



COMPREHENSIVE TECHNIQUES FOR INTRARADICULAR REHABILITATION OF WEAKENED ANTERIOR TEETH

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ABSTRACT

Statement of the problem: the restoration of weakened endodontically treated teeth with wide flared canal spaces and thin dentinal walls has presented several problems resulting from common insufficient sound coronal and radicular tooth structure.

Materials and method: fifty maxillary-carries , cracks and fractures free-central incisors were endodontically treated, decoronated at M-D cemento-enamel-junction and randomly distributed into five equal groups according to the intraradicular rehabilitation technique: **group A:** Coronal and intra-radicular cores using SDR (Dentsply, Weybridge, UK), **group B :** Coronal and intraradicular cores using Gradia Core (GC Corporation, Japan) and GC fiber post (GC Corporation, Japan), **group C:** Coronal and intraradicular cores using Xenious (StickTeck Ltd, Turku, Finland), **group D:** Coronal and intraradicular cores using flowable composite (Wave, SDI, Australia) and GC fiber post, and finally **group E:** Cast post and core. Which was cemented using resin cement (Rely X U 200, 3M ESPE, USA). Cr-Co copings were fabricated and cemented on all cores. All the specimens were thermocycled for 300 cycles and subjected to a compressive force at a 130° to the long axis of the tooth (Instron 8874; Instron Corp. Canton, Mass), until fracture.

Results: group A scored the highest mean value of (739.15 N), followed by group D (510.29 N), then group B (422.92 N), group C came next (288.16 N), and the least results were registered in group E (285.03 N). In addition, the maximum record was in group A (1135.72 N) while the minimum appeared in group E, (153.40 N). There was also a statistical significant difference between groups A and C on one hand (p-value 0.016) and between groups A and E on the other (p-value 0.016). However, no noticeable difference was found among other groups.

Conclusions: cast post should not be used to strengthen structurally compromised and weakened roots. Consequently, smart dentine substitute could be used alone to reinforce weakened roots or a combination of flowable composite resin and fiber post can also help in reinforcing frail roots.

KEY WORDS: fracture resistance, intraradicular rehabilitation, smart dentine replacement.

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INTRODUCTION

Restoration of endodontically treated teeth may presents a restorative problem, due to common insufficient sound coronal and radicular tooth structure⁽¹⁻³⁾. In some cases, development of secondary caries around pre-existing posts may further complicate the matter. Moreover, some cases may involve trauma to young permanent teeth which have large canal spaces prior to completion of root formation. Other conditions include internal resorption and iatrogenic damage resulting from large access preparations where flared root canals with thin dentinal walls are too weak to withstand normal masticatory forces and are prone to fracture⁽⁴⁻⁶⁾. If this occurs, the tooth would be permanently irresterable.⁽⁷⁾ The restorations of such teeth with a cast post can cause wedging forces, resulting in fracture of an already weakened root.^(5,8,9) Furthermore, the wide and tapered geometry of weakened root canals leads to irretentive posts⁽⁸⁾. In this case if a prefabricated post is used, the excess space would be taken up by the bulk of luting cement; a weak area for restoration. Thus, these conventional methods of restoration are unsatisfactory and often result in the extraction of the teeth^(8,10).

The successful management of weakened roots lies in reinforcing the remaining root structure and placing the prefabricated posts later for the retention of the crown or the fixed partial denture^(1,5,11-13). Previous studies found that glass ionomer and light-polymerized composite resin was effective in strengthening frail root structure. It also provided better prognosis⁽¹⁴⁻¹⁹⁾ for severely damaged teeth which otherwise had to be extracted. When the weakened root is internally rebuilt with suitable adhesive dental materials, it is dimensionally as well as structurally strengthened to support and retain a post and core. In this way the tooth will continue to function⁽⁵⁾. Restored teeth with intraradicular composite resin restoration have shown to be

50% more resistant to fracture⁽¹³⁾. They were reportedly absorbing and distributing the forces in a more uniform manner compared to metallic materials. Moreover, they have been advocated as a reinforcing build-up material for badly damaged endodontically treated teeth with flared canals^(1,20). Bonded restorations transmit and distribute occlusal forces to the remaining tooth structures homogeneously and potentially strengthening the restored tooth.⁽¹⁰⁾ Lui (1994 and 1987)^(5,21) described a technique of root reinforcement in which the internal aspect of the thin canal walls was etched, dentine bond was then applied, and lined with a chemically cured composite. Following the previous step; a passive, parallel-sided, metal post was cemented in place. The disadvantage of this system was exhibited in the lack of control over the polymerization reaction of the composite placed in the apical portion of the root canal. It is known that only 4–5 mm depth of composite resin could be polymerized in the intraradicular space because of partial transmission of light through the composite. However, the setting of composite relies on the ability of the light to access and initiate the curing at all depths.⁽²²⁾ In an attempt to overcome this problem, clear, plastic, light-transmitting posts (Luminex, Dentatus AB, Sweden) were introduced that could be placed through the composite in the root canal to allow the transmission of light along its entire post length.^(5,10,21)

