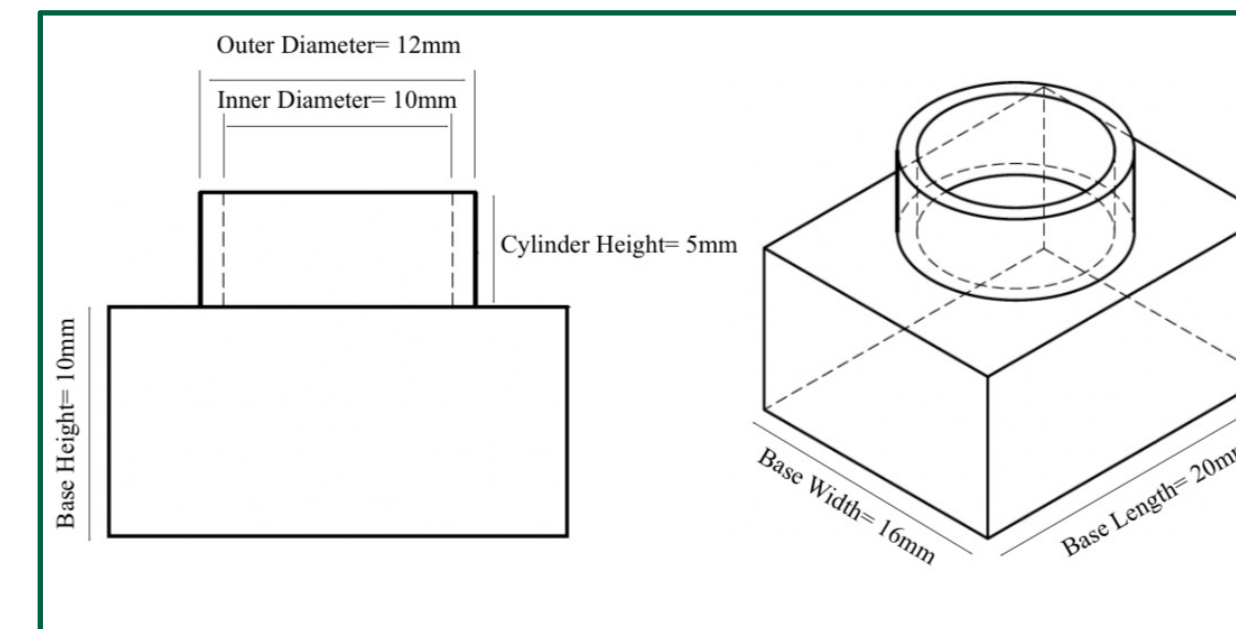


Fig. 3: Designed Test Coupon, Simulating Dimensions of