

A Comparative Evaluation of Fracture Toughness of Composite Resin vs Protemp 4 for Use in Strip Crowns: An *In Vitro* Study

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ABSTRACT

Aim: The aim of this study was to compare the fracture toughness of pedo shade packable composite resin (Z100, 3M ESPE, St. Paul, USA) vs Protemp 4 (3M ESPE, Seefeld, Germany) when used inside a strip crown to restore primary incisors.

Materials and methods: Thirty-six exfoliated noncarious human primary central and lateral incisors were randomly divided into two equal groups. The teeth were prepared to standardized dimensions to receive a strip crown. All the teeth were etched, rinsed, and dried following which bonding agent was applied and light cured. In group I, pedo shade packable composite resin (Z100, 3M ESPE, St. Paul, USA) was packed into strip crowns, placed on the prepared tooth, and light cured. In group II, the strip crowns were filled with Protemp 4 (3M ESPE, Seefeld, Germany), placed on the prepared tooth, and left to autopolymerize for 10 minutes. The strip crowns were removed, and the teeth were tested using the universal testing machine until fracture. Fracture toughness of the two groups was recorded and analyzed statistically using Student's "t" test.

Results: The mean force required to fracture strip crowns restored with Protemp 4 (416.89 ± 124.58 N) was higher when compared with pedo shade packable composite resin (338.27 ± 130.99 N). However, statistical analysis did not show a significant difference in the fracture toughness between the two groups ($p = 0.074$), based on Student's "t" test results.

Conclusion: The fracture toughness of teeth restored with Protemp 4 was comparable with pedo shade packable composite resin when used inside a strip crown.

Clinical significance: The use of Protemp 4 is a possible alternative to pedo shade packable composite resin in restoring the primary anterior teeth, when used inside the strip crowns. The data also showed that the fracture toughness of Protemp 4 was comparable with pedo shade packable composite resin.

Keywords: Composite resin, Fracture toughness, Primary incisors, Protemp 4, Strip crowns.

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INTRODUCTION

Restoring decayed primary anterior teeth presents a challenge for the pediatric dentist. The challenge is to obtain an esthetic, long-lasting restoration capable of withstanding masticatory forces.^{1,2} The treatment options for restoring such teeth include open-faced stainless steel crowns, veneered stainless steel crowns, zirconia crowns, polycarbonate crowns, artglass crowns, and strip crowns.³⁻¹⁰

Strip crowns have been used to restore decayed primary anterior teeth for more than 30 years.^{10,11} Acid etch resin crowns or strip crowns serve as one of the most esthetic restorations for the pediatric dentist to restore decayed primary anterior teeth. Retention rates of strip crowns range from 63% to 100% over different follow-up periods.¹²⁻¹⁸ Parental satisfaction was found to be excellent for strip crowns.¹² Salami et al.¹⁹ reported that strip crowns ranked lower than zirconia crowns but higher than veneered stainless steel crowns in terms of overall parental satisfaction.¹⁹ However, strip crowns have specific limitations such as durability and color stability.^{9,20,21} They are technique sensitive and difficult to place. Additionally, their retention depends on the amount of tooth structure present after caries removal.¹¹ Several modifications have been reported in the literature to improve the success rate of strip crowns. The use of mini pins, short posts, omega wire, and composite core posts has been reported to be successful in restoring teeth with little remaining coronal tooth structure.^{4,14,22} The use of resin-modified glass ionomer cement²³

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and natural tooth fragments to restore primary incisors has also been reported in the literature.²⁴

Dental material science advancements have made available newer generation of composites, bonding adhesive systems, and resin-based materials. Protemp 4 is a bis-acryl-based provisional resin consisting of an organic matrix and inorganic fillers. They are esthetically stable and have better color stability than polymethyl or

polyethyl methacrylate.^{25–27} Mehrpour et al.²⁸ described the flexural strength of different interim restorative materials (TempSpan, Protemp 4, Unifast III, Trim, and Revotek LC) with Protemp having high flexural strength among the materials tested. Amin et al.²⁹ evaluated and found that Protemp 4 had the least marginal discrepancy among the provisional materials tested (Luxatemp Star, Visalys Temp, and polymethyl methacrylate).

