

Original article

An In Vitro study of Fracture Resistance of Weakened Tooth Roots Reinforced with Two Types of Adhesive Restorative Materials

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Abstract

Introduction: Composite resin (CR) is among the commonly used material for intraradicular reinforcement of weakened tooth roots. **Purpose:** This study was to compare the fracture resistance of experimentally weakened tooth roots reinforced using auto-polymerized composite resin and light-polymerized composite resin. **Materials and Methods:** Fifty-six extracted human maxillary incisors were divided into 2 groups (n = 28) and the root canals were over prepared to weaken it. The samples in Group A were restored using light-cured CR Z100 and light-transmitting polymerizing post (Luminex), whereas Group B using auto-cured CR Alpha-dent. Both groups were placed with metal parapost cemented with a resin luting cement (Nexus 2). Specimens were subjected to compressive load (N) using Instron machine until fracture. Data were submitted to independent *t* test analysis of variance ($p < 0.05$). **Results:** There was no significant difference ($p = 0.233$) in fracture resistance between the teeth reinforced with light-polymerizing and auto-polymerizing CR are 549.3 (± 95.44) and 490.7 (± 110.37) respectively. **Conclusion:** The use of less technique sensitive auto-polymerizing CR give equivalent benefit effect on reinforcing weakened roots, as the more commonly light-polymerized composite resin.

Keywords: Fracture resistance, weakened tooth roots, reinforcement, adhesive materials.

Introduction

In clinical practice, endodontically treated teeth commonly present restorative problems because of frequent insufficient sound coronal and radicular tooth structure¹⁻³. In some cases, development of secondary caries around pre-existing posts may further complicate the matter. Some cases may involve necrotic young permanent teeth with large canal spaces prior to completion of root formation. Other less conditions include developmental anomalies such as fusion and germination, internal resorption, iatrogenic damage resulting in large access preparations where flared root canals with thin dentinal walls are too weak to withstand normal masticatory forces and are prone to fracture⁴⁻⁵.

The restorations of such teeth with a cast post can

cause wedging forces which may result in fracture of an already weakened root. Moreover, the wide and tapered geometry of weakened root canals results in unretentive posts⁶, and if a prefabricated post is used, the excess space would be taken up by the bulk of luting cement which will be a weak area in the restoration. Placement of pins to help retain the core is not feasible because of insufficient dentin present at the coronal portion of the root. Thus, these conventional methods of restoration are unsatisfactory and often result in extraction of the teeth⁶⁻⁷.

Therefore there is great interest in adhesive materials for reinforcement and later, the prefabricated posts will be placed for the retention of the crown or fixed partial denture^{1,6,8-10}. Previous studies found that glass ionomer and light-polymerized composite

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resin was effective in strengthening weakened root structure and provided better prognosis¹¹⁻¹⁶ for a severely damaged teeth which otherwise would be extracted. When the weakened root is internally rebuilt with suitable adhesive dental materials, the root is dimensionally and structurally reinforced to support and retain a post and core for continued function of the tooth⁵. Teeth restored with intraradicular composite resin restoration have been shown to be 50% more resistance to fracture¹⁰. They were reportedly absorb and distribute forces in a more uniform manner when compared to metal materials and have been advocated as a reinforcing build-up material for badly damaged endodontically treated teeth with flared canals^{1,17}.

Adhesive interfaces of bonded restorations transmit and distribute occlusal forces to the remaining tooth structures homogeneously, potentially strengthening the restored tooth⁷, allows light polymerization by transillumination. When the post does not allow for light transmission, only 2 to 3mm depth of CR could be polymerize in the intraradicular space which could be countered using commercially available light-transmitting posts. An alternative is to use autopolymerizing CR which is much cheaper without a need to use expensive light transilluminating post but no study had been done about the use of this material.

The purpose of this study was to compare the fracture resistance of experimentally weakened roots after reinforcement with auto-polymerized composite resins and compare it to light-polymerized composite resin. These being recommended in previous study since these materials were commonly used within root canals and post space¹.