a Molar Crown

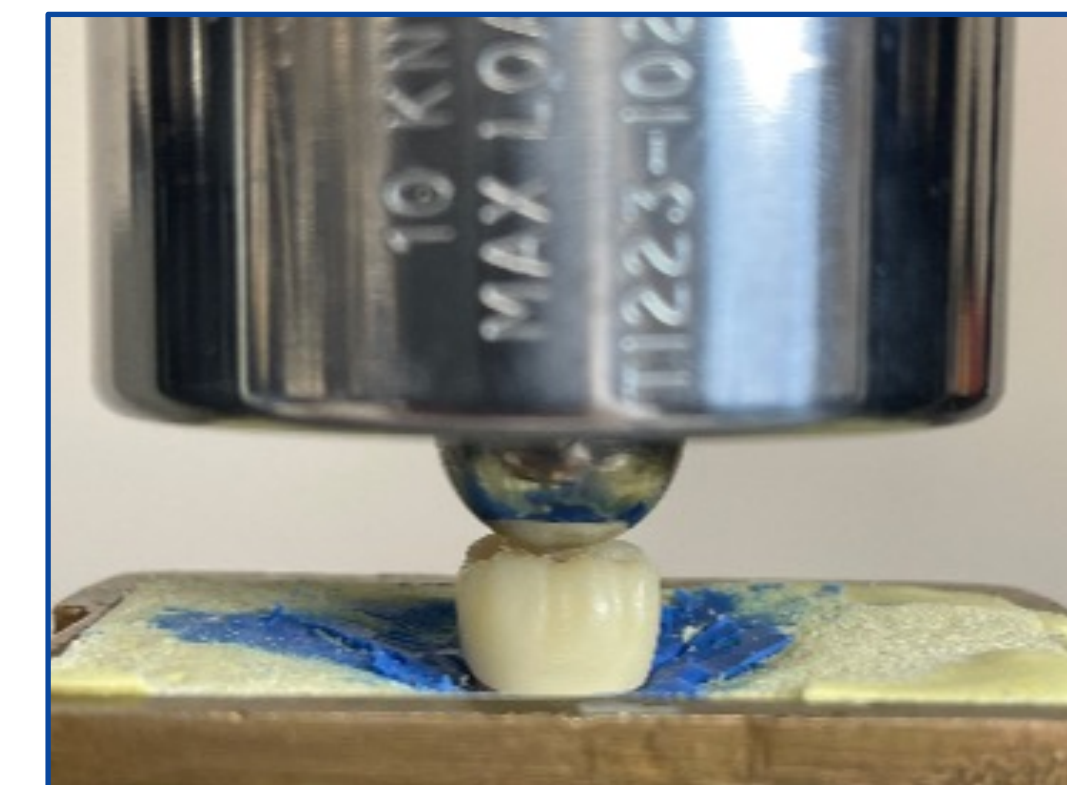


Fig. 2: Fracture Load Testing Using