RESEARCH PAPER

From Posts To Endocrowns: Assessing The Ferrule Effect In Premolar Restorations

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Abstract

AIM:

The purpose of this study was to evaluate the incorporation of a ferrule in premolar endocrown designs and its effect on fracture resistance.

MATERIALS AND METHODS:

Twenty maxillary first premolars that were extracted for orthodontic or periodontal treatments and had no cracks or cavities made up the sample. Coldcure acrylic resin was used to mount each tooth separately. Group A had composite endocrown without ferrule, while Group B had composite endocrown with a ferrule. Elastomeric polyvinyl siloxane (GC EXcalear) was used to create an endocrown former. The endocrown former was then used to prepare endocrowns utilizing dual-cure core build-up composite-core x flow (Dentsply Maillefer, Switzerland), resulting in nearly comparable morphologies. Dual cure resin cement was used to cement endocrowns in accordance with manufacturing guidelines. We assessed and compared the fracture resistance of endocrowns with and without ferrule.

RESULTS AND OBSERVATIONS:

Microsoft Excel was used to tabulate the data, while SPSS version 24 was used for analysis. The variables were presented with mean, standard deviation, and independent t-test. The $P \leq 0.05$ is considered statistically significant. Compared to Group A (546. 88) (without ferrule), Group B (with ferrule) had greater fracture resistance (606.47 N). The difference was statistically significant, according to the independent t-test ($P = 0.022$).

CONCLUSION:

When comparing the failure load results, it can be inferred that endocrowns with a ferrule exhibited higher failure loads than conventional endocrown restorations.

Keywords: Endocrown, Ferrule, Premolar, Fracture resistance, Composite restoration.

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1. Introduction

Endodontic therapy is frequently required in dentistry, but the subsequent loss of tooth structure can compromise mechanical properties.

A crucial component of dentistry is the restoration of teet h that have had endodontic treatment. This process entail s a variety of treatment choices with varying degrees of d ifficulty, which become more challenging when there is a significant loss of coronal tooth structure. (1)

Rather than dehydration and physical alterations in denti n structure, the primary cause of the decrease in stiffness and fracture resistance (FR) of endodontically treated teet h is the loss of tooth structure integrity brought on by cari es, trauma,or significant access cavity preparation.

These biomechanical alterations in teeth that have had en dodontic treatment jeopardize their long-term prognosis and complicate the restoration procedure. (2) Traditionally, post–core–crown systems were employed, as it was believed that they reinforced the remaining tooth. However, intracanal posts can only improve crown retention and postspace preparation erodes the remaining tooth structure and raises the possibility of root perforation or tooth fracture.(3)

An additional treatment option is endocrown restoration, which involves placing a single unit system in a tooth tha t has had a root canal and attaching it to the cavity's bord ers and inner pulp chamber to provide macromechanical and micromechanical retention. (4) With advancements in adhesive dentistry, endocrown restorations offers clinicians a more efficient and conservative alternative for restoring endodontically treated teeth. (5)

An endocrown is a monolithic all-ceramic restoration characterized by a circumferential butt-joint margin and a

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centrally positioned intracoronal cavity that engages the pulp chamber. Retention and stability are achieved through adhesive bonding and exploitation of the available pulpal surface area, in accordance with the principles of minimally invasive tooth preparation [12]. This concept was originally proposed by Pissi in 1995 as the "monoblock" technique [13] and was subsequently adapted for posterior teeth by Bindl and Mörmann [14], who introduced and established the term endocrown for molar restorations. According to reports, premolars that have endocrown restorations are more prone to fracture than molars. This may be attributed to the relatively greater coronal height and reduced bonding surface area of premolars. (6)

Incorporating a ferrule into cavity preparation design has been shown to increase bonding surface area and enhance restoration stability.(7)

However, the application of a ferrule design in the preparation of premolars for endocrown restorations has been relatively underexplored. Hence, the present study aims to evaluate the success rates of endocrown restorations on maxillary premolars in permanent teeth with and without ferrule designs.

AIMS AND OBJECTIVES

The purpose of this study was to evaluate the incorporation of a ferrule in premolar endocrown designs and its effect on fracture resistance.

MATERIALS AND METHODS

Selection of samples- Sample size estimation was performed using G*Power software (version 3.1.9.7; Heinrich-Heine-Universität Düsseldorf, Germany). Assuming a large effect size (Cohen's d = 0.8), an alpha error probability of 0.05, and a power (1−β) of 80%, the minimum required sample size was calculated to be 10 specimens per group for a two-tailed comparison. Accordingly, a total sample size of 20 maxillary molars was selected for this pilot study, which is consistent with previously published in-vitro fracture resistance studies and sufficient to assess feasibility, variability, and preliminary effect trends for future larger-scale investigations.

