Fracture Load Value of CAD-CAM Provisional Crowns - An in vitro Study

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Objective

The purpose of this study was to evaluate fracture load value of 5 types of provisional crowns with and without thermocycling.

Introduction

Interim restorations become critical where several teeth are involved, and they may be used for relatively long periods, ensuring the maintenance of the health of the remaining tissues, monitoring their stability, and making the necessary adjustments possible. Subtractive and additive techniques have gained popularity due to improved physical and mechanical properties of interim restorations fabricated by computer aided manufacturing (CAM). In subtractive technique milling machines will be used to mill external and internal restorations. Additive techniques use a layer by layer manufacturing process to create a 3D object, allowing the manufacturing of complicated geometries while using less time and material than milling. The fracture strength of interim prosthesis is essential for long-term provisionalization. Many studies have evaluated the fracture strength of 3D-printed interim resin restorations and the effect of different variants on the fracture strength of printed prosthesis; the data on DLS 3D printing technology, however, are scarce.

Materials and Methods

A complete coverage crown was designed on a mandibular first molar with a uniform 1.5-mm chamfer margin and 1.5-mm axial and occlusal reduction, and the STL file was exported to manufacture 100 crowns using 5 materials, 20 each. Materials used to manufacture crowns in this study, technology, manufacturers, and the composition of each group, are listed in Table. Each group where then divided into two subgroups; before and after thermocycling.

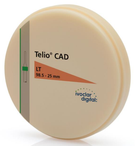
Materials	Fabrication Method	Composition
Telio CAD (Ivoclar)	Milling Machine (PM7; Ivoclar)	Polymethyl methacrylate
E-Dent 400 C&B MHF (EnvisionTEC Inc)	Direct Light Processing (VIDA HD; EnvisionTEC Inc)	Microfilled Hybrid Material
ZCAD Temp Esthetic (Harvest Dental)	Milling Machine (PM7; Ivoclar)	Polymethyl methcrylate and ester-based crosslinked polymers
DENTCA Crown & Bridge (DENTCA Inc)	Digital light synthesis (Carbon M1; DENTCA)	Methacrylate monomer, Diurethane dimethacrylate, Trimethylolpropane trimethacrylate, initiator proprietary, stabilizer proprietary, pigment
P pro Crown and Bridge (Straumann Inc)	Direct Light Processing (P30; Straumann Inc)	Acrylic resin, urethane dimethacrylate, 2,2-bis (acryloyloxymethyl) butyl acrylate; trimethylolpropane triacrylate Diphenyl (2,4,6-trimethylbenzoyl) phosphine oxide

Table 1. CAM Temp Materials

Temporary Crown Materials

ZCAD Temp Esthetic | TelioCAD | DENTCA C&B | E-Dent 400 C&B | P Pro C&B











Manufacturing

PM7 Programill | EnvisionTEC | Carbon M1 | P30 Straumann









Post-Processed

The STL file of the mandibular first molar die was used to manufacture 100 resin dies (P pro Master Model; Straumann Inc) using a 3D-printing machine (P30; Straumann Inc). They were then post-processed following the manufacturers' instructions. Each die was assigned to one interim crown. The marginal integrity of interim crowns was assessed on the assigned die using an explorer. The group with thermocycling went through 1000 cycles of 5 and 55 degrees centigrade with 15 seconds interval time. Their marginal integrity was reassessed on their assigned die. Interim crowns were then luted to their assigned die using a temporary luting agent (TempBond NE; Kerr Dental) under a constant pressure of 450 grams and set for more than 24 hours at room temperature. The fracture strength of crowns was assessed using a universal testing machine (Instron 33R4204; Illinois Tool Works Inc.)(Fig 1). A stainless-steel sphere (r=5mm) was placed on the occlusal surface at the central pit. The location of the stainless-steel sphere was confirmed using an articulating paper. Then, the compressive load was applied to the long axis of the tooth at a crosshead speed of 2 mm/min until fracture occurred.

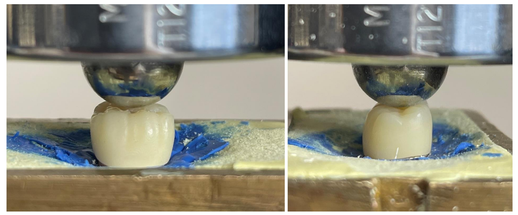


Figure 1. Die–crown unit positioned in the universal testing machine

Results

Fabrication Technique	Materials	Sample Size	Mean ± SD	Median
Subtractive Technique	SM-ZCAD	20	3344±353^{A}	3432
	SM-TCAD	20	3410±324^{A}	3349
Additive Technique	AM-PPRO	20	3718±468^{B}	3793
	AM-EDENT	20	3800±421^{B}	3813
	AM-DENTCA	20	2413±289^{C}	2375

Same Upper letter presents no significant difference (p>0.05)
ZCAD Temp Esthetic (ST-ZCAD); Telio CAD (ST-TCAD); P pro Crown and Bridge (AT-PPRO); E-Dent 400 C&B MHF (AT-EDENT); DENTCA Crown & Bridge (AT-DENTCA)

Table 2. Mean ±standard deviation (SD) fracture strength (N) of interim crowns for studied materials

Treatment	Sample Size	Mean ± SD	Median
With Thermocycling	50	3173±611	3178
Without Thermocycling	50	3501±587	3624

Table 3. Mean ±standard deviation (SD) fracture strength (N) of interim crowns with and without thermocycling

Conclusions

Within Limitations of this study, significant differences in fracture loads were found between interim crowns fabricated through subtractive and additive technologies, shedding light on the importance of technology choice and material considerations in dental prosthesis manufacturing. Moreover, It was found that thermocycling significantly reduced the fracture load of interim crowns.

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