Weakened teeth restored in this manner have shown to be 50% more resistant to fracture than those without composite resin reinforcement.^(13,23) The purpose of this study was to compare the fracture resistance of experimentally feeble roots after reinforcement using different restorative techniques. The materials were involving either post or intraradicular core or both.⁽¹⁾ The hypothesis of this research is that cast post and core will present the lowest fracture resistance among all groups.

MATERIALS AND METHOD

Fifty caries and restoration-free human maxillary central incisors characterized by single canal and straight roots of approximate sizes were collected. The teeth were cleaned and sterilized in an autoclave at 121°C, 15 Psi for 40 minutes. They were then mounted 2mm below the cement-enamel junction (CEJ) in an auto-polymerized acrylic resin (Vertex-Dental B.V., The Netherlands) blocks with a size of 10mm x 10mm x 20 mm. The clinical crowns were sectioned horizontally close to the mesio-distal CEJ, leaving a root length of 13mm. Root canals were manually instrumented using K-files (Dentsply Maillefer, Switzerland) with #40 master apical file using step-back technique. The irrigation solution used was 2.5% sodium hypochlorite followed by a final irrigation with 2ml of distilled water, the canals were then aspirated and finally dried using absorbent paper points (Dentsply Maillefer, Switzerland). They were obturated with gutta-percha points (Dentsply Maillefer, Switzerland) and endodontic sealer (AH Plus, Dentsply, DeTrey, Germany) using lateral condensation technique. Specimens were placed in distilled water at room temperature for 72 hours. Post space preparation was initiated by the removal of 9 mm of gutta-percha with Gates Glidden #1 drills (Dentsply Maillefer, Switzerland) then completed using Peeso reamers #1 to #6 (Largo, Dentsply Maillefer, Switzerland). Over preparation of each canal was done to simulate extensive clinical structural damage by cutting out the internal dentin full post space length with residual dentinal wall thickness of 0.5mm to 0.75mm at the CEJ, using Lab burs # H231FSQ followed by # H79FSQ (Komet, Brasseler, Germany). (Fig.1)

The weakened specimens were then randomly divided into 5 groups -according to intraradicular rehabilitation technique- with 10 specimens each. (Table I)

For group A: canal walls were painted with self-etching adhesive (Xeno V+, Dentsply, UK) using



Fig. (I) Weakened specimen

TABLE (I) Sample grouping

Group	Rehabilitation technique	No of samples
A	Coronal and intraradicular cores using SDR	10
B	Coronal and intraradicular cores using Gradia Core and GC fiber post	10
C	Coronal and intraradicular cores using Xenious	10
D	Coronal and intraradicular cores using flowable composite and fiber post	10
E	Cast post and core	10
Total		50

Microbrush-X (Microbrush, Grafton, USA) for 20 Sec. The material was then thinned out using air blasts for 5 sec and cured for 10 sec using LED-curing light (Elipar S10, 3M ESPE, USA). Pre-dosed SDR compule was injected slowly into canal using special gun, to a depth of 4 mm and then cured for 20 sec, using custom-made radicular light curing tip. Another 4 mm was injected and cured then a third layer was applied to overfill the canal and

cured. A special core former (Coltène/Whaledent, Switzerland) was filled with SDR and inverted on the root-face and cured.

For group B: dual cured composite for post cementation and core build up (Gradia Core, GC Corporation, Japan), Gradia Core self etching bond liquid A and B were mixed for 5 sec using microbrush X in a dispensing dish. The bond was then applied to the canal walls and left for 30 sec, excess material was blotted using paper points and air-dried for 10 sec. The bond was then light cured for 10 sec. Gradia Core was dispensed into canal and adjusted GC fiber post (GC Corporation, Japan) was inserted into canal. Curing light was applied on the post head for 20 sec. The core former was filled with Gradia Core and inverted on the root-face and cured.

For group C: the same technical steps as group A were repeated, except for the type of radicular and coronal core filling material; short-fiber reinforced composite (Xenious, StickTeck Ltd, Turku, Finland) was used.