Materials and Methods

Fifty-six caries and restoration-free human maxillary central incisors with single canal and straight root measuring approximately 14mm were selected. The clinical crowns were sectioned transversally close to the cemento-enamel junction, leaving a root length of 13mm. Root canals were manually instrumented to a working length of 12mm (1mm above the apical foramen) with K-files (Dentsply Maillefer, Ballaigues, Switzerland) with #40 master apical file using step-back technique¹⁸. Irrigation solution used was 2.5% sodium hypochlorite followed by final irrigation with 2ml of distilled water, and the canals were aspirated and dried with absorbent paper points¹⁹. Root canals were obturated with gutta-percha

points (Dentsply-Herpo, Petropolis, Brazil) and endodontic sealer (AH 26, Dentsply, Rio de Janeiro, Brazil) using a lateral condensation technique before vertically condensed. Specimens were placed in wet pieces of gauze within a container in an incubator (Sanyo, Japan) at 37°C for 72 hours.

Post space preparation was initiated by removal of 8mm of gutta-percha with Gates Glidden drills and completed using number 6 ParaPost drill (Coltene Whaledent, USA). Over preparation of each canal was done to simulate extensive clinical structural damage by cutting out the internal dentin with an 8mm length of flat fissure diamond bur to gain 8mm of post space length with residual dentinal wall thickness of 0.50mm to 0.75mm at the cemento-enamel junction. The weakened specimens were then randomly divided into Group A and Group B with 28 specimens each.

For samples in Group A, total etch technique was done. They were filled with light-cured composite resin (Z100, 3M ESPE, USA) with the use of light-transmitting smooth plastic post (Luminex, Dentatus, USA) of 1.5 mm in diameter coated with vaseline to help in curing in a 2 mm increment from the apex to the cervical portion. Group B samples were filled with auto-cured CR (Alpha-Dent, Dental Technologies, USA) and Luminex post was used to standardize the post space. Later, the Luminex post in both groups were dislodged from the canal interior using needle-nose pliers (Denlors Tools, USA), left a post space of 1.5mm in diameter and 8mm in length ready for the cementation of the prefabricated titanium post (ParapostXH, Coltene/Whaledent, USA) using dual-cured universal resin cement system (Nexus 2, SDS Kerr, USA).

To mimic oral environment, all the specimens were thermocycled for 300 cycles with the sequence of 5 seconds at 5°C and 20 seconds at 55°C²⁰. The periodontal membrane simulation constructed using rubberized self curing silicon film (Dent-e-con, Germany). Samples were then mounted 2mm below the CEJ in an auto polymerized acrylic resin (Simplex Rapid, UK) blocks with a size 16mm x 16mm x 32mm in preparation for the mechanical test. They were submitted to a compression test using a universal testing machine (Instron 8874; Instron Corp. Canton, Mass) under a constant crosshead speed of 2.00 mm/min. The specimens were fixed in the frame cell at a 130° to the long axis of the tooth to simulate the average angle of contact between maxillary and mandibular incisors in Class I occlusion.

The fracture is confirmed by sudden drop in force measurements in the testing machine. Descriptive analysis was used to describe the means and standard deviation (SD) for both groups. Independent *t* test was used to compare the difference in the amount of fracture resistance between groups with *P* value to be less than 0.05 to be considered statistically significant.

Results

The mean values and SD of the compressive load required to fracture the roots for Z100 and Alpha-Dent group were 549.3 (95.44) N and 528.2 (123.80) N respectively. The independent *t* test indicated no significant differences among groups (*P* 0.283), showed in Table I.

Table I: Fracture resistance between Z100 group and Alpha-Dent group.

