10.5005/jp-journals-10024-1554

ORIGINAL RESEARCH

Resistance of Teeth with Simulated Incomplete Rhizogenesis with Intraradicular Post or Root Canal Filling

[1]Mario Tanomaru-Filho, [2]Gustavo Sivieri-Araujo, [3]Juliane M Guerreiro-Tanomaru, [4]Eduardo A Bortoluzzi, [5]Erica G Jorge [6]Filipe O Abi-Rached, [7]José Mauricio SN Reis

ABSTRACT

Aim: The aim of this study was to evaluate the fracture strength (FS) of bovine incisors with simulated incomplete rhizogenesis (IR) after different intraradicular treatments.

Materials and methods: Incomplete rhizogenesis was simulated by sectioning the crowns and roots of 40 bovine incisors. Root canal preparation was performed and the samples divided into 4 groups (n = 10): GI-negative control with intra-radicular preparation; GII-positive control without intra-radicular preparation; GIII-glass fiber post cemented with resin cement and GIV-root canal obturation with Epiphany/Resilon system. In GIII and GIV, 4.0 mm apical plugs of mineral trioxide aggregate (MTA) were done. The samples were embedded into cylinders with polystyrene resin, and the periodontal ligament was simulated with a medium-viscosity polyether-based impression material (Impregum Soft). The specimens were submitted to compressive fracture strength test (0.5 mm/min at 135° in relation to the long axis of the tooth) in a mechanical testing machine MTS 810. Data were submitted to ANOVA and Tukey's test ($\alpha = 0.05$).

Results: GIII produced the highest FS values ($p < 0.05$). GI and GIV showed similar FS results ($p > 0.05$) but smaller than GII ($p < 0.05$).

Conclusion: Glass fiber intraradicular posts provided the FS increase of teeth with simulated incomplete rhizogenesis. Epiphany/Resilon root canal filling with MTA plug did not provide the increase of the fracture strength to teeth with simulated incomplete rhizogenesis.

Clinical significance: The fiber post reinforces the root structure of teeth with incomplete rhizogenesis.

Keywords: Post and core, Root canal treatment, Incomplete rhizogenesis, Intraradicular post, Root canal obturation.

[1-3,4,6,7]Professor, [5]Doctor

[1,3,5]Department of Restorative Dentistry, Araraquara Dental School, Araraquara, São Paulo, Brazil

[2]Department of Restorative Dentistry, Araçatuba Dental School Araçatuba, Sao Paulo, Brazil

[4]Department of Dentistry, Santa Catarina Federal University Santa Catarina, Brazil

[6,7]Department of Prosthodontics, Araraquara Dental School Araraquara, São Paulo, Brazil

Corresponding Author: Mario Tanomaru-Filho, Professor Department of Restorative Dentistry, Araraquara Dental School, Araraquara, São Paulo, Brazil, Phone: 551633016390 e-mail: tanomaru@uol.com.br

How to cite this article: Tanomaru-Filho M, Sivieri-Araujo G, Guerreiro-Tanomaru JM, Bortoluzzi EA, Jorge EG, Abi-Rached FO, Reis JMSN. Resistance of Teeth with Simulated Incomplete Rhizogenesis with Intraradicular Post or Root Canal Filling. J Contemp Dent Pract 2014;15(4):413-416.

Source of support: Nil

Conflict of interest: None declared

INTRODUCTION

Caries or tooth trauma may occur in teeth with incomplete rhizogenesis (IR), leading to endodontic treatment. Calcium hydroxide has been indicated as intracanal medication for endodontic therapy of teeth with IR.[1]

Calcium hydroxide dissociates into calcium and hydroxyl ions favoring its properties for clinical use.[2-4] Calcium hydroxide exhibits important advantages as intracanal medication: antimicrobial activity,[5] root resorption inhibitory effect,[2] and ability to stimulate the deposition of apical mineralized tissue in teeth with IR,[2] promoting the periapical repair.[6] However, calcium hydroxide maintenance for long periods can promote the weakening of dentine walls, reducing root fracture strength (FS), and inducing changes in the physical properties of the dentine.[7-9] Also, calcium hydroxide treatment delay the placement of final restoration.[3,10]