For group D: the canal was etched, bonded and then a flowable composite (Wave, SDI, Australia) was injected into the canal and adjusted GC fiber

post was inserted into canal. Curing light was applied on the post head for 20 sec. The core former was filled with flowable composite and inverted on the root-face and cured. For group E resin patterns (Duralay, Reliance, USA) were fabricated for the canals and cast into a Co-Cr (Remanium Star, Dentaurem, Germany) custom made post and cores. Each cast post was cemented into its corresponding canal using self-adhesive resin cement (Rely X U 200, 3M ESPE, USA).

For all groups a 1.5 length ferrule and 0.5 mm chamfer finish line was prepared using round-end taper diamond bur with guiding pin # 8881 P (Komet, Brasseler, Germany) on a parallelometer (Amann Girrbach, Germany). Using a silicon-index technique for standardization, Co-Cr copings were fabricated for all groups and cemented using self-adhesive resin cement (Rely X U 200, 3M ESPE, USA). (Fig. II A&B)

All the specimens were thermocycled for 300 cycles with the sequence of 20 sec at 5°C and 20 sec at 55°C and 10 sec transport.

Samples were submitted to a compression test using a universal testing machine (Instron 8874; Instron Corp. Canton, Mass) under a constant

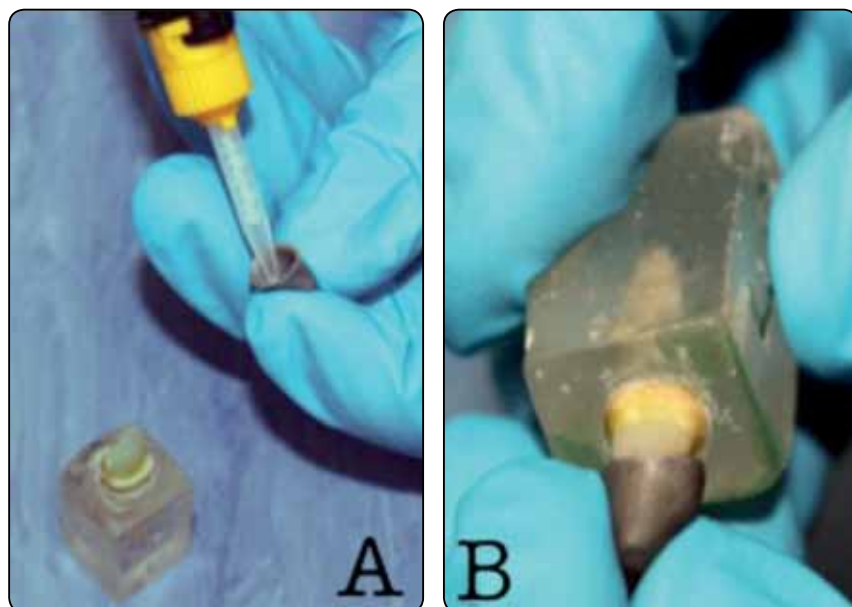
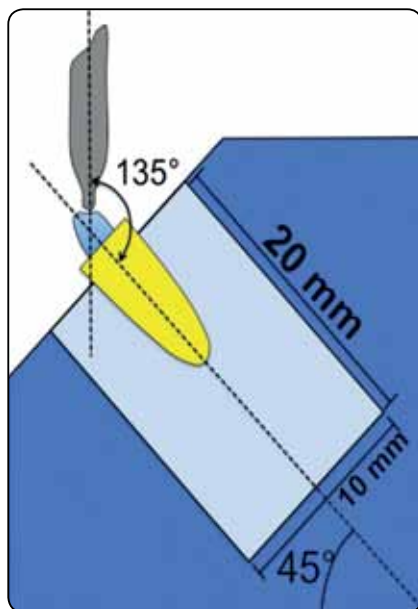


Fig. (II) A & B: Cementing of coping over prepared cores

crosshead speed of 1.00 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. (Diag. I) The fracture was confirmed by sudden drop in force measurements in the testing machine.

The data recorded was coded, entered using the statistical package SPSS version 15 and summarized using descriptive statistics such as: mean, standard



Diag. (I) Fixed specimens during fracture resistance.

deviation, minimal and maximum values for quantitative variables. Statistical differences between groups were tested using Nonparametric Mann Whitney test quantitative variable, which isn't normally distributed. P- values less than or equal to 0.05 were considered statistically significant.

