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AVALIAÇÃO DA RESISTÊNCIA À FRATURA DE RAÍZES DE INCISIVOS HUMANOS EM DIFERENTES CONDIÇÕES DE REMANESCENTES DENTÁRIOS E DISTINTOS RETENTORES INTRA-RADICULARES

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Dissertação apresentada ao Programa de Pós-graduação em Odontologia da Pontifícia Universidade Católica de Minas Gerais. Área de Concentração: Clínicas Odontológicas - Ênfase: Prótese Dentária.

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AGRADECIMENTO

Os verdadeiros mestres...

Sejam eles dos nossos laços familiares ou profissionais...

São todos aqueles que deixam passar pelos lábios o que fazem amadurecer no coração, no esforço silencioso de cada dia de luta do melhor SERVIR.

São todos aqueles que atingem o mais profundo de nosso ser e que fazem mover nossos pés, numa vontade indizível de trabalhar pelo bem maior, vontade iluminada que repousa no meu coração humilde...

J. Lima

RESUMO

Objetivos: Restaurar dentes com a porção coronária destruída e tratados endodonticamente continua sendo um desafio na odontologia. Diante das condições adversas que os dentes se encontram e da variedade de técnicas e materiais disponíveis, a seleção da que melhor atende as condições de estética e longevidade se torna crítica. O objetivo do presente estudo foi avaliar a resistência a compressão em raízes de incisivos centrais humanos com diferentes remanescentes coronários que receberam distintos sistemas de retentores intra-radiculares, até a sua fratura. Materiais e métodos: Para a realização desta pesquisa utilizou-se 60 incisivos centrais superiores humanos. O total da amostra foi dividida em dois grupos em função do remanescente dentinário: dentes com remanescente coronário de 2 mm acima da junção entre o cemento e o esmalte (A); dentes sem remanescente coronário (B). Cada grupo anterior foi dividido em 3 subgrupos (n=10): 1 - os que receberam Núcleo Metálico Fundido (NMF); 2 - Núcleo Anatômico Estético (NAE) e núcleo de preenchimento em resina composta; 3 - Núcleo de Fibra de Vidro (NFV) e núcleo de preenchimento em resina composta. Foi aplicada carga compressiva em ângulo de 135^{o}, com velocidade de carregamento de 0,5mm/min até a fratura da amostra. Os dados foram submetidos ao teste ANOVA dois fatores, e ao teste de Tukey ($P < 0,05$). Resultados: Nos grupos onde não havia remanescente dentinário não houve diferença entre os tipos de retentores utilizados. Já no grupo em que havia presença de remanescente, aquele em que se utilizou o NMF apresentou diferença entre os que receberam NAE e NFV, e esses dois últimos não apresentaram diferença entre si. Quando se comparou a diferença entre a presença e ausência de remanescente dentinário, apenas nos para o NMF houve diferença para este fator, sendo que a presença resultou em maiores valores. Conclusão: A presença de remanescente influenciou na resistência a fratura somente quando se utilizou o NMF.

Palavras chave: Força compressiva. Técnica pino e núcleo. Restauração dental.

ABSTRACT

Aim: Restorative procedures in endodontically treated tooth presented destroyed coronal portion remains a challenge for dentistry. Based on adversely conditions of these tooth and on variety of available techniques and materials, the selection of the better condition to obtain aesthetic and clinical longevity is critical. The aim of this present study was to evaluate the compression strength of human central incisors varying the extension of coronal remaining and the intra-radicular retainer type. Material and Methods: Sixty human central incisors were used in this study. The teeth were allocated to two groups according to coronal remaining: (A) – 2 mm of coronal remaining; (B) – absence of coronal remaining. The samples of each groups received one of following retainers (n=10): 1 – cast core and dowel (CDC); 2 – relined fiber post (RFP) and core with composite; 3 – fiber post (FP) and core with composite resin. A compressive load was applied over the core with an angle of 135° and cross-head of 0.5 mm/min until the fracture. Data were submitted to two-way ANOVA and Tukey's test ($P<0.05$). Results: In the absence of coronal remaining, there was no difference between the retainers evaluated. Although for the presence of coronal remaining, CDC showed higher fracture strength than other retainers, which showed similar values. When the presence and absence of coronal remaining were compared, only for CDC there was difference for this factor, while the presence resulted in highest values. Conclusions: The presence of coronal remaining affected the fracture strength only the CDC was used.

Keywords: Compressive strength. Post and core technique. Dental restoration.