Maxillary premolars extracted due to periodontal mobility or for orthodontic purposes were included in the study. Teeth presenting with caries, fractures, curved root canals, or immature apices were excluded from the investigation. Twenty extracted maxillary first premolars of similar size and shape were selected for the study. The teeth were initially immersed in 5% sodium hypochlorite for 15 minutes, followed by ultrasonic cleaning, and subsequently stored in saline until further use. Each specimen was mounted in cold-cure acrylic resin, leaving 2 mm of root structure exposed apical to the cemento-enamel junction (CEJ). The crowns were then sectioned 2 mm coronal to the CEJ.

Endodontic treatment was performed by establishing the working length 1 mm short of the apex, with root canal patency verified using a #10 K-file. Canal preparation was completed using HyFlex CM rotary files (Coltene) till 30/4%. After each filing procedure, the canals were irrigated with 5.25% (w/v) sodium hypochlorite, dried with paper points, and obturated using a matched gutta-percha cone and the lateral compaction technique. An eugenol-free resin sealer (AH Plus; Dentsply Maillefer, Switzerland) was applied. Excess gutta-percha was removed with a heated instrument, and a periapical radiograph was obtained to confirm the adequacy of obturation.

The teeth were then randomly allocated into two groups (n = 10 per group):

Group A: Bulk-fill composite endocrown without ferrule

Group B: Bulk-fill composite endocrown with ferrule

An endocrown former made from condensation silicone putty was used to fabricate identical endocrowns with dual-cure composite material (Core X Flow, Dentsply Maillefer). The teeth were prepared with a 3 mm deep round inlay cavity, and internal line angles were rounded using a cylindrical diamond bur. In sample of group B, a ferrule of height 1.5 mm as well as a chamfer margin along the circumference of the tooth was prepared. After etching, the prepared tooth surface of all endocrowns was then bonded with dual-cure resin cement. (Figure 1)

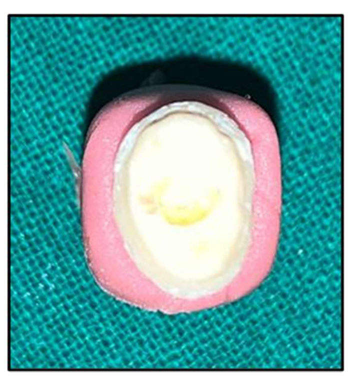

Figure 1- (a) Preparation without ferrule (b) Preparation with ferrule © Endocrown without ferrule (d) Endcrown with ferrule

The specimens were subsequently positioned on a laboratory-fabricated carrier inclined at 30° and mounted in a universal testing machine (Figure 2). Fracture resistance was recorded in Newtons, and the failure modes of all specimens were assessed through visual inspection and periapical radiographic evaluation following fracture. (Figure 3)

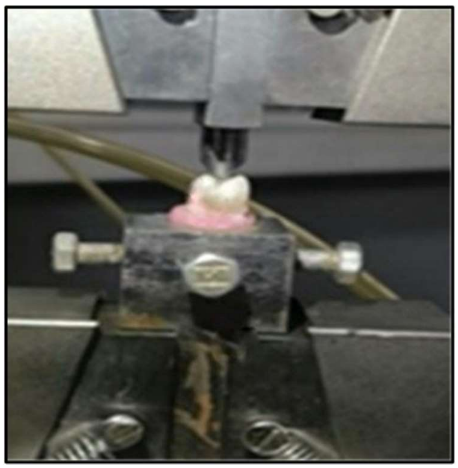

Figure 2- Specimen loaded in Universal Testing Machine

Unfavorable failures were classified as non-repairable, catastrophic fractures occurring below the CEJ.Favorable failures were defined as repairable fractures occurring above the CEJ and were categorized as adhesive failures.