Teeth with IR present thin root walls with divergent morphology in apical third,[3,10] making them more susceptible to root fractures, especially during traumas.[4,8] The use of intraradicular posts and prosthetic reconstruction has been recommended in cases with large crown destruction[11] to increase root strength.[12-15] In teeth with IR, it has been evidenced that root FS increases when intraradicular posts and luting agents are employed.[12] The cementation may be performed with resin composite,[13] glass ionomer cement[16] and resin cements[17] aiming to a greater adhesion between post and dentine wall of root canal.[18] Glass fiber posts are an alternative for the restoration of teeth with IR due they have modulus of elasticity similar to dentine.[19,20]

The use of an apical plug with MTA has been suggested for endodontic therapy of teeth with IR,[21-23] resulting in a faster treatment and inducing the mineralized tissue formation in the root apex.[24] The root canal filling using Epiphany/

Resilon system was proposed to provide a greater bonding between filling materials and root canal wall.[25,26] Therefore, the use of the MTA plug and root canal filling with Epiphany/Resilon system could lead to a higher root resistance in teeth with incomplete rhizogenesis.

The aim of this study was to *in vitro* evaluate the fracture strength of bovine incisors, using a model of simulated incomplete rhizogenesis, after different intraradicular treatments.

MATERIALS AND METHODS

Forty bovine teeth with straight roots and similar root canals were selected for the study. The specimens were kept in 2.5% sodium hypochlorite for 7 days and then in 0.9% saline solution. The teeth were examined under ×4 magnifying and radiographed to evaluate the tooth anatomy and internal morphology of pulpal cavity. The crowns and roots of the teeth were sectioned, respectively, at 8.0 mm above and 12 mm below the cementoenamel junction. The pulp tissue was removed using a #60 Hedstrom file (Dentsply Maillefer, Ballaigues, Switzerland). Root canals were irrigated with 1.0% sodium hypochlorite solution.

The specimens were randomly distributed into four experimental groups (n = 10), according to Table 1. Thirty roots were prepared with a size 703 carbide bur (Jet-Set Beavers Dental Products Ltd, Morrisburg, ON, Canada) at crown-apex and apex-crown directions to standardize the internal diameter at 2.1 mm. The remaining ten teeth received no preparation. During these procedures, the teeth were kept in moist gauze and the root canals were irrigated with 1.0% sodium hypochlorite.

According to Bramante et al 2004,[27] 4.0 mm thickness MTA apical plugs were prepared in GIII and GIV. MTA (Angelus Soluções Odontológicas, Londrina, PR, Brazil) powder was mixed with distilled water according to the manufacturer's instructions. MTA was inserted up to the apical length using a Lentulo spiral and condensed with cotton pellet moistened in distilled water, and a #70 K file (Dentsply Maillefer, Ballaigues, Swiss).

In GI (negative control), root canals were submitted to intraradicular preparation with no treatment and in GII (positive control), the root canals were not submitted to intraradicular preparation.

In GIII, after intraradicular preparation and MTA apical plug, the conical-shape glass fiber post (Exacto - Angelus Soluções Odontológicas, Londrina, PR, Brazil) was placed into the root canal according the root canal design. Root canal was submitted to 37% phosphoric acid for 15 seconds. Following, the root canals were washed with water and dried with absorbent paper points. A chemically-activated adhesive agent was applied onto the root canal/post, according to the manufacturer's instructions. The posts were luted with resin cement (Cement-Post, Angelus Soluções Odontológicas, Londrina, PR, Brazil).

In GIV, the root canals received intraradicular preparation and MTA apical plug as previously described. Epiphany/Resilon system (Pentron Clinical Technologies, LLC, Wallingford, CT, USA) was used for root canal filling according to the manufacturer's instructions. The root canals were dried and then the lateral condensation technique was performed. The Resilon point #80 was covered with Epiphany sealer and placed up to MTA plug, followed by lateral compaction using Resilon accessory points until the complete root canal filling.

The access cavities were sealed with glass ionomer cement (Vidrion R - SS White, Rio de Janeiro, RJ, Brazil) and the specimens were stored in an incubator at 37°C and relative humidity of 100% for 48 hours.