SUMÁRIO

1 INTRODUÇÃO

O restabelecimento da estética e da função de dentes anteriores com destruição da porção coronária e tratados endodonticamente, definitivamente, trata-se de procedimento desafiante e crítico, utilizado com o intuito de promover, ainda, a longevidade de tais dentes. Com frequência, nessa conduta, depara-se com pequena ou nenhuma quantidade de remanescente coronário, havendo, assim, a necessidade de utilização de retentores intrarradiculares para a reabilitação do ou dos elementos comprometidos (CARVALHO et al., 2005).

O método mais antigo e utilizado como retentor intrarradicular é o núcleo metálico fundido, porém este apresenta algumas desvantagens, como: maior desgaste da estrutura radicular remanescente; módulo de elasticidade superior ao da dentina radicular; transmissão de estresse à estrutura dental, podendo levar à fratura de raiz; possibilidade de corrosão, dependendo do tipo de liga, que pode levar ao escurecimento do remanescente radicular; dificuldade de remoção, se necessário; aumento do tempo de trabalho e custos laboratoriais (MASSA; DIAS; BLOS, 2010; SIRIMAI; RIIS; MORGANO, 1999; LASSILA et al., 2004).

Os sistemas adesivos revolucionaram a técnica de fixação dos pinos intrarradiculares e possibilitaram a adesão de retentores intrarradiculares feitos de fibra com características mais semelhantes ao da estrutura dental, com alta adesividade e módulo de elasticidade mais próximo. Dessa forma, de acordo com Heydecke, Butz e Strub (2001); Eskitascioglu, Belli e Kalkan (2002) e Lassila et al. (2004), inexistiriam fraturas, e alguns autores justificariam esse fato como decorrente da semelhança das propriedades biomecânicas dos pinos intrarradiculares às da estrutura dental.

Em busca da evolução, têm-se estudado sistemas de núcleos com propriedades físicas e biológicas mais próximas à estrutura dentária perdida e que possam atuar como dentina artificial. Uma das técnicas propostas por Grandini, Sapio e Simonetti (2003) e Clavijo et al. (2006) para o tratamento de canais amplos é a utilização de pinos anatômicos, modelados no conduto radicular, com resina composta, associada aos pinos pré-fabricados de fibra. A individualização do pino, além de adaptação no conduto radicular, possibilita a formação de camada fina e uniforme de cimento resinoso e proporciona melhor polimerização da resina composta, associada ao pino de fibra de vidro, criando, dessa forma, condições favoráveis para a retenção deste.

A quantidade de remanescente coronal existente também é um fator relevante na variação da resistência à fratura. Comprovando tal afirmação, Silva et al., em 2010,

concluíram que a presença de remanescente melhorou o comportamento mecânico dos espécimes restaurados. Contrariando essa hipótese, Santana et al., em 2011, concluíram, por sua vez, que dentes restaurados com pino de fibra de vidro e núcleo metálico fundido apresentam resistência a fratura semelhantes, independentemente da quantidade de remanescente.

Em virtude dessas controvérsias, optou-se por desenvolver uma pesquisa que permitisse avaliar, tanto o tipo de retentor radicular como do remanescente coronário, na resistência a fratura de remanescentes dentários tratados endodonticamente, com o objetivo de colaborar na indicação clínica do procedimento mais eficaz.

2 OBJETIVOS

Avaliar, *in vitro*, a variável resistência à fratura, em diferentes condições de remanescentes dentários de incisivos humanos, que receberão retentores intra-radiculares, construídos com distintos materiais e técnicas, com intuito de identificar quais apresentam maior e menor resistência, quando submetidos à carga compressiva, em máquina de ensaio universal.

3 ARTIGO

O artigo intitulado "**Effect of the increased post length by presence of coronal remaining on fracture strength of post-retained restorations**" será submetido ao periódico Operative Dentistry (Qualis A1), tendo sido formatado de acordo com suas normas.

Effect of the increased post length by presence of coronal remaining on fracture strength of post-retained restorations

Short Title: Post length and fracture strength

Clinical Relevance

The increasing of the post length cemented into root canal due to presence of coronal remaining is able to improve the fracture strength when cast core-and-post is used. However, the same effect does not occur for fiber posts.