There have been no reported studies in the literature on the use of Protemp 4 (3M ESPE) in primary anterior teeth, inside the strip crown. Therefore, the purpose of this *in vitro* study was to compare the fracture toughness of Protemp 4 (3M ESPE, Seefeld, Germany) vs pedo shade packable composite resin (Z100, 3M ESPE, St. Paul, USA) when used inside a strip crown to restore primary incisors.

MATERIALS AND METHODS

Approval for the study protocol was obtained from Institutional Review Board (for student projects) of Sri Ramachandra University, Chennai (CSP/14/AUG/36/114). In this *in vitro* study, 36 exfoliated human primary maxillary and mandibular central and lateral incisors were collected and stored in isotonic saline at 37°C, until it was used for the study. Teeth that were used showed no evidence of dental caries or any fracture. All the teeth were cleaned of gross debris using an ultrasonic scaler (Magbole, Guangzhou, China). They were embedded in a block of self-cure acrylic resin (DPI-RR cold cure pink, Denture base polymer resins, Dental Products of India, Mumbai), using a rigid plastic template. The teeth were numbered separately, and the three dimensions (buccolingual, mesiodistal, and cervicoincisal) were measured by two investigators independently using a Vernier caliper (SV-08 Stainless Steel Digital Vernier Caliper, E-Base Measuring Tools Co., Aluminum Ruler Manufacturer, Taiwan), and the mean was taken to establish baseline dimensions to guide the tooth preparation. The buccolingual dimension was measured at the greatest curvature of the tooth at the cingulum region. The mesiodistal dimension was measured at the greatest dimension of the tooth mesiodistally. The cervicoincisal dimension was measured at the buccal surface from the most apical point of the cervical line to the incisal edge.

The crowns of the teeth were prepared to receive a full coverage restoration with a strip crown. A TF-12 diamond bur (Mani Inc., Germany) was used with a high-speed hand piece under water cooling. Care was taken to ensure parallelism of the proximal surfaces. The teeth samples were prepared so as to have a buccolingual width of 3.5 mm, a mesiodistal width of 4 mm, and a cervicoincisal length of 4 mm. All the aforementioned measurements were made using a Vernier caliper by the two investigators independently and recorded. A kappa value of 0.74 was obtained for the values measured by the two investigators. The strip crown (size B2) of primary maxillary left lateral incisor (3M ESPE, St. Paul, USA) was checked with the tooth and used for both the groups.

The strip crowns were trimmed off using sharp-curved scissors according to the manufacturer's instructions, and vent holes were placed on the palatal surface to ensure escape of air and excess material. The teeth in both the groups were dried and etched (Scotchbond Multi-purpose Etchant, 3M ESPE, St. Paul, USA) for 15 seconds.¹² The etchant was rinsed off, and the dentin surface was dried with gentle air spray, taking care not to overdry the tooth. The bonding agent (Adper Single Bond, 3M ESPE, St. Paul, USA)

was applied and light-cured (Bluedent LED, Smart, Bulgaria) for 20 seconds at 1,200 mW/cm².

The teeth were randomly divided into two groups at this stage.

Group I (pedo shade packable composite resin group)—teeth which received a full coverage restoration with pedo shade packable composite resin (Z100, 3M ESPE, St. Paul, USA), inside the strip crown.

Group II (Protemp group)—teeth which received a full coverage restoration with Protemp 4 (3M ESPE, Seefeld, Germany; A2 shade), inside the strip crown.

In group I, pedo shade packable composite resin (Z100, 3M ESPE, St. Paul, USA) was packed into the strip crown. In group II, the strip crowns were filled with Protemp 4 (3M ESPE, Neuss, Germany). In all the samples, care was taken to avoid void formation. The strip crown was seated on the tooth gently, and the excess material was removed using a sharp explorer. Group I was light-cured through the strip crown as per the manufacturer's instructions (labially for 40 seconds and lingually for 40 seconds) at 1,200 mW/cm². Group II was left to autopolymerize for 10 minutes at room temperature.

The strip crown was then removed by cutting it on the lingual surface with a spoon excavator (GDC Marketing, India). The crowns were stripped off from the tooth. The teeth were stored in isotonic saline for 24 hours prior to testing for fracture toughness. The samples were tested for fracture toughness using a universal testing machine (Instron, Blue Hill 2 Version, Pneumatic Side Action Grips, India). The force was applied at the incisal edges of the crown at a crosshead speed of 1 mm/minute, and the force of fracture was recorded in Newton (N).