Universal Testing Machine

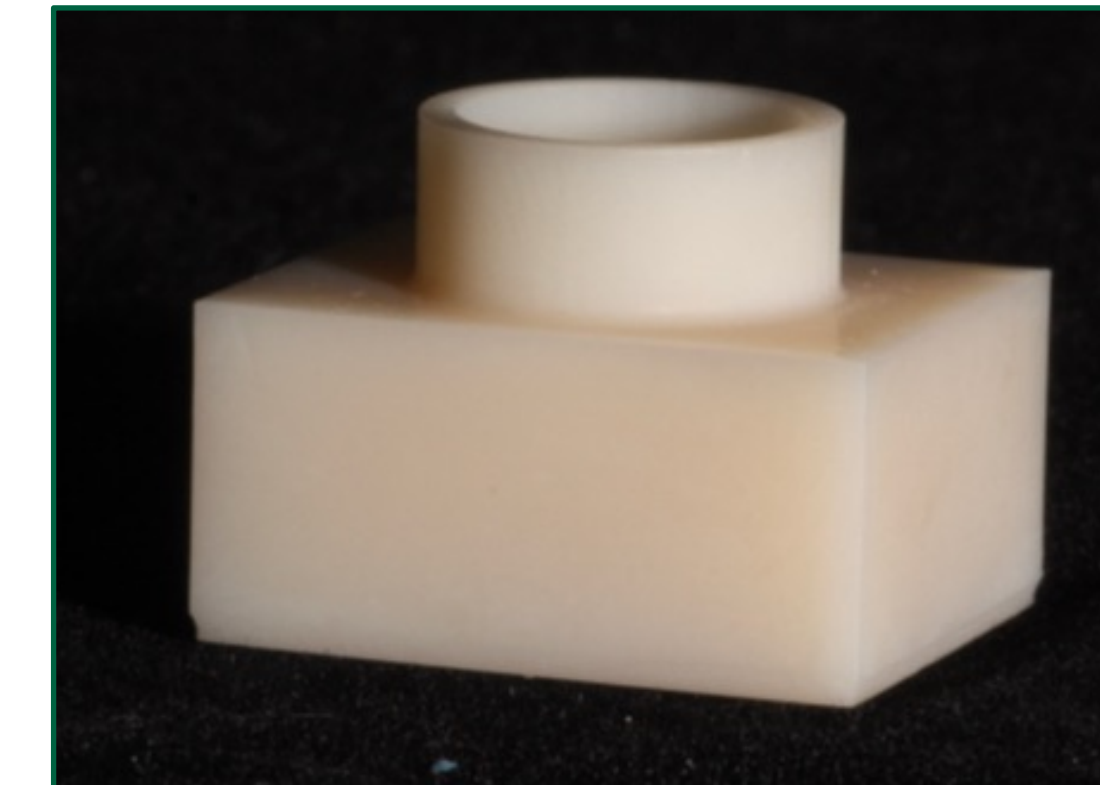


Fig. 4: 3D-Printed Dimensional Test Coupons