All teeth were embedded in polystyrene resin (Cristal, Piracicaba, SP, Brazil) into polyvinyl chloride (PVC) cylinders. During the phase of tooth inclusion, periodontal ligament was simulated as previously described.[27,28] The teeth were immersed into melted wax (Horus; Herpo Produtos Dentários, Petrópolis, RJ, Brazil), at 2.0 mm below the cementoenamel junction. An average thickness of 0.25 mm of wax was obtained around the roots. Then, the teeth were embedded into PVC cylinders (20 mm diameter × 25 mm height), with polystyrene resin. The teeth were removed from the PVC cylinders and the wax eliminated from both the root surface and resin cylinders sockets using warm water. Then, the resin cylinders were filled with a medium-viscosity polyether-based impression material (Impregum Soft 3M ESPE AG, Seefeld, Germany) using a syringe for elasto-

Table 1: Distribution of groups according to intraradicular preparation, MTA apical plug, post, cementation and obturation of root canals

Groups	*Intraradicular preparation*	*MTA apical plug*	*Intraradicular post*	*Cementation*	*Root canal filling*
GI (– Control)	Yes	—	—	—	—
GII (+ Control)	No	—	—	—	—
GIII	Yes	Yes	Glass fiber posts Exacto	Resin Cement Cement-Post	—
GIV	Yes	Yes	—	—	Epiphany/Resilon system

Table 2: Mean values of fracture strength (N) and standard deviations (SD) observed in different experimental groups

Groups	*Mean (N)*	*SD*
GI (– Control)	717.9 C	176.0
GII (+ Control)	1361.0 B	200.1
GIII	2052.0 A	190.4
GIV	872.3 C	129.2

Means designated with different capital letters (A, B and C) were statistically different ($p < 0.05$)

mer material. The teeth were again inserted into their PVC cylinders and the impression material excess was removed using a size 12-scalpel blade. Thus, a simulated periodontal ligament was achieved with a thickness of 0.25 to 0.30 mm of polyether-based impression material.

Fracture Strength Test

All specimens were submitted to fracture strength test in a mechanical testing machine (MTS 810 MTS Systems Corp, Eden Prairie, MN, USA), using a load cell of 10 kN,[27,28] at a crosshead speed of 0.5 mm/min. Each specimen was positioned into a cylindrical device as described by Melo et al 2005[29] and Bortoluzzi et al 2007,[15] which enables an angle of 135º in relation to the long axis of the tooth.

The obtained data of fracture strength were statistically evaluated by using one-way analysis of variance (1-way ANOVA), and the Tukey test ($\alpha = 0.05$).

RESULTS

Table 2 described the means and standard deviations of data from different experimental groups. GIII produced the highest values of fracture strength ($p<0.05$). GI and GIV had similar results ($p>0.05$) but smaller than GII (+ control) ($p<0.05$).

DISCUSSION

Bovine root dentine has dentinal tubules with morphology similar to human dentine.[30,31] For this reason, the bovine teeth have been largely used in researches as alternative to human teeth.[32-34] The present study used an IR simulated model in bovine teeth according to Bortoluzzi et al in 2007.[15] The periodontal ligament was simulated to distribute the tension during the mechanical test.[28,35] The plug of MTA has been employed to induce apexification in teeth with IR, as well as to act as protection to root canal filling.[36]

The results of this study evidenced that intraradicular glass fiber post in association with MTA apical plug reinforces the root with incomplete rhizogenesis, according to other results.[15,21-24,37] The greatest fracture strength in this group could be related to the low elasticity modulus of glass fiber post promoting load distribution along the post length.[38] GII (positive control without preparation of the dentine walls) exhibited fracture strength smaller than GIII, and greater than GI and GIV.

Both GIV (apical MTA plug in association with root canal filling with Epiphany/Resilon system) and GI (negative control group with only intracanal preparation) showed the smallest root fracture strength. The root canal filling with Epiphany/Resilon system in an IR simulated model did not promote the increase of root fracture strength. These results are not in accordance with previous studies,[25,26,39] in which a model with single-rooted human teeth with complete rhizogenesis was employed.

However, the results of the present study are in accordance with Hemalatha et al 2009,[40] who studied the fracture strength of human teeth with simulated IR and observed that the root canal filling with Resilon/Epiphany system did not increase the root resistance.

CONCLUSION

Taking into consideration the evaluation method, the use of MTA apical plug associated with intraradicular glass fiber posts promotes root reinforcement for teeth with IR. The MTA apical plug associated with the root canal filling with Epiphany/Resilon system did not increase the resistance of teeth with IR.

