

# Retention of Quartz-Fibre Endodontic Posts with a Self-Adhesive Dual Cure Resin Cement

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**Abstract** – This study examines retention of a quartz-fibre endodontic post cemented in extracted human teeth using two cement types. Fifty-four extracted human central incisor teeth were prepared for a tapered quartz-fibre post. Posts were cemented in 28 teeth using conventional resin cement (RelyX ARC™), and 26 teeth using self-adhesive resin cement (RelyX Unicem™). Posts were cyclically-loaded. Bond strengths were tested and dependability assessment was carried out. Although there was no significant difference in Weibull modulus between groups ( $p < 0.05$ ), greater dependability was displayed by RelyX Unicem™ group. Easy application and greater dependability of self-adhesive cement may improve bonding of fibre-based posts in root canals.

KEY WORDS: Dental resin cement, In-vitro testing, Post retention, Quartz-fiber post

## INTRODUCTION

Restoration of endodontically treated teeth often requires a post and core. Traditionally, these posts have been cast or machined from metal. It is acknowledged however that these posts can weaken roots and predispose the tooth to root fracture. Previous studies have suggested that post-retained crowns have high failure rates<sup>1,2</sup>. These studies, which were cross-sectional surveys of post crowns showed that most failures were as a result of cement failure. Other failure modes included caries, root fracture, post fracture and endodontic failure<sup>3</sup>. Of greatest concern clinically is failure with root fracture necessitating extraction of the tooth. In 1990 Duret<sup>4</sup> reported a non-metallic material for the fabrication of posts based on the principle of carbon-fibre reinforcement. Laboratory-based studies have shown that these posts have a high tensile strength<sup>5</sup> and a modulus of elasticity similar to that of dentine<sup>6</sup>. Previously, rigid metal posts resisted lateral forces without distortion and hence this stress was transferred to the less rigid dentine, which could lead to root fracture. Fibre posts are postulated to flex under stress and distribute stresses uniformly between the post and the dentine<sup>4</sup>. These posts are cemented with resin cements that have a similar compliance.

A systematic review investigating literature on fibre-based post types by Bateman *et al.*<sup>7</sup> has shown that the majority of studies employed carbon-fibre posts and few the newer translucent quartz-fibre posts. Those studies that investigated the retention of such post types drew conflicting conclusions. Therefore, further work to analyze the behaviour of these posts is necessary before they can be recommended unreservedly for clinical use.

Fibre posts are bonded into the canal with an adhesive resin cement. Traditionally this has involved multiple stages including etching, washing, priming, placing bond and then cement into the canal. This is time consuming and it can be difficult to ensure that the surface preparation is predictable and uniform along the whole length of

the post space. Work by Ferrari *et al.*<sup>8</sup> has suggested that three-step bonding systems are more effective in forming resin tags in dentine in the apical third of the post space preparation than 'one-bottle' systems. A new composite resin cement, described as a self-adhesive dual cure agent, RelyX Unicem<sup>d</sup> has been recommended for luting posts. This cement obviates the stages of etching, priming and placing a bonding agent in the post space. It has significant potential clinical value if bonding to the post space can be made more predictable. Few studies are available in peer-reviewed journals and the authors are unaware of any studies investigating its use with quartz-fibre posts.

Post crowns may fail for a number of reasons. A retrospective clinical analysis of 1304 fibre-posts by Ferrari *et al.*<sup>9</sup> has shown that most failures of are related to loss of retention at the stage of removing temporary restorations. Assessment of post retention in-vitro may therefore allow the clinician an improved understanding of the clinical failure behaviour of fibre-based posts.

The objective of this study was to investigate the retention of quartz-fibre posts in extracted human teeth cemented with a traditional composite resin luting cement control group and a new self-adhesive dual cure cement technique. The null hypothesis was that the application of an adhesive system to the post together with a compatible resin cement is as effective as a system in which the retention is dependent upon the adhesion produced by a resin cement alone. This would be determined by the tensile force to failure, applied through the cemented post in specimens that had been conditioned by cyclic loading.