Summary

Aim: The aim of this present study was to evaluate the effect of presence of coronal remaining and type of post on fracture strength of upper incisors. *Material and Methods*: Sixty human central incisors were used in this study. Thirty teeth were sectioned at cement-enamel junction (CEJ), while the remaining teeth were cut 2 mm above the CEJ. The roots received cast core-and-posts, fiber posts or re-lined fiber posts (n=10). The core for specimens that received fiber posts was built-up with composite resin. A compressive load was applied over the core with an angle of 45° and cross-head of 0.5 mm/min until the fracture. Data were submitted to two-way ANOVA and Tukey's test ($P<0.05$). *Results*: In the absence of coronal remaining, there was no difference between the post types evaluated. Although for the presence of coronal remaining, cast core-and-post showed higher fracture strength than other posts, which showed similar values. The presence of coronal remaining affected the fracture strength only for cast core-and-post. *Conclusions*: The increasing of post length by presence of coronal remaining affected the fracture strength only when cast core-and-post was used.

Keywords: Compressive strength; Post and core technique; Dental Restoration.

Introduction

Despite the evolution of restorative materials, the restoration of endodontically treated tooth remains a challenge for clinicians. For years, cast core-and-dowels were usually used to restore teeth when the remaining crown was not enough to retain the restoration.[1] Metallic posts can to compromise the aesthetic of restoration when are used in anterior tooth and increase the chance of root fracture due mainly to high elastic modulus.[1-3] Furthermore, the necessity of laboratorial step increase of cost and time of treatment for cast core-and-dowels.

More recently, fiber-reinforced resin post have been commonly used in restoration of endodontically-treated tooth.[4] The similarity between the elastic modulus of dentin and fiber post has been related to lower incidence of root fracture.[5-7] However, a recent study showed that the reduction on rate of root fracture is due to fact that the post and core presents higher failure risk than the root.[8] De-bonding of post; and fracture of post and/or core are more common causes of failure when this type of post is used.[4,9] Despite the cited advantages, the mismatch between the diameters of the post space and the fiber post remains a clinical problem.[10] The post re-lining with composite resin has been advocated to improve the adaptation of fiber post to the root walls and reduces the thickness of the resin cement.[11-14]

Independently of post type chosen, the presence of coronal remaining has been related to improved success rate of post-retained restoration. The presence of ferrule alters the stress distribution have been associated to improved longevity of restoration.[4,9,15] However, most of studies evaluating the ferrule effect on fracture strength of restoration used standardized length of post for restorations with both presence and absence of ferule.[2,16.17] In this experimental design, a favorable effect of increased length of post can to hide the true ferule effect. Thus, the aim of this study was to evaluate the effect of length of post caused by presence of coronal remaining on fracture strength of post/root. The null hypothesis was that the length of post cementation does not alter the fracture strength.

Methods & Materials

Sixty human upper incisors extracted by periodontal reasons were selected to this study. The teeth presented similar dimensions and straight roots, while teeth with caries lesions or cracks were discarded. Half of teeth were sectioned 2 mm above of enamel-

cement junction. The axial walls of coronal remaining were prepared with an ogival diamond bur # 3215 (KG Sorensen, Barueri, SP, Brazil) to obtain a chamfer finish line. The preparation was performed at high-speed under water-cooling. The other 30 incisors were sectioned at enamel-cement junction, without any coronal remaining. A step-back preparation technique was used for endodontic treatment of teeth; while the root canals were filled with gutta-percha cones using the lateral condensation technique and Sealer-26 resin sealer (Dentsply Ind. Com. Ltda, Petrópolis, RJ, Brazil). The specimens were stored in 100% humidity for at least 72 h to allow for the resin sealer to set.

After the storage period, the gutta-percha was removed with a hot Rhein instrument at 10 mm depth, followed by use of bur Peeso #2 at this same depth. The bur #3 of fiber post sytem WhitepostDC (FGM, Joinville, SC, Brazil) was used to standard the post-holes. In order to simulate the periodontal ligament, the external surfaces of the root remainders were dipped into melted wax until 3 mm bellow of enamel-cement junction. Afterwards, the wax-covered roots were included in acrylic resin cylinders. After resin polymerization, the roots were removed from the cylinder, the wax removed from the root surface creating a space in the resin cylinder. The polyether impression material (Impregum F, 3M-Espe, Seefeld, Germany) was mixed and placed in the space created in the resin cylinder. The tooth was re-inserted into the cylinder and the excess material removed with a scalpel blade. Specimens with and without coronal remaining received one of following post types: cast core-and-post, fiber post or re-lined fiber post (n=10).