Variable	Z100 (n=27) Mean (SD)	Alpha-Dent (n=28) Mean (SD)	Mean diff. (95% CI)	<i>t</i> statistic [†] (<i>df</i>)	<i>p</i> [‡] Value
Fracture Resistance (N)	549.3 (95.44)	528.2 (123.80)	21 (-38.8, 81)	0.75 (53)	0.283

[†] Independent *t* test [‡] Significant at *p* < 0.05

Discussion

Results show that there is no difference between the fracture resistance of the root reinforced either using auto or light-polymerized CR. Traditionally known that the resistance to fracture is likewise directly related to the amount of remaining tooth structure^{5,8,10,15}. This study focused on the restoration of structurally compromised and weakened roots, seeking to find the capability of auto-cured CR which was usually cheaper than light-cured CR to be used in intraradicular restorations. No significantly difference mean that, this auto-cured CR could give a similar function as normally used light-cured CR in strengthening weakened root. The hypothesis of this study is followed the results. For *in vitro* tests, the moment of fracture is confirmed by a sudden decrease in force measurements in the testing machine. The choice of light-polymerized composite resin for control group was based on researches that recommended this resin for restorative purposes in conjunction with endodontic therapy^{1,5-7,23}. Unfortunately, till todate there were no published data about the use of auto-cured CR in intraradicular reinforcement. Among the advantages of using auto-cured CR are the elimination of the use of light-transmitting post which is quite expensive and not

always available in most clinics and at the same time minimizes the steps, indirectly shorten the time. After intraradicular restoration was fixed, the wall thickness will be increased. Saupe *et al.*¹⁰ have affirmed that the intraradicular restoration of weakened teeth changes the internal shape of the roots, increasing their thickness and rendering them more resistant to fracture. The same adhesive being used in this experiment might also contribute to the similar results. Another important feature for consideration is the standardization by the use of light-transmitting post system which gives a precise space ready for passive insertion of the prefabricated post^{3,5,21}. When comparing the results of this study with the human maximum biting force which is ranging from 500 to

600 N²², it was theoretically able to withstand the mastication force. In addition if samples in this study were prepared further with core foundation as in real clinical situation, value of fracture resistance were expected to be higher.

Conclusion

Auto-polymerized composite resin could be used to reinforce weakened teeth and gave similar results as light-polymerized composite resin. The fracture resistance value also could compensate the human mastication force.

Clinical Relevance

The auto-polymerized CR are found able to reinforce the weakened root structure as light-polymerized composite resin and this will simplify the clinical procedures as well as reduce the cost of treatment.

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References

1. Goncalves LA, Vansan LP, Paulino SM, Sousa Neto MD. Fracture resistance of weakened roots restored with a transilluminating post and adhesive restorative materials. *J Prosthet Dent.* 2006; 96:339-44. <http://dx.doi.org/10.1016/j.prosdent.2006.08.030> PMID:17098497
2. Howlader TH, Alam MK, Sultana A. An in vivo comparison of different impression materials for reproduction of intra-radicular surface anatomy using injection technique. *International Medical Journal.* 2013;20(1):95-98. PMID:11678543
3. Howlader TH, Alam MK, Sultana A. Efficacy of silicone as a dowel impression material. *Bangladesh Journal of Medical Science.* 2012;11(4):331-334. <http://dx.doi.org/10.3329/bjms.v11i4.12614>
4. Johnson ME, Stewart GP, Nielsen CJ, Hatton JF. Evaluation of root reinforcement of endodontically treated teeth. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2000; 90:360-4. <http://dx.doi.org/10.1067/moe.2000.108951> PMID:10982959
5. Lui JL. Composite resin reinforcement of flared canals using light-transmitting plastic posts. *Quintessence Int.* 1994; 25:313-9. PMID:7938415
6. Tait CM, Ricketts DN, Higgins AJ. *Weakened anterior roots--intraradicular rehabilitation.* *Br Dent J.* 2005; 198:609-17. <http://dx.doi.org/10.1038/sj.bdj.4812351> PMID:15920585
7. Lui JL. Enhanced post crown retention in resin composite-reinforced, compromised, root-filled teeth: a case report. *Quintessence Int.* 1999; 30(9):601-6. PMID:10765865 PMID:12787460
8. Freedman GA. Esthetic post-and-core treatment. *Dent Clin North Am.* 2001; 45:103-16. PMID:11210689 PMID:12184214 PMID:17098497 PMID:10982959
9. Lui JL. A case report of reattachment of fractured root fragment and resin-composite reinforcement in a compromised endodontically treated root. *Dent Traumatol.* 2001; 17: 227-30. <http://dx.doi.org/10.1034/j.1600-9657.2001.170508.x> PMID:11678543
10. Saupe WA, Gluskin AH, Radke RA. A comparative study of fracture resistance between morphologic dowel and cores and a resin-reinforced dowel system in the intraradicular restoration of structurally compromised roots. *Quintessence Int.* 1996; 27:483-91. PMID:8941826
11. Bonfante G, Kaizer OB, Pegoraro LF, do Valle AL. Fracture strength of teeth with flared root canals restored with glass fibre posts. *Int Dent J.* 2007; 57: 153-60. PMID:17695735
12. Cheong Ian AT, Abdul Muttlib NA, Wan Bakar WZ, Alam MK. Comparison between microleakage of composite and porcelain in class V restoration: an in vitro study. *International Medical Journal.* In-Press. 2012. PMID:22204296
13. Goldberg F, Kaplan A, Roitman M, Manfre S, Picca M. Reinforcing effect of a resin glass ionomer in the restoration of immature roots in vitro. *Dent Traumatol.* 2002; 18:70-2. <http://dx.doi.org/10.1034/j.1600-9657.2002.00083.x> PMID:12184214
14. Marchi GM, Paulillo LA, Pimenta LA, De Lima FA. Effect of different filling materials in combination with intraradicular posts on the resistance to fracture of weakened roots. *J Oral Rehabil.* 2003; 30:623-9. <http://dx.doi.org/10.1046/j.1365-2842.2003.00990.x> PMID:12787460
15. Mendoza DB, Eakle WS, Kahl EA, Ho R. Root reinforcement with a resin-bonded preformed post. *J Prosthet Dent.* 1997; 78: 10-4. PMID:15089948 [http://dx.doi.org/10.1016/S0022-3913\(97\)70081-7](http://dx.doi.org/10.1016/S0022-3913(97)70081-7)
16. Pierrisnard L, Bohin F, Renault P, Barquins M. Corono-radicular reconstruction of pulpless teeth: a mechanical study using finite element analysis. *J Prosthet Dent* 2002; 88: 442-8. PMID:12447223 PMID:12398170 PMID:10931252 <http://dx.doi.org/10.1067/mpr.2002.128376>