## MATERIALS AND METHODS

### Tooth preparation

60 extracted human central incisor teeth were selected for this study. The teeth were cleaned of any attached

debris and stored in water until required.

Each tooth was sectioned coronally using a high speed handpiece with a diamond fissure bur and copious water spray, to leave a root approximately 13mm long. The root-face was then adjusted with a diamond wheel to be approximately perpendicular to the long axis of the tooth and ensure a flat coronal surface.

### Endodontic treatment

The teeth were endodontically treated according to the following protocol:

- Working length was determined by the careful placement of a size 10 K-Flex file<sup>a</sup> so that the apical 1mm of the file extended beyond the apex and preparation took place with a crown-down technique using rotary Ni-Ti Profiles™ .04 taper rotary files<sup>b</sup>.
- The roots were irrigated copiously with 2ml of 2.5% NaOCl after the use of each file and the apical constriction was prepared to an ISO size 30 Profile™ with a taper of 0.04.
- A final irrigation regime of 10ml 50% citric acid was used to remove the endodontic smear layer, followed by 10mls of 2.5% NaOCl and the canal was dried with paper points.
- The teeth were obturated with cold lateral compaction of gutta-percha and AHPlus Sealer<sup>b</sup>.
- Gutta-percha was removed to a depth of 8mm with size 090 and 110 Gates Glidden burs.

### Post space preparation

The post spaces were prepared, according to the manufacturer's instructions, with the RTD DT™ post preparation burs<sup>c</sup> for a #3 DT quartz-fibre post<sup>c</sup> at a depth of 8 mm measured with a silicone stop. An interdental brush dipped in alcohol was used to clean sealer and particles of gutta-percha from the post space. A final irrigation was carried out with 2mL of 2.5% NaOCl followed by 2ml water to ensure a clean surface for post placement. The post space was dried with paper points ready for post cementation.

The teeth were then randomly divided into two equal experimental groups as follows.

Group 1 Posts cemented with RelyX ARC™<sup>d</sup>.

Group 2 Posts cemented with RelyX Unicem™.

### Cementation

#### Group 1

The post space in this group was etched with 35% Phosphoric acid gel for 15 seconds.

The canals were then washed thoroughly using 10ml of water from an endodontic irrigating syringe and gently blotted dry with paper points. Scotchbond1™ adhesive<sup>d</sup> was applied to the post space with a microbrush and gently air dried. Excess at the apical end of the post space was gently blotted dry with a paper point. The bonding agent was light cured for 15 seconds with a 3M Visilux™ curing unit<sup>d</sup>. RelyX ARC™ was mixed according to instructions and placed into the canal with a periodontal probe and on the fitting surface of the post. The RTD DT™ post was then placed into the canal to the full working length with a gentle pumping motion. Excess cement was removed from the root surface with a microbrush.

The cement was cured for 40s by directing the curing light along the long axis of the post .

#### Group 2

The post space was irrigated with 10ml of water and gently dried with paper points. The RelyX Unicem™ was mixed according to manufacturer's instructions and placed on the fitting surface of the post. The post was then placed into the canal with a pumping motion to the full working length. Excess cement was removed from the root surface with a microbrush. The cement cured for 40s by directing a curing light along the long axis of the post .

All specimens were stored dry for two weeks before mounting for testing.

### Specimen set-up

The specimen design is illustrated in *Figure 1*.