Figure 3- Fracture recorded

RESULTS AND OBSERVATIONS

Fracture resistance in both groups was evaluated using a universal testing machine. The collected data were tabulated in Microsoft Excel and statistically analyzed using SPSS software (version 24) [Tables 1-3]. Descriptive statistics, including mean and standard deviation, were calculated, and comparisons between groups were performed using an independent t-test. A P value ≤ 0.05 was considered statistically significant. The fracture resistance outcomes for the two groups were as follows:

Table 1- Fracture resistance in group A (without ferrule)

Fracture resistance in group A- without ferrule (Newton)
440.62
485.98
686.20
467.52
664.20
653.19
473.27
624.35
439.77
485.04

Table 2- Fracture resistance in group B (with ferrule)

Fracture resistance in group B- with ferrule (Newton)
510.17
530.08
670.27
689.73
672.50
536.17
667.47
515.11
533.04
682.56

Table 3- Comparison of fracture resistance between group A and group B

Group	**Minimum**	**Maximum**	**Mean±SD**	**p**
Group A (without ferrule)	439.77	686.20	542.01±101.24	0.169
Group B (with ferrule)	510.17	689.73	600.71±80.51	

DISCUSSION

Fehrenbach et al. state that there is no clear consensus in the literature about the best restorative material or technique, making the rehabilitation of endodontically treated anterior teeth with significant coronal loss a clinical challenge. Thus, it is crucial to look into new strategies that streamline the process and improve clinical results. (new 1)

However, even though crowns are frequently placed on post-and-core systems with a ferrule effect in traditional restorations, which are still accepted as the normal procedure, these methods can also fail because of post retention loss, fracture, deformation, or root perforation. With the development of adhesive dentistry, more conservative methods have become more popular, prompting a reassessment of the need for conventional post-and-core procedures. (new 2)

According to studies, full coverage restorations using p osts and cores produce higher internal forces than endo crown. (8,9) Endocrowns were suggested to be used only in molars, according to a few research. (10)

This study evaluated how preparation design affected the fra cture resistance of maxillary premolars restored with compos ite endocrowns after endodontic treatment.

The null hypothesis was that there would be no signific ant difference in the FR of the two groups with differen t preparation design (with and without ferrule). The difference in FR was statistically significant among the two groups ($P < 0.05$). Thus, the null hypothesis was rejected.

Michael Einhorn et al. [7] reported that incorporation of a 2-mm ferrule in endocrown design increased the bonding surface area by over 47% compared to conventional endocrowns. Although no significant difference in fracture strength was noted, ferrule-equipped endocrowns tended to fail at higher loads. In the present analysis, failure load was used as the primary outcome measure, and accordingly, the ferrule group demonstrated superior performance. Failures that initially appeared to be adhesive in nature and potentially repairable on visual inspection were later identified as non-repairable fractures; depending on their location, these fractures may or may not be detectable on routine periapical radiographs. Due to resource constraints, fracture assessment was limited to evaluation under a dental operating microscope. Catastrophic failures were defined as fractures involving the tooth structure within the preparation margins, whereas cohesive root fractures occurring apically were excluded from the analysis.

The fracture resistance values of standard endocrowns in this study were comparable to those reported by Biacchi and Basting [11], while higher values reported in other studies may be attributed to differences in restorative materials, loading direction, and testing protocols [12,13]. Unlike ceramic endocrowns evaluated previously, bulk-fill composite was used in this study, which may explain the observed differences.

Although some authors suggest that ferrule incorporation may weaken the tooth due to increased dentin removal [14], conservative preparation combined with adequate bonding can enhance endocrown performance.

The use of dual-cure bulk-fill flowable composite facilitated void-free fabrication and resulted in high mean fracture resistance values, consistent with earlier reports [15,16]. Additionally, bulk-fill composites are associated with reduced polymerization stress, which may enhance fatigue resistance [17,18].

In the present study, catastrophic fractures were infrequent across all experimental groups. However, it should be emphasized that the findings may not be directly extrapolated to clinical situations, as the experimental setup involved a standardized 30° angulated loading condition. Gresnigt et al. (new 3) reported that axial loading generates higher fracture forces than lateral loading, often exceeding average human masticatory forces (approximately 600–900 N in females and males, respectively), thereby potentially overestimating the fracture resistance of restorations. In contrast, the current investigation evaluated endocrowns under oblique loading at 30°, which may better simulate functional stresses. Furthermore, a recent meta-analysis and comprehensive review by Thomas et al. (new 4) on endocrown restorations in permanent molars and premolars demonstrated comparable performance and no significant difference in failure rates between the two tooth types, suggesting that premolars can be considered suitable candidates for endocrown restorations.

Overall, the findings support the use of endocrowns as reliable postendodontic restorations for maxillary premolars, with ferrule incorporation contributing to improved fracture resistance.

CONCLUSION

When comparing the failure load results, it can be inferred that endocrowns with a ferrule exhibited higher failure loads than conventional endocrown restorations.

Despite the presence of a ferrule, this study observed only a few catastrophic failures, which occurred at forces exceeding normal masticatory levels.

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