REFERENCES

1. Andreasen JO, Andreasen FM. Essentials of Traumatic Injuries to the Teeth 2nd ed. Copenhagen: Munksgaard, 2000. p. 188.
2. Frank AL. Therapy for the divergent pulpless tooth by continued apical formation. J Am Dent Assoc 1966;72(1):87-93.
3. Keinan D, Moshonov J, Smidt A. Is endodontic re-treatment mandatory for every relatively old temporary restoration? A narrative review. J Am Dent Assoc 2011;142(4):391-396.
4. Andreasen FM, Andreasen JO, Bayer T. Prognosis of root-fractured permanent incisors: prediction of healing modalities. Endod Dent Traumatol 1989;5(1):11-22.
5. Bystrom A, Claesson R, Sundqvist G. The antibacterial effect of camphorated paramonochlorophenol, camphorated phenol and calcium hydroxide in the treatment of infected root canals. Endod Dent Traumatol 1985;(5):170-175.
6. Paula-Silva FW, Santamaria M Jr, Leonardo MR, Consolaro A, Silva LA. Cone-beam computerized tomographic, radiographic, and histologic evaluation of periapical repair in dogs' post-endodontic treatment. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009;108(5):796-805.
7. Cvek M. Prognosis of luxated non-vital maxillary incisors treated with calcium hydroxide and filled with gutta-percha. A retrospective clinical study. Endod Dent Traumatol 1992;8(2):45-55.
8. Andreasen JO, Farik B, Munksgaard EC. Long-term calcium hydroxide as a root canal dressing may increase risk of root fracture. Dent Traumatol 2002;18:(3):134-137.
9. Hatibovic-Kofman S, Raimundo L, Zheng L, Chong L, Friedman M, Andreasen JO. Fracture resistance and histological findings of immature teeth treated with mineral trioxide aggregate. Dent Traumatol 2008;24(3):272-276.