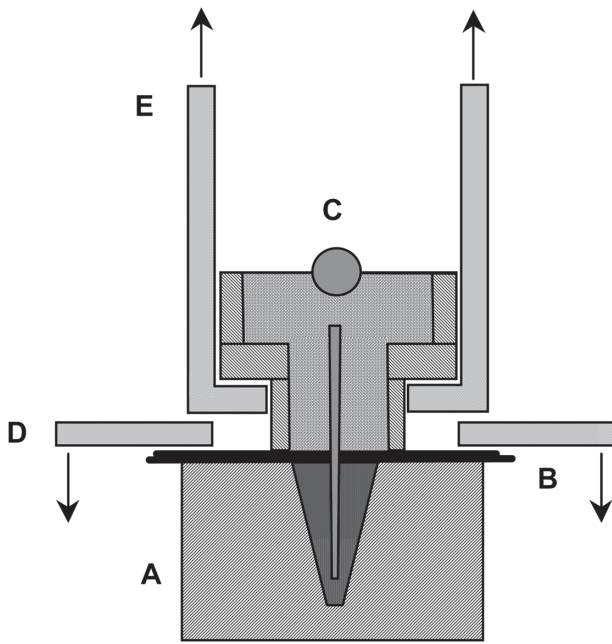
The roots were mounted in an epoxy resin base<sup>e</sup> with the axis of the post vertical and perpendicular to the surface of the base. The selected epoxy formulation has a low polymerization exotherm of less than 20°C in the volume used. Two layers of 0.6mm thick, latex-free rubber dam<sup>f</sup> were placed on the base before insertion of the post to act as a separator between the base and coronal sections and a seal around the post during production. (At this stage six specimens were lost due to epoxy resin infiltration along the coronal surfaces of the posts through an inadequate seal between the post and dam). Following polymerization of the embedding epoxy resin and its removal from the mould, the coronal surface of the post was acid treated (35% phosphoric acid gel for 60s) and washed copiously with water. Then Scotchbond™ 1 bonding resin was applied to its surface, gently air dried and light cured for 15 s. A T-shaped, circular cross-section composite "restoration" was built-up upon the rubber dam to a height of 15mm. using a three-part Perspex ring mould. Z100 MP Restorative<sup>d</sup> composite resin was built up incrementally and the rings remained in place during the subsequent force applications (*Figure 1*). A spherical glass ball (4mm diameter) was placed centrally, on the top of the specimen, before the final increment of composite was polymerised (*Figures 1* and *2*). Half was exposed to act as a (compression) loading point. The low compliance of the intervening rubber dam (relative to that of the post) resulted in the transmission of practically applied compressive force through the post and not across the composite/(dam)/tooth interface.

### Conditioning cycled loading

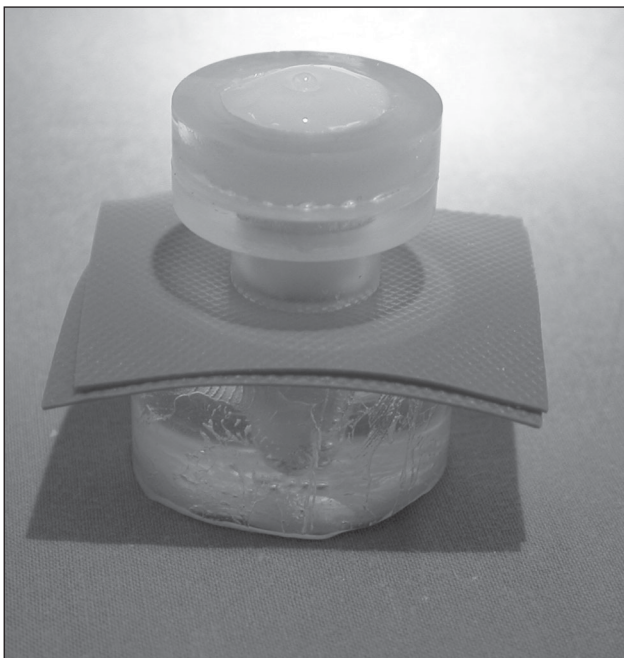
Each specimen was set on the compression plate of an Instron™ Model 4469 universal testing machine<sup>g</sup> and loaded through the glass ball in point contact with the cross-head anvil. The compressive force was cycled between -12N and -50N at 0.17 Hz for 1000 load cycles. This took place in air at ambient laboratory temperature (22 ± 2°C).