To permit the confection of cast core-and-post, the root canal impressions were made with pre-fabricated pins (Angelus, Londrina, PR, Brazil) self-cured acrylic resin (Duralay, Reliance Dental, Worth, IL, USA). The core was build-up with acrylic resin with 5 mm of high, while a standardized notch was placed across the palatal surface core 3 mm from the incisal edge for load application in mechanical tests. Following, the dowel and cores were cast in a nickel-chromium alloy (Kromalit, Knebel, Porto Alegre, RS, Brazil). The cast core-and-posts were cemented with a resin cement Multilink (Ivoclar Vivadent, Liechtenstein, Germany) used in accordance with the manufacturer's instructions. An impression of cast core was done using polyvinylsiloxane impression material (Express, 3M ESPE, St. Paul, MN, USA) to permit the standardization of resin core of specimens that received fiber posts. The impressions were poured with Type IV stone (Durone, Dentsply, Petrópolis, RJ, Brazil) and matrixes of acetate were confectioned.

In twenty specimens that received fiber post (Whitepost DC #3, FGM, Joinville, SC, Brazil), the post surfaces were cleaned with ethanol and dried with air-stream. Following, the surfaces were silanized and the fiber posts cement with a resin cement Multilink. For other twenty specimens, the fiber posts were re-lined with composite resin before the cementation procedures. For this purpose, the canal walls were lubricated with hydro-soluble gel (KY, Johnson & Johnson, São José dos Campos, SP, Brazil) followed by insertion of composite Filtek Z-350 (3M ESPE, St. Paul, MN, USA) into root canal. The adhesive of system Scotchbond Multipurpose (3M ESPE, St. Paul, MN, USA) was applied and light-cured over the previously silanized post. The fiber post was inserted into root canal and the resin composite was light-cured for 20 s. The re-lined fiber post was removed, and the resin composite was light-cured for another 40 s. Copious rinsing removed the lubricant gel from the root canal before the cementation with Multilink. The core of specimens that received relined or not fiber posts were build-up with the composite resin Filtek Z-350 inserted incrementally. Before the light-activation of last increment, the matrixes obtained by impression of cast core were positioned to standardize the cores.

Specimens were positioned in custom apparatus that allowed the insertion of metal knife blade tip in notch of palatal surface of core at 45◦ with long axis of tooth. Following, the specimens were submitted to a tangential compressive loading at 0.5 mm/min in a universal testing machine until the fracture. Data in N were submitted to two-way ANOVA (‘presence of coronal remaining’ x ‘post type’) followed by Tukey’s test ($\alpha = 0.05$).

Results

ANOVA showed significant effect for the factors presence of coronal remaining’ ($P < 0.001$) and ‘post type’ ($P = 0.002$); and for the interaction between the factors ($P = 0.003$). The results of Tukey’s test are displayed at Table 1. There was no difference between the types of post in absence of coronal remaining. When the coronal remaining was present, cast core-and-post showed the highest values of fracture strength, while there was no difference between the other types of posts. The presence of coronal remaining only alters the fracture strength for cast core-and-post.

Discussion

The preservation of coronal remaining structure has been advocated to improve the [4,9,15] longevity of post-retained restorations. It has been demonstrated that maintaining cervical tissue of crown permits that the restoration surrounds the parallel walls of the dentine extending coronal creating a protective effect on tooth structure.[2] This occurs by reduction of stress within a tooth and it is called the "ferrule effect". However, the presence of coronal remaining also increases the length of post cemented into root canal. Thus, part of favorable effect attributed to ferrule effect can be due to increasing of post length into root canal. The outcomes of the present study showed that the presence of coronal remaining improved the fracture strength only when cast core-and-posts were used. The presence of coronal remaining did not alter the fracture strength when re-lined or not fiber posts were used. Thus, the null hypothesis was rejected.

The most of studies that evaluating the effect of presence of coronal remaining on fracture strength use metallic[2,17] or ceramic [2,16] crowns cemented over the core. Thus, the load is applied over the palatine face of crown similarly to clinical condition. In this experimental design, the stress created by load application is partially generated in coronal dentin (ferrule effect), reducing the stress into root canal.[2] In opposite, the compressive load was applied directly over the core in the present study. Considering the absence of ferrule effect in this experimental design due to absence of full crown, only the effect of differences on post length can explain the results observed within this experimental design.