RESULTS

Fracture resistance mean, minimum, maximum and standard deviation are displayed in table II. Group A scored the highest mean value of (739.15 N), followed by Group D (510.29 N) then Group B (422.92 N) leading to Group C (288.16 N). The least is Group E (285.03 N). (Chart I & 2) Among the groups the maximum record was in group A (1135.72 N) while the minimum was exhibited in group E, (153.40 N). There was a statistical significant difference among groups with (p-value 0.042) on one hand, between groups A and C (p-value 0.016) and between group A and E (p-value 0.016) on the other. However, no significant difference was found between other groups. (Table III) It should be noted that fracture modes showed different patterns even inside the same group.

TABLE (II) Fracture resistance mean and standard deviation

	Minimum	Maximum	Mean	Std. Deviation
Group A	363.22	1135.72	739.15	320.00
Group B	257.81	593.39	422.92	155.19
Group C	199.11	418.14	288.16	87.38
Group D	182.45	817.54	510.29	226.15
Group E	153.40	423.21	285.03	97.67

TABLE (III) P-Values between groups

	Group A	Group B	Group C	Group D	Group E
Group A		0.172	0.016	0.465	0.016
Group B	0.172		0.172	0.599	0.172
Group C	0.016	0.172		0.117	0.917
Group D	0.465	0.599	0.117		0.076
Group E	0.016	0.172	0.917	0.076	

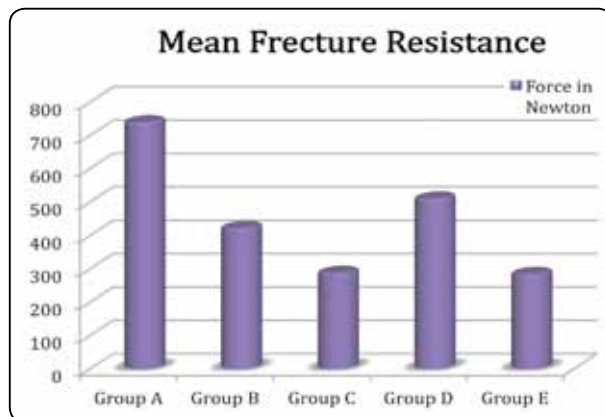


Chart (I) Mean fracture resistance

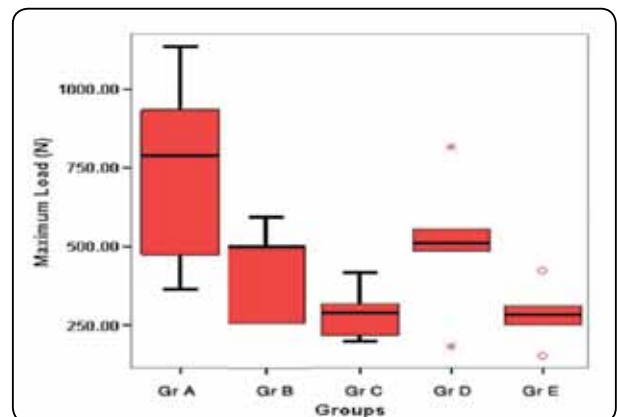


Chart (II) Fracture resistance results.

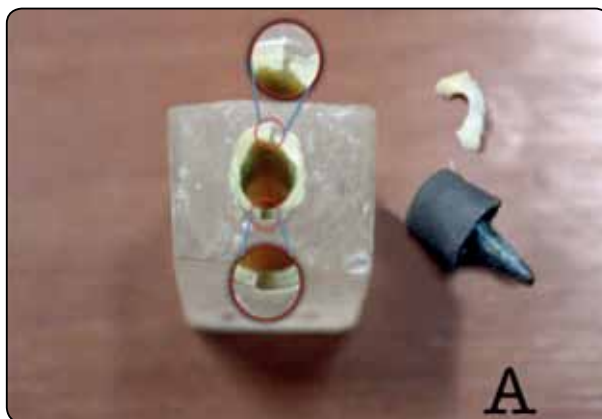


Fig. (III) A&B: Fracture patterns among groups

DISCUSSION

It is well documented that the resistance to fracture is directly related to the amount of remaining tooth structure ^(5, 11, 13, 18). This study focused on the restoration of structurally compromised and weakened roots, seeking to find a new, more reliable and efficient techniques in intraradicular restorations. For in vitro tests, the moment of fracture is confirmed by a sudden decrease in force measurements in the testing machine. A noticeable difference was found between tested groups, and between groups A&C and groups A&E. This means that the method of intraradicular rehabilitation affects the fracture resistance of teeth. The latter finding is parallel to Goncalves LA, et al, ⁽¹⁾ who in 2006 found out that; no significant differences among the conventionally prepared specimens and the weakened-roots filled with Luminex and composite resin. And both Freedman G, et al, ⁽²⁴⁾ and Solomon CS, et al, ⁽²⁵⁾ stated that, Luminex, light-transmitting posts in conjunction with composite resin provided an alternative treatment option in strengthening weakened, endodontically treated teeth .