### Post retention testing

Following its cyclic load-conditioning, the specimen was mounted in a custom made attachment to apply tensile force (*Figure 1*) and attached to the cross-head mounted Instron load cell. The specimens (and thus posts) were loaded axially at a speed of 1mm min<sup>-1</sup>, in air at ambient



**Figure 1.** Vertical section through the specimen when it is set within the attachments used to measure the tensile force to failure. Key elements are : A – The lower half of the specimen. The de-coronated tooth containing the post set in the epoxy resin thick disk. B – The double layer of rubber dam. C – The upper half of the specimen. The three Perspex rings filled with composite resin and containing the post and glass ball. D – The lower steel retention ring (with arrows to indicate the loading direction). E – The upper (top) two-part steel grip (with arrows to indicate the loading direction).



**Figure 2.** The specimen. Its component parts can be differentiated by reference to the cross section drawing given in Figure 1.

laboratory temperature ( $22 \pm 2^\circ\text{C}$ ), until failure. The force required to dislodge the posts was recorded.

**Statistical analysis**

As the bonded surface area of the post to the tooth varied by  $< 2\%$  the failure force was not converted to a

stress. Arguably, in this instance force rather than stress is the more relevant parameter, clinically. The mean force to debond and its standard deviations were calculated for each cement. A comparison of mean debond strengths was made with a t-test. For each Group, the debond forces were subject to Weibull analysis<sup>10</sup> to permit both a measure of the bond dependability to be made (Weibull Modulus) and allow the probability of failure, at a known applied tensile force level, to be calculated.

**RESULTS**

The mean force to failure was significantly different between groups (*Table 1*:  $p < 0.005$ ). The mean failure force represents failure at a high rate, 50% (assuming a normal distribution) and as such its clinical relevance is debatable. A statistical comparison of the Weibull Moduli (based upon the standard error) revealed no statistically significant difference between the groups, indicating similar distributions of force to failure (*Table 1*). The clear difference in the force to failure observed in mean values is apparent when the data sets are further analyzed to determine the force level for other specified probabilities of failure (*Table 2*). As it is a relatively small but clinically significant number of failures that give a component a poor reputation for reliability, this approach could be considered to give a good measure of cement dependability. On this basis, RelyX Unicem™ can be considered to offer greater dependability.

All specimens failed by the post pulling out following failure of the bond.

The de-cemented posts and the post space in root samples were examined by one observer at 2.5 x magnification and under enhanced lighting conditions. Resin cement was evident on the surfaces of all posts and absent from the prepared dentine surfaces. This would suggest that the bond failure had occurred between the root dentine and the cement, and was of an adhesive rather than cohesive nature.

**Table 1.** Statistical analysis. The Weibull parameters, mean strengths and sample sizes.

| Parameter                               | Rely Unicem | RelyX Arc |
|---|-------------|-----------|
| Weibull Modulus (m)                     | 2.258       | 2.866     |
| Correlation coefficient (R)             | 0.93        | 0.89      |
| Standard Error of the Modulus           | 0.126       | 0.200     |
| Normalising parameter ( $\sigma_0$ )    | 0.265       | 0.148     |
| Mean strength                           | 228 N       | 131 N     |
| Standard Deviation of the mean strength | 80 N        | 50 N      |
| Number of samples tested                | 26          | 28        |

**Table 2.** Survival analysis: The stress level to produce a defined failure rate calculated from a Weibull analysis of the results.