Statistical analysis was done using SPSS 16.0 statistical analysis software (SPSS Inc., Chicago Ill., USA). Mean and standard deviations were calculated. Student's "t" test was used to compare the results between the groups ($p < 0.05$).

RESULTS

The fracture toughness of the two groups (pedo shade packable composite resin and Protemp) is shown in Table 1. The difference in the fracture toughness between the two groups was not found to be statistically significant ($p = 0.074$) based on Student's "t" test results.

DISCUSSION

Full coverage restorations are often required for primary anterior teeth that are affected by early childhood caries and traumatic dental injuries.³⁰ Several treatment options (such as strip crowns, prestainless steel crowns, and zirconia crowns) are reported in the literature for restoring decayed primary anterior teeth.^{3,4,6,7,9,11,12,15,23,30–40} Although strip crowns have been in clinical use for more than 30 years, most of the published data about strip crowns are in the form of retrospective studies, parental satisfaction, case reports, and clinical performance.^{4,11,12,15,37,38,41} *In vitro* testing

Table 1: Fracture toughness values of two groups

Groups (n = 18)	Mean (N)	Standard deviation (N)	t value	p value
I (pedo shade packable composite resin)	338.27	130.99	1.845	0.074*
II (Protemp)	416.89	124.58		

*There is no statistical significant difference between the two groups ($p < 0.05$)

of the mechanical and physical properties of the dental materials serves as a benchmark for its use in clinical practice.⁴² However, to the best of our knowledge, there are no published *in vitro* studies evaluating the mechanical properties of human primary incisor teeth restored using a strip crown. Hence, the methodology used in this study was adapted from similar studies.

This study was designed to compare the fracture toughness of pedo shade packable composite resin vs Protemp 4, for its use in strip crowns. Although Protemp 4 is a provision material, it contains bisphenol A-glycidyl methacrylate which is commonly found in the resin component of composite resins. Hence, we modified the technique described by McLaren⁴³ to etch and bond Protemp 4 to tooth structure.

In this study, Protemp 4 had higher fracture strength values than pedo shade packable composite resin, but the result was not statistically significant. The probable reasons for this could be due to the relatively small sample size and the varying amounts of dentin exposed during tooth preparation. All the samples were prepared to a standard size, to ensure uniformity of the final samples tested. Since both primary central and lateral incisors were used for this study, there is a possibility that varying amounts of dentin may be exposed and act as the bonding substrate. This could be a potential limitation of this study, since it can cause variability in the strength values. Protemp 4 had been used with a dispensing tip in a mixing gun.²⁹ Dispensing methods of Protemp 4 into strip crowns need further research due to the larger size of the dispensing tip when compared with the size of the crown. In pediatric dentistry, dispensing tips or cartridges of Protemp 4 can be made specifically for use in future.

Color stability is also another factor to be considered when restoring teeth using a strip crown. Further research is necessary to evaluate the color stability of Protemp 4. Protemp 4 being a self-polymerizing resin undergoes an exothermic reaction during the setting stage. Khajuria et al.⁴⁴ proved that Protemp 4 caused less intrapulpal temperature change and less exothermic heat when compared with other provisional materials.⁴⁴ However, the effect on primary tooth is yet to be investigated. Protemp 4 can also be used in a two-step process where it can be fabricated, followed by cementation with resin cements. The effect of temperature can be eliminated, if a two-step procedure (fabrication and cementation) is used to fabricate and cement the strip crown.

This study provides a preliminary assessment into the use of a new material for an existing treatment modality. However, the clinical situation cannot be reproduced through the test performed in this study. The obtained values for fracture toughness of the groups should be regarded as a preliminary indicator of the strength of the material when used for the strip crown.⁴⁵ Consequently, further studies are required to investigate the performance of the primary anterior teeth restored by strip crown under cyclic stress to simulate the normal loading conditions. Further research is also needed to compare the clinical performance of pedo shade packable composite resin and Protemp 4 using strip crowns to provide reliable data for future decision-making.

CONCLUSION

Within the limitations of this *in vitro* study, it is concluded that the fracture toughness of Protemp 4 was comparable to pedo shade packable composite resin when used inside the strip crown.

CLINICAL SIGNIFICANCE

The use of Protemp 4 is a possible alternative to pedo shade packable composite resin in restoring the primary anterior teeth, when used inside the strip crowns. The data also showed that the fracture toughness of Protemp 4 was comparable to pedo shade packable composite resin.

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