SDR group scored the highest fracture resistance among all groups. It is a smart dentine replacement used in bulk fill technique. It has a self-leveling property and minimal polymerization shrinkage coupled by polymerization stress relieving properties. ⁽²⁶⁻²⁸⁾ This may lead to minimal shrinkage and solved the potential problem of using composite resin within the root canal, which is shrinkage towards the post and away from the dentinal walls thus leaving a gap at the composite dentine interface. ⁽²⁹⁻³¹⁾

Surprisingly SDR alone -without a fiber post- scored the highest fracture resistance results, justified by the increased thickness of SDR when it is placed alone versus when used in combination with fiber post, or it may be due to decrease in the number of interfaces within the complex radicular part.

The choice of light-polymerized flowable composite resin for reinforcement in group D was based on researches that recommended it for restorative purposes in conjunction with endodontic therapy ^(1,5, 10, 32). After intraradicular restoration was fixed, the wall thickness will be increased. Saupe *et al.* ⁽¹³⁾ 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. Composite resins reveal great capabilities to reinforce and strengthen the remaining root ⁽³³⁻³⁵⁾. However, the difficulty in removing this resin when endodontic retreatment or placement of post is needed can be considered a drawback in using it.

The main advantage of fiber posts was that they were more flexible than metal ones and had approximately the same modulus of elasticity as dentin. ⁽⁷⁾ When bonded in place with resin cement, forces would be distributed more evenly in the root, resulting in fewer root fractures. Also they reinforce the root canal and aid in retention of the core material.

Group D was chosen based upon the function of bulk short fiber composites. In this group fibers work as crack stopper layer. The reinforcing effect of the fiber fillers is not only based on stress transfer from polymer matrix to fibers but also on the behavior of individual fiber as a crack stopper. It seems that intraradicular dynamics is different than intracoronal ones. Xenious performed inferior to what was expected according to a one-year acceptable intracoronal clinical performance. ⁽³⁶⁾

Group E showed lower fracture resistance values. This is may be due to difficulty of the adaptation of the viscous Gradia to radicular walls.

The use of cast metal post revealed decreased fracture strength according to Davy D T, et al ⁽⁸⁾ And Deutsch A S, et al ⁽⁹⁾ resulting from wedging forces that may cause fracture of the already feeble root. ⁽⁵⁾ Metal cat posts have higher modulus of

elasticity than the tooth and hence higher potential to transfer and concentrate applied stresses to the surrounding compromised root structure. In contrary to that result, Solomon CS, et al, ⁽³⁷⁾ on 2011 found that, compromised roots restored with cast posts, had fracture resistance values more than twice that of the fiber post groups. Although later in the conclusion, they admitted that, all cast post group fractures resulted in irreparable roots, while only 60 to 80% of the fiber post failures resulted in irreparable root fractures.

Moreover, when comparing the results of this study with the human maximum biting force, which ranges from 500 to 600 N⁽³⁸⁾, the tooth was theoretically able to withstand the mastication force. A solid point worth mentioning regarding this research is the use of cemented metal copings on the coronal cores in the purpose of simulating the real clinical situation & compared to other researches which stopped at the post, core step and applied force on the cores, which may have affected the results. As in their case, the post alone- without being covered by a coping- actually weakens their tooth. At the end, the hypothesis of this study was indeed supported by the results.

Although it is beyond the scope of this research it is valuable to note that, in group E, all casts post were intact after fracture resistance test indicating that all forces were transmitted to the tooth, while specimen showed vertical root fracture rendering the tooth irreparable. (Fig. III A) while in other groups both tooth and intraradicular reinforcement were fractured. (Fig. III B) SDR group exhibited fracture patterns just below the level of the ferrule rendering the tooth restorable.

CONCLUSION

Within the limitation of this study it may be concluded that;

- 1) Cast post should not be used to reinforce structurally compromised and weakened roots.
- 2) Smart dentine substitute is an excellent choice in reinforcing weakened roots.

- 3) A Combination of flowable composite resin and fiber post could be used to reinforce weakened roots.

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