| Chance of failure (%) | Rely Unicem<br>(Force required, N) | RelyX Arc<br>(Force required, N) |
|-----------------------|------------------------------------|----------------------------------|
| 10                    | 10                                 | 67                               |
| 20                    | 136                                | 88                               |
| 30                    | 168                                | 103                              |
| 40                    | 197                                | 117                              |
| 50                    | 225                                | 130                              |
| 95                    | 431                                | 217                              |
| 99                    | 521                                | 252                              |

## DISCUSSION

Currently, many quartz-fibre posts are being placed in clinical practice. There is a lack of quality evidence<sup>7</sup> however, investigating the performance of this relatively new technology. Clinicians should be cautious about adopting new materials and techniques before thorough laboratory and clinical trials have been carried out. This laboratory-based research, therefore investigated the retention of a tapered quartz-fibre post type when cemented with a novel self-adhesive dual cure adhesive resin luting cement compared to a conventional resin cementation technique.

Root specimens were embedded in an epoxy resin base, a metallographic product selected for its low polymerization exotherm, since it has been shown by other workers that a rise in temperature may significantly affect bond strength to dentine<sup>11</sup>. The exotherm produced a temperature rise that could not increase the tooth temperature beyond the normal physiological range.

Mannocci *et al.*<sup>12</sup> have shown that fibre-based posts stored in water showed lower flexural strength values than posts which were stored dry. They concluded that fibre-posts must not be in contact with oral fluids. It was felt important therefore to avoid storage of the posts in water to prevent premature failure during cyclic loading although the authors acknowledge that the use of dry teeth limits the simulation of clinical conditions in the study.

Fibre-based posts are brittle when load is applied perpendicular to the orientation of the fibres<sup>13</sup>, therefore the specimen was designed to produce axial loading, as is the predominance in clinical restoration. It should be noted however that incisors are also stressed by non-axial guidance pathways and this study did not attempt to simulate these. Cyclic loading was applied to simulate one of the major environmental factors that might affect performance. This axial load "conditioning" was achieved through the test piece geometry and point contact through the glass ball at the top of the specimen as a precursor to tensile testing. A relatively short duration of fatiguing was selected in view of the fact that most fibre-post restorations appear to fail at removal of temporary crowns<sup>9</sup>. The authors acknowledge that a longer duration of cyclic loading may have led to decreased cement dependability in both groups.

A previous examination of the applicability of the Weibull Statistical Distribution Function to dental data<sup>14</sup> demonstrated that between 20 and 30 specimens were sufficient to allow a meaningful analysis to be undertaken as was the case in the work reported here. It should be pointed out that although the present study initially started with 30 specimens in each group, a number (Unicem™ = 4, ARC™ = 2) were lost during production of the specimens. Consequently the sample size initially was adequate for its purpose and remained so after production. From the Weibull analysis it is usual practice to calculate the likelihood of failure at a defined critical force. Unfortunately, there is no clear consensus on forces that fibre-posts are subject to in clinical use. Consequently, the results are presented as a table of the applied force that will result in a series of specified percentage failures. Such a table could be considered a suitable substitute in the

absence of a defined force, to give a measure of cement dependability.

Resin cement was evident on the surfaces of all extracted posts and absent from dentine surfaces. This would suggest that the bond failure had occurred between the root dentine and the cement, contrary to the findings in another report<sup>17</sup>. Further experiments that take account of protocol differences are required to resolve this issue.

This study used a double-tapered quartz-fibre post which is reported to conform to the anatomical shape of the root canal<sup>15</sup>. No perforation occurred during post preparation and posts appeared to conform well to the apical and coronal sections of the post spaces. Parallel-sided fibre-based posts have been shown however, to have superior retention to tapered posts in a recent study<sup>16</sup> suggesting that more extensive testing is necessary before tapered post designs can be regarded as a suitable alternative for parallel posts.

