ORIGINAL RESEARCH

ISSN: 2456-8090 (online)
DOI: https://doi.org/10.26440/IHRJ/0611.02559

QR CODE

Location of Ferrule and Its Effect on Fracture Resistance of Endodontically Treated Mandibular Premolar: An *in-vitro* Study

ISRA NAZIR[1], SAIMA ARSHIE[2], MOHAMMAD HS HILAL[3]

ABSTRACT

INTRODUCTION: Presence of ferrule during delivery of a fixed prosthesis onto an endodontically treated tooth is important for fracture resistance of the tooth in function.

AIM: This study aims to investigate the location of ferrule on fracture resistance of endodontically treated extracted mandibular premolars.

MATERIALS AND METHOD: Sixty extracted mandibular premolars were divided into 6 groups where each group consisted of 10 teeth. The groups were as follows: control group, GHT; endodontically treated teeth without endodontic posts and crowns, GCF; teeth with a 2 mm circumferential ferrule, GBF; teeth with a 2 mm buccal ferrule; GLF, teeth with a 2 mm lingual ferrule; GBLF, teeth with a 2 mm buccal and lingual ferrule; and teeth without ferrule, GWF. All the teeth were endodontically treated and glass fibre posts were cemented and crowns were luted. All the teeth were loaded in a universal testing machine until fractured. Fracture lines were also assessed according to their location onto the teeth. The results were recorded and were statistically analyzed.

RESULTS: Mean ±SD loads for the groups ranged from 770.3 ±212.9 N to 1008.1 ±176.5 N. One way ANOVA revealed a statistically significant difference between the groups (P_.05). However, no statistically significant differences were observed among groups (P>.05), except between GHT (control group) and group GWF (without ferrule).

CONCLUSION: The study reported that although the presence of ferrule leads to improved fracture resistance, specific location of the ferrule had no significant differences in the fracture strength of endodontically treated teeth restored with glass fiber posts.

KEYWORDS: Ferrule, Fracture Resistance, Fibre Post, Premolar

INTRODUCTION

Success and longevity of an endodontically treated tooth is governed by numerous factors. Endodontic treatment of tooth followed by tooth preparation for placement of prosthetic crowns results in loss of tooth structure, thereby making the tooth vulnerable to fracture. To overcome the limitation of this, concept of ferrule was introduced in dentistry. A ferrule effect is defined as a 360^{o} metal collar of the crown surrounding the parallel walls of the dentine extending coronal to the shoulder of the preparation. This results in elevation of resistance form of the crown from the extension of dentinal tooth structure.[1] The parallel walls of dentine, when encircled by a crown, provides a protective effect by reducing stresses within a tooth, leading to the 'ferrule effect'.[2] Ferrule effect is just one part of the restored that represents a complex system.

The clinical performance of the entire endodontically treated tooth complex is not only affected by tooth alone but is also affected by several other factors including material of post and core, luting agent used, the overlying type of crown and functional occlusal loads.[3] A study reported that increasing the number of residual walls and the ferrule height increased the fracture strength of endodontically treated teeth, but they did not evaluate the effect of the ferrule location on the fracture strength.[4] Another study revealed the effect of posts on the fracture strength of endodontically treated teeth with different wall numbers, but they did not evaluate the influence of ferrule location.[5]

Numerous post types are currently available such as cast post and cores, CAD/CAM post and Cores and prefabricated post systems of different materials. Several studies recommended use of posts having a modulus of elasticity close to dentin and have stated that teeth restored with fibre posts and composite resin core materials have a higher fracture resistance in comparison to those restored with cast post cores as elastic post materials, cement used for luting and dentin demonstrated structural deformations similar to dentin under load.[6,7] But, a retrospective study revealed no significant increase in fracture resistance or

© Isra Nazir et al. This is an open access article distributed under the terms of the Creative Commons Attribution License CC-BY-NC 4.0, which permits unrestricted use, distribution and reproduction in any medium, provided the use is not commercial and the original author(s) and source are cited.
Submitted on: 09-Dec-2022; **Accepted on:** 10-Feb-2023

resistance to dislodgement when intracoronal reinforcement with post and core materials were used.[8] The present study was conducted to evaluate the effect of ferrule location on the fracture strength of endodontically treated mandibular premolars.