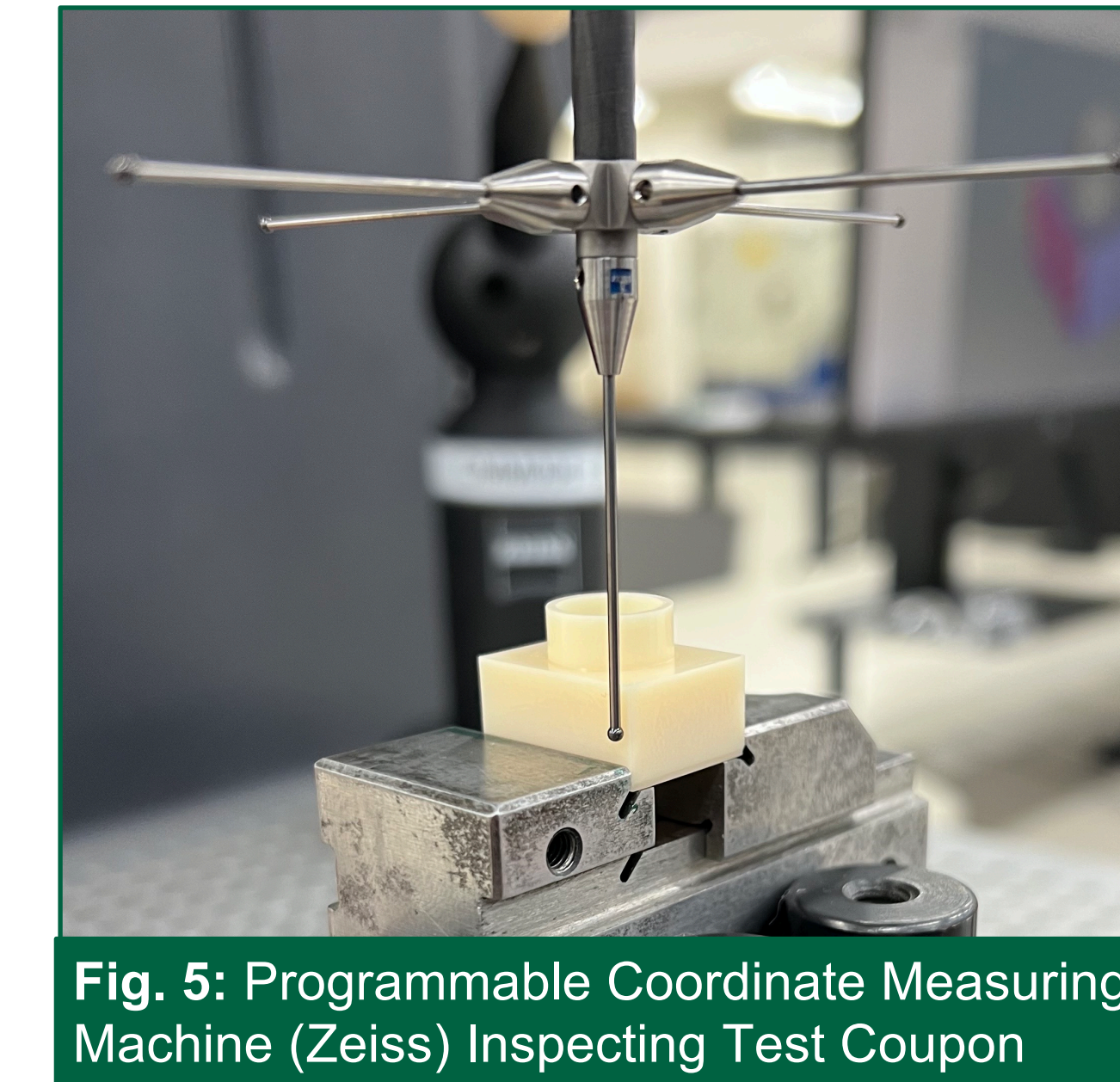
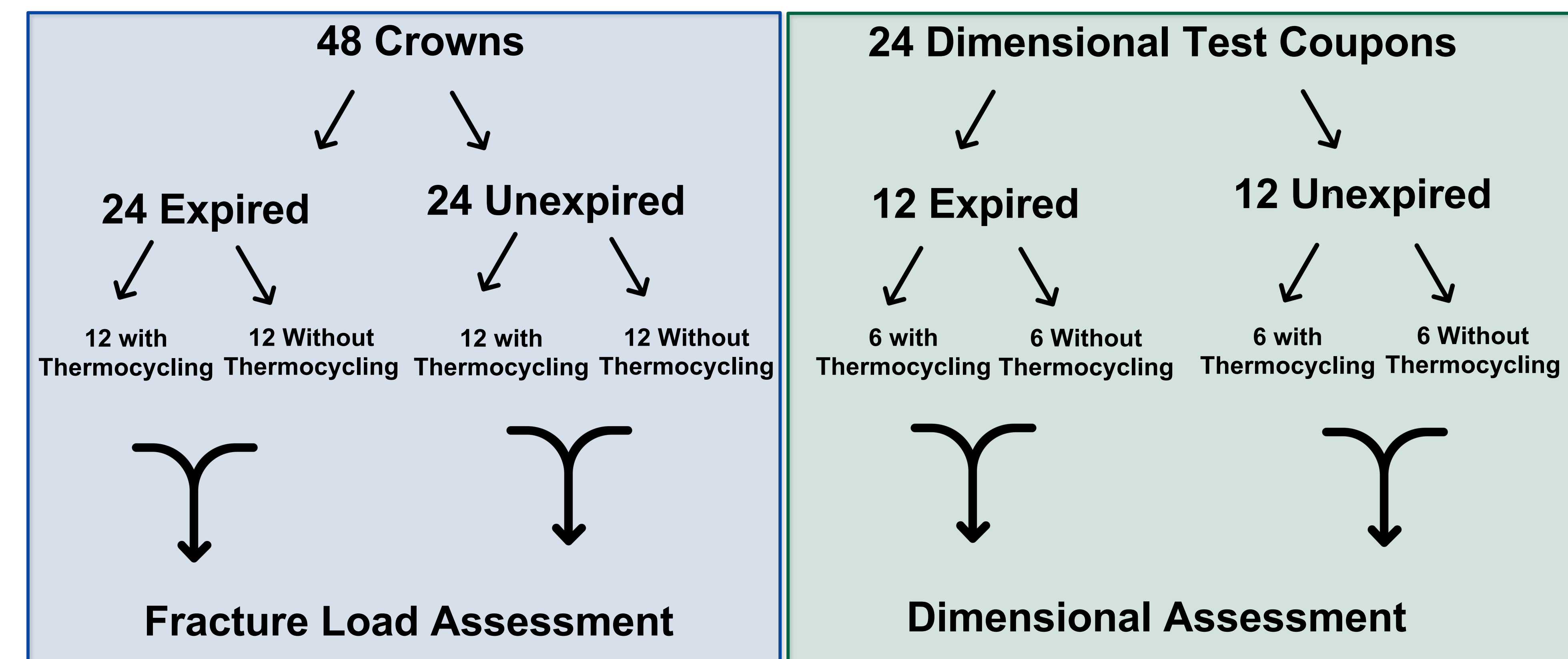