## CONCLUSIONS

In the present study a novel self-adhesive dual cure adhesive resin luting cement was compared to a conventional resin cementation technique. The manufacturer of the self-adhesive dual cure cement, RelyX Unicem™<sup>d</sup>, claims that it allows a more predictable, less time consuming luting procedure than a conventional resin cementation technique. Within the limitations of an in-vitro study, the results might suggest that this self-adhesive dual cure resin luting cement, at least is comparable with, and potentially more reliable than, conventional luting systems in terms of tensile bond strength. This coupled with their predictability in post space treatment and clinical ease of use may make this cement an attractive and viable alternative or replacement for current materials.

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## MANUFACTURERS' DETAILS

- a Kerr Corp., Orange, CA, USA.
- b De-Trey /Dentsply, Zurich, Switzerland.
- c RTD, St Egreve, France.
- d 3M Dental Products, St. Paul, MN, USA
- e Buehler Epoxicure™ Resin, Buehler, Lake Bluff, IL, USA.
- f Roeko Flexidam™, Roeko, Langenau, Germany.
- g Instron Limited, High Wycombe, Bucks, UK.

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## REFERENCES

1. Turner, C.H. Post-retained crown failure: a survey. *Dent. Update*, 1982; **9**: 221, 224–226.
2. Lewis, R. and Smith, B.G. A clinical survey of failed post retained crowns. *Br. Dent. J.*, 1988; **165**: 95–97.
3. Vire, D.E. Failure of endodontically treated teeth: classification and evaluation. *J. Endodontics* 1991; **17**:338–342.
4. Duret, B., Reynaud, M. and Duret, F. [New concept of coronoradicular reconstruction: the Composipost (1)] *Chirurgien-Dentiste de France*, 1990; **60**: 131–141.
5. King, P.A. and Setchell, D.J. An in vitro evaluation of a prototype CFRC prefabricated post developed for the restoration of pulpless teeth. *J. Oral Rehabil.*, 1990; **17**: 599–609.
6. Asmussen, E., Peutzfeldt, A. and Heitmann, T. Stiffness, elastic limit, and strength of newer types of endodontic posts. *J. Dent.*, 1999; **27**: 275–278.
7. Bateman, G., Ricketts, D.N. and Saunders, W.P. Fibre-based post systems: a review. *Br. Dent. J.*, 2003; **195**: 43–48.
8. Ferrari, M., Vichi, A., Grandini, S. and Geppi, S. Influence of microbrush on efficacy of bonding into root canals. *Am. J. Dent.*, 2002; **15**:227–231.
9. Ferrari, M., Vichi, A., Mannocci, F. and Mason, P.N. Retrospective study of the clinical performance of fiber posts. *Am. J. Dent.*, 2000; **13 (Spec No)**: 9B–13B.
10. Weibull, W. A statistical distribution function of wide applicability. *J. Applied Mechanics* 1951; **18**: 293–297.
11. Brackett, W.W., Covey, D.A. and Haisch, L.D. The effect of elevated temperatures on the dentin adhesion of resin composites. *Oper. Dent.*, 2003; **28**:303–306.
12. Mannocci, F., Sherriff, M. and Watson, T.F. Three-point bending test of fibre posts. *J. Endodontics*, 2001; **27**: 758–761.
13. Stewardson, D.A. Non-metal post systems. *Dent. Update*, 2001; **28**:326–332.
14. McCabe, J.F. and Carrick, T.E. A statistical approach to the mechanical testing of dental materials. *Dent. Materials*, 1986; **2**: 231–234.
15. Boudrias, P., Sakkal, S. and Petrova, Y. Anatomical post design meets quartz fibre technology: rationale and case report. *Comp. Cont. Educ. Dent.*, 2001; **22**:337–340.
16. Qualtrough, A.J., Chandler, N.P. and Purton, D.G. A comparison of the retention of tooth-coloured posts. *Quintessence Int.*, 2003; **34**:199–201.
17. Rovatti, L., Mason, P.N. and Dallari, A. [New research on endodontic carbon-fibre posts] *Minerva Stomatologica* 1994; **12**: 557–563.