MATERIALS AND METHOD

Sixty human mandibular premolars, which were extracted for orthodontic treatment purposes, were collected. The teeth were then soaked in 5% formol/saline solution at room temperature. The absence of cracks onto tooth surface was confirmed under magnification. Dental stains, plaque, calculus and periodontal tissue remnants were removed with hand scaler. Teeth with similar dimensions were selected and assigned to 6 groups of 10 specimens each. The root of each tooth was embedded into an autopolymerizing acrylic resin up to a level 2 mm below the CEJ and with its long axis vertical by using a custom-made surveyor. Roots were notched to avoid dislodgement from the acrylic resin blocks. To simulate the periodontal ligament, the roots were immersed in melted wax at a depth 2 mm below the CEJ and were embedded in acrylic resin blocks. The roots were removed when the primary signs of polymerization were noticed on resin blocks. The wax spacer was then replaced by a silicone-based impression material injected into the acrylic resin. The tooth was then reinserted into the resin block. The excess of the impression material was removed. The crowns were prepared with a 0.8 mm wide shoulder finishing line 1 mm above the CEJ faciolingually and 2 mm mesiodistally with diamond rotary instruments with a 3- degree taper under continuous air-water coolant. All 60 teeth were assigned to 6 groups as follows: GHT, control group of healthy root filled tooth specimens without endodontic posts and crowns; GCF, teeth with a 2 mm circumferential ferrule; GBF, teeth with a 2 mm buccal ferrule; GLF, teeth with a 2 mm lingual ferrule; GBLF, teeth with a 2 mm buccal and lingual ferrule; and GWF, teeth without ferrule. All ferrules were 2 mm in height and 1 mm in thickness. In order to eliminate variables caused by difference in post length, post spaces were prepared (for all groups except GHT) with a low-speed corresponding drill provided by the post manufacturer and a post space length of 10mm was achieved for all teeth.

The posts were then seated with finger pressure for 10 seconds. Excess resin cement was utilized to fill the occlusal part of the post. Cores of light-polymerizing composite resin were built. All procedures were performed by the same operator. The tooth surfaces were cleaned with a rotary brush and pumice, rinsed with water and dried before crown cementation. NiCr cast crowns were luted with glass ionomer cement. While luting, the crown was held in a position for 7 minutes, under a 29 N force with custom-made device. All specimens were tested quasistatically with a universal testing machine until fracture. The testing load was applied at an angle of 30 degrees to the long axis of tooth. Compressive load was applied onto a prepared notch on the lingual surface (in the middle of the lingual slope of the buccal cusp). The failure load was recorded when the force-versus-time graph showed a sudden dip. Specimens were inspected visually to determine the location, type and the direction of fracture line. Data were explored for normality with the Anderson- Darling test, which showed that data were normally distributed. Among the 6 groups, fracture load data were analyzed with one-way analysis of variance (ANOVA) followed by multiple comparisons with the Tukey honestly significant difference (HSD) test (p=.05). Fracture load data were analyzed with software, SPSS. According to the significance level (p=.05) and the sample size (n=10), the test of choice had adequate power to detect significant differences which could justify the clinical relevance.

RESULTS

The mean fracture loads of 6 groups and standard deviations are presented in Table 1. The values ranged from 770.3 ±212.9 N to 1008.1 ±176.5 N. The highest mean fracture load was recorded for GHT, and the lowest one was recorded for GWF. Upon further analysis, the one-way ANOVA (table 1) revealed statistically significant differences among groups (p=0.021). However, further analysis with the Tukey HSD test (Table 1) indicated that differences between GHT and the test groups were only significant for GWF(p=.021) and is shown in table 2.

GROUP	MEAN±SD
GHT (Control Group)	1008.1 ±176.5
GCF (2mm circumferential ferrule)	890.6 ±221.7
GBF (buccal 2mm ferrule)	786.4 ±180.3
GLF (lingual 2mm ferrule)	792.5 ±220.8
GBLF (buccal and lingual ferrule)	810.6 ±202.9
GWF (without ferrule)	770.3 ±212.9

Table 1. Fracture Load (N)

Source	Sum of Squares	df	Mean Square	F	p value
Between Groups	761845.478	5	178248.321	3.105	.021
Within Groups	32471658.792	54	46427.764		
Total		60			

Table 2. ANOVA table for analysis of failure loads

The failure mode was determined by visual inspection of the fracture line. There were two types of root fracture. Groups that presented cervical third fracture were classified as favorable mode, whereas specimens that presented fracture line in middle and apical third were considered failure. All groups (except GHT) showed complete favorable fracture mode (table 3).

Group	Fracture Mode (%)
GHT (Control Group)	22%
GCF (2mm circumferential ferrule)	80%
GBF (buccal 2mm ferrule)	70%
GLF (lingual 2mm ferrule)	74%
GBLF (buccal and lingual ferrule)	78%
GWF (without ferrule)	90%

Table 3. Favourable fracture line outcomes for each group

DISCUSSION

The present study investigated the influence of ferrule locations on the fracture resistance of crowned mandibular premolars. The use of natural teeth is a reliable method in testing fracture resistance and has been used in several studies.[4,9] In order to achieve adequate strength, a ferrule of 2mm was chosen.10 Mandibular premolar teeth were selected for the study because they are quite easily available as these teeth are most frequently extracted for orthodontic treatment purposes.