10. Nair U, Ghattas S, Saber M, Natera M, Walker C, Pileggi R. A comparative evaluation of the sealing ability of 2 root-end filling materials: an in vitro leakage study using enterococcus faecalis. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;(2):e74-77.
11. Nothdurft FP, Schmitt T, Motter PJ, Pospiech PR. Influence of fatigue testing and cementation modeon the load-bearing capability of bovine incisors restored with crowns and zirconium dioxide posts. Clin Oral Invest 2008;112(2):331-336.
12. Katebzadeh N, Dalton BC, Trope M. Strengthening immature teeth during and after apexification. J Endod 1998;24(4):256-259.
13. Pene JR, Nicholls JI, Harrington GW. Evaluation of fiber-composite laminate in the restoration of immature, nonvital maxillary central incisors. J Endod 2001;27(1):18-22.
14. Andreasen JO, Munksgaard EC, Bakland LK. Comparison of fracture resistance in root canals of immature sheep teeth after filling with calcium hydroxide or MTA. Dent Traumatol 2006; 22(3):154-156.
15. Bortoluzzi EA, Souza EM, Reis JMSN, Esberard RM, Tanomaru-Filho M. Fracture strength of bovine incisors after intra-radicular treatment with MTA in an experimental immature tooth model. Int Endod J 2007;40(9):684-691.
16. Shah P, Gugwad SC, Bhat C, Lodaya R. Effect of three different core materials on the fracture resistance of endodontically treated deciduous mandibular second molars: an in vitro study. J Contemp Dent Pract 2012;13(1):66-70.
17. Scotti N, Scansetti M, Rota R, Pera F, Pasqualini D, Berutti E. The effect of the post length and cusp coverage on the cycling and static load of endodontically treated maxillary premolars. Clin Oral Investig 2011;15(6):923-929.
18. Cauwels RG, Pieters IY, Martens LC, Verbeeck RM. Fracture resistance and reinforcement of immature roots with gutta percha, mineral trioxide aggregate and calcium phosphate bone cement: a standardized in vitro model. Dent Traumatol 2010; 26(2):137-142.
19. Oskoee PA, Chaharom ME, Kimyai S, Oskoee JS, Varasteh S. Effect of two types of composite fibers on fracture resistance of endodontically treated maxillary premolars: an in vitro study. J Contemp Dent Pract 2011;12(1):30-34.
20. Kivanç BH, Görgül G. Fracture resistance of teeth restored with different post systems using new-generation adhesives. J Contemp Dent Pract 2008;9(7):33-40.
21. Hachmeister DR, Schindler WG, Walker WA 3rd, Thomas DD. The sealing ability and retention characteristics of mineral trioxide aggregate in a model of apexification. J Endod 2002; 28(5):386-390.
22. Ghaziani P, Aghasizadeh N, Sheikh-Nezami M. Endodontic treatment with MTA apical plugs: a case report. J Oral Sci 2007; 49(4):325-329.
23. Park JB, Lee JH. Use of mineral trioxide aggregate in the open apex of a maxillary first premolar. J Oral Sci 2008;50(3):355-358.
24. Witherspoon DE, Ham K. One-visit apexification: technique for inducing root-end barrier formation in apical closures. Pract Proced Aesthet Dent 2001;13(6):455-460.
25. Nagpal A, Annapoorna BM, Prashanth MB, Prashanth NT, Singla M, Deepak BS, Singh A, Tavane PN. A comparative evaluation of the vertical root fracture resistance of endodontically treated teeth using different root canal sealers: an in vitro study. J Contemp Dent Pract 2012;13(3):351-355.
26. Vishwanathan PK, Muliyar S, Chavan P, Reddy PM, Reddy TP, Nilawar S. Comparative evaluation of the fracture resistance of teeth prepared with rotary system, filled with single cone gutta-percha and laterally condensed with zinc oxide eugenol and resin based (AH26) sealers to that of Resilon. J Contemp Dent Pract 2012;13(6):773-781.
27. Bramante CM, Bortoluzzi EA, Broon NJ. Agregado Trióxido Mineral (MTA) como plug para la obturación de conductos radiculares: descripcion de la tecnica y caso clínico. Endodoncia 2004;22(3):155-161.
28. Soares CJ, Pizi EC, Fonseca RB, Martins LR. Influence of root embedment material and periodontal ligament simulation on fracture resistance tests. Braz Oral Res 2005;19(1):11-16.
29. Melo MP, Valle AL, Pereira JR, Bonachela WC, Pegoraro LF, Bonfante G. Evaluation of fracture resistance of endodontically treated teeth restored with prefabricated posts and composites with varying quantities of remaining coronal tooth structure. J Appl Oral Sci 2005;13(2):141-146.
30. Tagami J, Tao L, Pashley DH. Correlation among dentin depth permeability and bond strength of adhesive resins. Dent Mater 1990;6(1):45-50.
31. Sano H, Ciucchi B, Matthews WG, Pashley DH. Tensile properties of mineralized and demineralized human and bovine dentin. J Dent Res 1994;73(6):1205-1211.
32. Kim KH, Ong JL, Okuno O. The effect of filler loading and morphology on the mechanical properties of contemporary composites. J Prosthet Dent 2002;87(6):642-649.
33. Bouillaguet S, Troesch S, Wataha JC, Krejci I, Meyer JM, Pashley DH. Microtensile bond strength between adhesive cements and root canal dentin. Dent Mater 2003;19(3):199-205.
34. Schilke R, Lisson JA, Bauss O, Geurtsen W. Comparison of the number and diameter of dentinal tubules in human and bovine dentine by scanning electron microscopic investigation. Arch Oral Biol 2000;45(5):355-361.
35. Rees JS. An investigation into the importance of the periodontal ligament and alveolar bone as supporting structures in finite element studies. J Oral Rehabil 2001;28(5):425-432.
36. Albadri S, Chau YS, Jarad F. The use of mineral trioxide aggregate to achieve root end closure: three case reports. Dent Traumatol 2012 Mar 5. [Epub ahead of print].
37. Sterzenbach G, Kalberlah S, Beuer F, Frankenberger R, Naumann M. In-vitro simulation of tooth mobility for static and dynamic load tests: a pilot study. Acta Odontol Scand 2011;69(5):316-318.
38. Signore A, Benedicenti S, Kaitsas V, Barone M, Angiero F, Ravera G. Long-term survival of endodontically treated, maxillary anterior teeth restored with either tapered or parallel-sided glass-fiber posts and full-ceramic crown coverage. J Dent 2009;37(2):115-121.
39. Al-Kahtani AM, Al-Fawaz H, Al-Sarhan M, Al-Ali K. Fracture resistance of teeth obturated with RealSeal using two different chelating agents: an in vitro study. J Contemp Dent Pract 2010; 11(1):E025-32.
40. Hemalatha H, Sandeep M, Kulkarni S, Yakub SS. Evaluation of fracture resistance in simulated immature teeth using Resilon and Ribbond as root reinforcements - an in vitro study. Dent Traumatol 2009;25(4):433-438.