17. Bitter K, Kielbassa AM. Post-endodontic restorations with adhesively luted fiber-reinforced composite post systems: a review. *Am J Dent.* 2007; 20(6):353-60. PMID:18269124

18. Shanmugam CAL, Purmal K, Alam MK, Abdul Aziz BCZA. The comparison of Protaper® and K-flexofiles in preparation of curved canals - In vitro study. *International Medical Journal.* In-Press. 2013. PMID:15920585 PMID:17714964

19. Vassiliadis L, Genc O, Arslan S, Alacam T, Gorgul G. Fracture resistance of roots obturated with three different materials. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2007;104:705-8. <http://dx.doi.org/10.1016/j.tripleo.2007.07.013> PMID:17714964

20. Ortega VL, Pegoraro LF, Conti PC, do Valle AL, Bonfante G. Evaluation of fracture resistance of endodontically treated maxillary premolars, restored with ceromer or heat-pressed ceramic inlays and fixed with dual-resin cements. *J Oral Rehabil.* 2004; 31:393 [7.http://dx](http://dx)

doi.org/10.1046/j.13652842.2003.01239.x
PMid:15089948

21. Yoldas O, Alacam T. Microhardness of composites in simulated root canals cured with light transmitting posts and glass-fiber reinforced composite posts. *J Endod.* 2005; 31:104-6. <http://dx.doi.org/10.1097/01.DON.0000133160.08600.47>

22. Rosentritt M, Furer C, Behr M, Lang R, Handel G. Comparison of in vitro fracture strength of metallic and tooth-coloured posts and cores. *J Oral Rehabil.* 2000; 27:595-601. <http://dx.doi.org/10.1046/j.1365-2842.2000.00548.x> PMID:10931252

23. Pontius O, Hutter JW. Survival rate and fracture strength of incisors restored with different post and core systems and endodontically treated incisors without coronaradicular reinforcement. *J Endod.* 2002; 28:710-5. <http://dx.doi.org/10.1097/0000477020021000000008> PMID:12398170