The fracture resistance values of all specimens ranged from 770.3 ±212.9 N (GWF) to 1008.1 ±176.5 N (GHT), and these readings were consistent with the previous in vitro studies.[11,12] The lowest fracture strength values were found for group GWF, whereas group GHT showed a significantly higher fracture resistance. These results justify that fact that the presence of a ferrule is an important factor in enhancing the fracture resistance of endodontically treated teeth.[4,13] In this study, it was reported that the groups with different location of ferrule did not had significant differences in fracture resistance. This finding is consistent with the observation of another in vitro study which reported that the site and location of the missing coronal wall did not affect the fracture resistance of endodontically treated teeth.[14]

All groups (except GHT) reported complete favorable fracture mode. These findings were consistent with the previous studies that observed that prefabricated fiber posts reported more favorable failure modes.[4] This finding can be attributed to the low rigidity of glass fiber posts. The location of the ferrule seems not to be an important factor in terms of increasing the fracture strength of endodontically treated premolars.

CONCLUSION

Within the limitations of this study, the present study reported that although the presence of ferrule leads to improved fracture resistance, specific location of the ferrule had no significant differences in the fracture strength of endodontically treated teeth restored with glass fiber posts.

REFERENCES

1. Juloski J, Radovic I, Goracci C, Vulicevic ZR, Ferrari M. Ferrule effect: A literature review. J Endod 2012;38:11-19.
2. Stankiewicz NR, Wilson PR. The ferrule effect: a literature review. Dent Update 2008; 35: 222-28.
3. Al-Omiri MK, Mahmoud AA, Rayyan MR, et al. Fracture resistance of teeth restored with post-retained restorations: an overview. J Endod 2010;36:1439-49.
4. Samran A, El Bahra S, Kern M. The influence of substance loss and ferrule height on the fracture resistance of endodontically treated premolars. An in vitro study. Dent Mater 2013;29:1280-6.
5. Mangold JT, Kern M. Influence of glass-fiber posts on the fracture resistance and failure pattern of

endodontically treated premolars with varying substance
loss: an in vitro study. J Prosthet Dent 2011;105:387-93.
6. Balkaya MC, Birdal IS. Effect of resin-based materials on fracture resistance of endodontically treated thin-walled teeth. J Prosthet Dent. 2013;109(5):296-303.
7. Goracci C, Ferrari M. Current perspectives on post systems: a literature review. Aust Dent J. 2011;56(Suppl 1):77-83.
8. Sorensen JA, Martinoff JT. Intracoronal reinforcement and coronal coverage: a study of endodontically treated teeth. J Prosthet Dent 1984;51:780-4.
9. Amarnath GS, Swetha MU, Muddugangadhar BC, Sonika R, Garg A, Rao TR. Effect of Post Material and Length on Fracture Resistance of Endodontically Treated Premolars: An In-Vitro Study. J Int Oral Health. 2015;7(7):22-8.
10. Mamoun JS. On the ferrule effect and the biomechanical stability of teeth restored with cores, posts, and crowns. Eur J Dent. 2014;8(2):281-86.
11. Ng CC, Dumbrigue HB, Al-Bayat MI, Griggs JA, Wakefield CW. Influence of remaining coronal tooth structure location on the fracture resistance of restored endodontically treated anterior teeth. J Prosthet Dent 2006;95:290-6.
12. Dikbas I, Tanalp J, Ozel E, Koksal T, Ersoy M. Evaluation of the effect of different ferrule designs on the fracture resistance of endodontically treated maxillary central incisors incorporating fiber posts, composite cores and crown restorations. J Contemp Dent Pract 2007;8:62-9.
13. Buttel L, Krastl G, Lorch H, Naumann M, Zitzmann NU, Weiger R. Influence of post fit and post length on fracture resistance. Int Endodont J 2009;42:47-53.
14. Arunpraditkul S, Saengsanon S, Pakviwat W. Fracture resistance of endodontically treated teeth: three walls versus four walls of remaining coronal tooth structure. J Prosthodont. 2009;18(1):49-53.

Source of support: Nil, **Conflict of interest:** None declared

Cite this article as:
Nazir I, Arshie S, Hilal MHS. Location of Ferrule and Its Effect on Fracture Resistance of Endodontically Treated Mandibular Premolar: An in-vitro Study. Int Healthc Res J. 2023;6(11):OR1-OR4. https://doi.org/10.26440/IHRJ/0611.02559

AUTHOR AFFILIATIONS: (*: Corresponding Author)
1. Post-Graduate Student, MR Ambedkar Dental College, Bengaluru, Karnataka, India.
2. Post-Graduate Student, VS Dental College, Bengaluru, Karnataka, India.
3. Professor, MR Ambedkar Dental College, Bengaluru, Karnataka, India.

Contact e-mail for corresponding author: isranazir.in[at]gmail[dot]com