Only when cast core-and-posts were used the presence of coronal remaining improved the fracture strength, while did not alter the results for fiber post use. A previous study evaluating the length of post cementation showed similar results.[18] In the present study, the length of post into root canal varied from 10 mm (without coronal remaining) to 12 mm. It has been demonstrated that the strain values of cast posts increasing with the post length decreasing.[18] Thus, the reduced strain at presence of coronal remaining improves the fracture strength and explains the results observed when cast core-and-post was used. In opposite, the similarity between the elastic modulus between fiber post, composite resin and dentin explains the absence of effect of presence of coronal remaining on fracture strength. This type of post can to generate high stress level on root structure, but the risk of fracture of root is lower than those observed for core and fiber post.[8] Considering that the fracture of fiber post-retained restoration occurs commonly on post or core (resin

composite), it is reasonable to assume that the length of post into root canal have limited effect on final fracture strength.

It has been demonstrated that proper bonding of fiber post to root canal walls reduces the risk of fracture.[8] Re-lining procedure was used in this study seeking to increase the adaptation between the fiber posts and root walls. Higher adaptation between posts and root canal walls increases the sustained pressure during cementation and improves the bond strength.[13,19] Thus, it can be expected that re-lined fiber post could result in higher fracture strength than non-relined fiber post. However, no difference was observed. One important observation is that the root canal was not flared in the present study. The most of studies that demonstrated improvements on bond strength with re-lining procedure used flared root canal.[13,19,20] In this last condition, the discrepancy between the post and root canal is higher and the positive effect of re-lined procedure is probably more pronounced. Thus, the use of re-lined fiber post can be efficient to increase the fracture strength for flared root canal. However, this statement must be confirmed by further studies.

The outcomes of this study showed that the use of cast core-and-post resulted in highest fracture strength in presence of coronal remaining. These results must be carefully evaluated. Metal posts generally are related to root fracture hindering the preservation of tooth. In opposite, failures on post or core commonly observed for fiber post are restorable favoring the maintenance of tooth.[1] Thus, the mode of failure can be more important than the values of fracture strength. Another important observation is that the increasing of post length due the presence of coronal remaining does not alter the fracture strength when fiber post was used. Thus, the clinical benefits reached by presence of coronal remaining are probably due to ferrule effect than post length.

Conclusion

Within the limitations of the current study, the following conclusions can be drawn:

- The presence of coronal remaining improved the fracture strength only when cast core-and-post was used, which showed higher strength than fiber post (re-lined or not).
- There was no difference on fracture strength between the types of posts used in the absence of coronal remaining.

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Tables

Table 1. Means (standard deviation) of fracture strength in N.

Type of post	Coronal remaining	
	Absent	Present
Cast core-and-post	335.5 (228.2)^{Ba}	773.1 (407.3)^{Aa}
Relined fiber post	345.2 (128.3)^{Aa}	379.0 (107.2)^{Ab}
Fiber post	179.9 (39.7)^{Aa}	213.5 (41.5)^{Ab}

Distinct letters (uppercase for line, lowercase for columns) indicate statistical difference ($\alpha = 0.05$).

4 CONSIDERAÇÕES FINAIS

A capacidade dos dentes de suportar cargas com adequada distribuição das tensões sobre os tecidos dentinários remanescentes parece ser decisiva, quando o objetivo é obter restaurações com elevada resistência à fratura (SOARES et al., 2005). Dentes tratados endodonticamente, com grandes perdas de estrutura coronária, são comumente restaurados com pinos e núcleos de preenchimento e sobre estes, coroas (GIOVANI et al., 2009; MACCARI et al., 2007).

Maccari et al. (2007), Santos-Filho et al. (2008) e Makade et al. (2011), por sua vez, avaliaram diferentes sistemas de retentores intrarradiculares e chegaram à conclusão de que a resistência a fratura seria influenciada diretamente pelo tipo de retentor empregado, resultados esses que corroboraram os obtidos por meio desta pesquisa.

A variedade, tanto de materiais quanto de técnicas disponíveis no mercado relacionadas com o tema desta pesquisa, é grande, no entanto, tem a mesma dimensão a necessidade de pesquisas que orientem o profissional no sentido da melhor escolha, nas distintas situações. Nesse aspecto, os autores deste trabalho enfatizam que os resultados obtidos com PFV e revestido com resina composta, aqui denominado Núcleo Anatômico Estético, foram animadores, quando comparados com os outros tipos de retentores. É importante ressaltar a facilidade de construção e o baixo custo do referido tipo de retentor. Dessa forma, e até pela ausência de literatura que trate desse tipo de retentor, registra-se a necessidade de se realizarem mais pesquisas que comprovem, ou não, a sua eficácia.

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