Fig. 5: Programmable Coordinate Measuring Machine (Zeiss) Inspecting Test Coupon

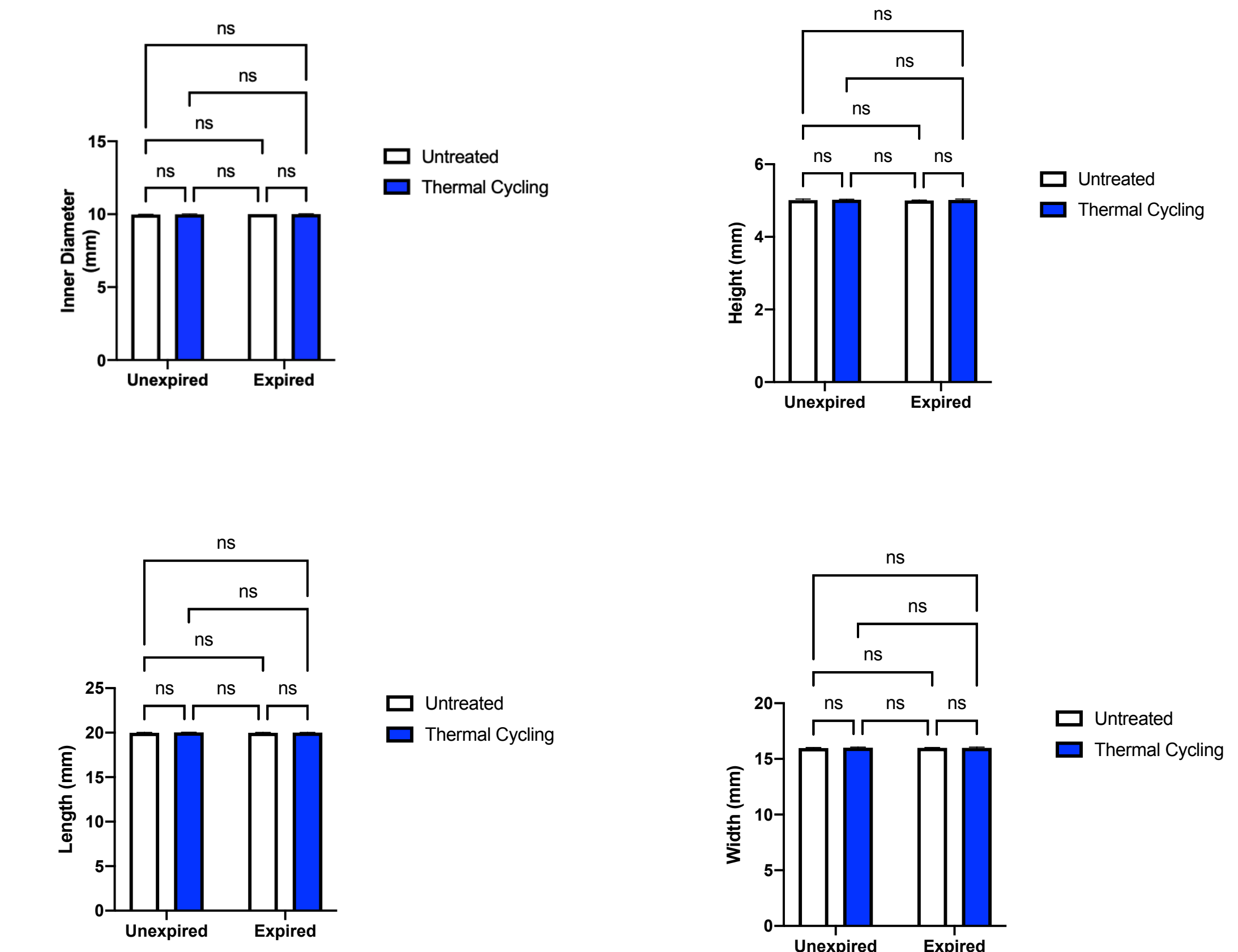
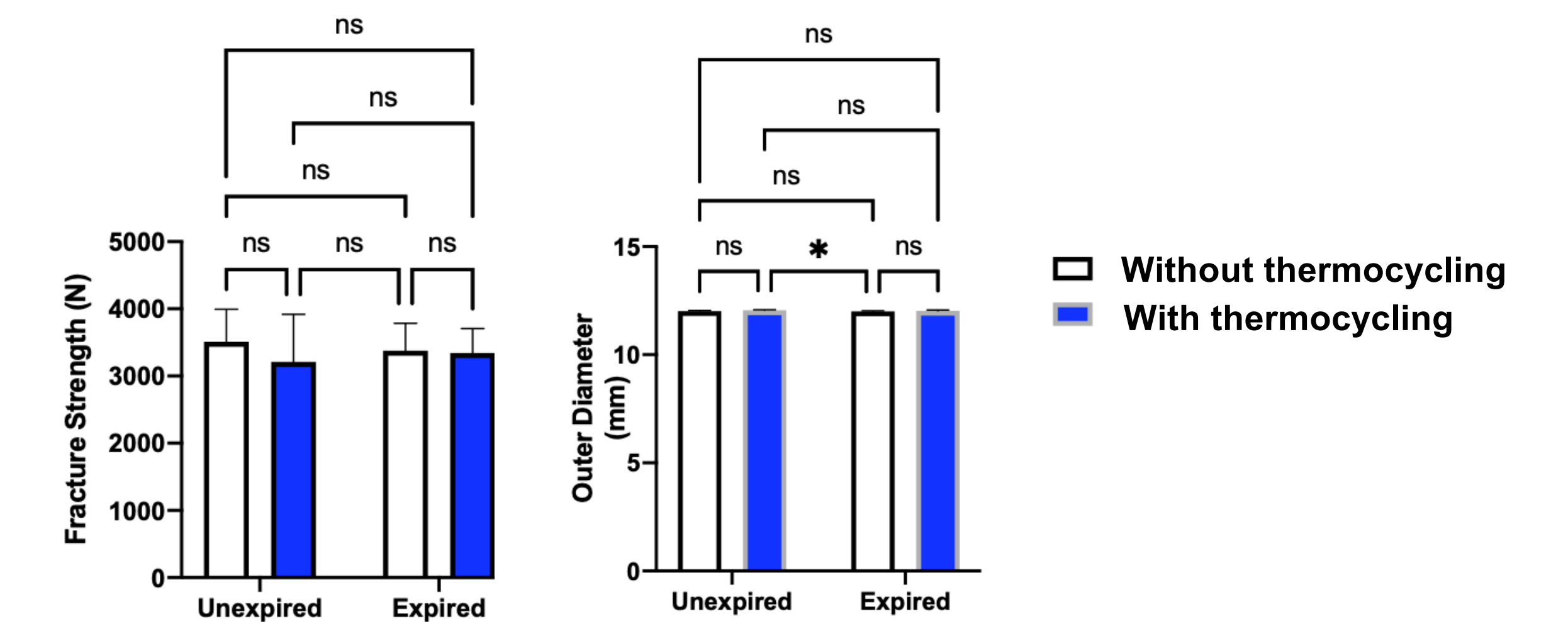
Study Design



Two-Way ANOVA

Results

Expiration date, thermocycling, and their interaction did not have a significant impact on the fracture load value crowns and dimensional accuracy of Coupon ($p>0.05$).



Conclusions

Within the limitation of this study, the one-year expiration date has no impact on the fracture load value and accuracy of temporary 3D-printed resin material.