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ORIGINAL ARTICLE

# Does an intracanal composite anchorage replace posts?

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**Abstract**

*Objectives* This study aims to assess the effectiveness of an intracanal composite anchorage to replace conventionally cemented titanium or bonded glass fibre posts.

*Materials and methods* Post space preparation was performed up to depths of 6 mm (groups 1 and 2) and 3 mm (group 3) in root filled mandibular premolars. In group 1, titanium posts were cemented with zinc phosphate cement. Glass fibre posts were adhesively cemented in group 2 using a dual-cure composite resin. In group 3, intracanal anchorage was solely performed with a dual-cure composite. All teeth were restored with standardised direct composite crowns without a ferrule. After thermo-mechanical loading, static load was applied until failure. Fracture patterns were assessed, and a microscopic analysis was performed to analyse the occurrence of additional cracks.

*Results* Group 2 revealed a significantly higher median fracture value (408 N) than groups 1 and 3, while no difference was detected between group 1 (290 N) and group 3 (234 N) ($p$=.1417). In group 3, the more favourable fracture patterns were observed. However, the majority of teeth within this fracture category revealed additional minor cracks of the root.

*Conclusions* Within the limitations of this study, adhesive intracanal anchorage to a depth of 3 mm with resin composite only has the same fracture resistance as titanium posts conventionally cemented to a depth of 6 mm. Even teeth with repairable main fractures exhibited additional dentinal cracks on the root.

*Clinical relevance* Additional dentinal root cracks in the teeth with repairable main fractures may considerably impair their longevity.

**Keywords** Root canal posts · Titanium post · Glass fibre posts · Intracanal anchorage · Dentinal cracks

## Introduction

In severely decayed root canal treated teeth, the necessity for using root canal posts is broadly accepted [1]. For many decades, it was stated that root canal posts should reach up to the apical third of the root in order to provide sufficient retention and stabilise the weakened radicular tooth substance [2, 3].

Recent data from the literature indicated that shorter posts may be feasible as long as adhesive bonding to the root canal is provided. Luting shorter posts to the root canal dentin has been shown to provide sufficient retention for coronal restoration while minimising the risk of perforation [4]. Moreover, bonding in the coronal part of the root proved to be more efficient and more predictable than bonding in deeper regions [5]. Dispensing with posts completely simplifies the restorative procedure considerably and may reduce the risk of destabilisation of the residual tooth structure of the root filled tooth.

Different studies have compared the fracture resistance of teeth, which were either restored with a composite radicular retention or with different posts with or without ferrule. The use of a post was not found to improve fracture resistance [6–10]. Interestingly, however, none of these studies included a fatigue test prior to the load to fracture test, although this approach more accurately reflects the real clinical situation. The fracture analysis performed in the quoted studies focused

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on the location of the main fracture line. A thorough inspection of the whole root surface was, however, not performed, and minor cracks induced by the simulated clinical function cannot be ruled out. These cracks, which may be invisible in a clinical situation, possibly impair tooth longevity.

The aim of this study was to examine the fracture behaviour of endodontically treated teeth restored with different types of intracanal anchorage and direct composite crowns. The null hypotheses tested were that (1) the use of posts does not affect the fracture resistance of premolars restored with composite crowns and (2) the type of corono-radicular reinforcement has no influence on the failure mode of the specimens tested.

## Materials and methods

### Tooth selection and root canal treatment

Seventy-two extracted mandibular premolars with similar dimensions at the cemento-enamel junction (CEJ) (long diameter, mean 6.5 mm and SD 0.5 mm; short diameter, mean 4.4 mm and SD 0.4 mm) were cleaned mechanically with scalers and stored for 1–3 months before further processing. A stereomicroscope (Wild-Heerbrugg AG, Heerbrugg, Switzerland) at a magnification of ×16 was used to examine the roots meticulously and to ensure the absence of cracks, fractures or root caries.

The clinical crowns were removed 1 mm below the buccal CEJ using a diamond bur and leaving a root length of 13±1 mm. Instrumentation of the root canals was performed using NiTi rotary instruments (Race, FKG, La Chaux-de-Fonds, Switzerland) under intermittent rinsing with 1 % sodium hypochlorite to an apical size of ISO 45. All root canals were filled with vertical condensed gutta-percha (Obtura II, Obtura Corp; Fenton, USA) using an epoxy sealer (AH plus, De Trey, Konstanz, Germany).

### Experimental groups

The roots were randomly distributed into three experimental groups ($n$=24) and treated with different types of intracanal anchorage (Fig. 1).

#### *Group 1*

Titanium posts (CM post, size 4, Cendres+Metaux, Biel, Switzerland) with a cervical diameter of 1.5 mm were used. The coronal part of the post was reduced in order to achieve a total post length of 8.5 mm. Post space preparation was performed up to a depth of 6 mm using the corresponding drill supplied by the manufacturer. All posts were cemented with Harvard zinc-oxy-phosphate cement (Harvard Dental International GmbH, Hoppegarten, Germany).

#### *Group 2*

Fibre-reinforced composite posts (FRC) (Postec, size 1, Ivoclar Vivadent, Schaan, Liechtenstein) with comparable shapes and similar cervical diameters to the titanium posts in group 1 were used. The post space was prepared using the drill provided by the manufacturer. Post length was adapted as described for group 1. The post surface was cleaned with phosphoric acid and treated with a silane coupling agent (Monobond S, Ivoclar Vivadent). For adhesive cementation, the dentinal surface was etched with phosphoric acid for 10 s and pretreated with a dual-cure adhesive (Excite DSC, Ivoclar Vivadent) before the post was cemented with a dual-cure resin (Multicore flow, Ivoclar Vivadent).

#### *Group 3*

No posts were used for intracanal anchorage, but a post space 3 mm in length was prepared. The same drills as those as in group 2 were used, but the drills' tips were shortened by 3 mm before use in order to obtain similar cervical dimensions of the intracanal anchorage across all specimens. After post space preparation, dentin bonding was performed similar to the procedure in group 2, after which the post space was completely filled with Multicore flow.

### Final restoration

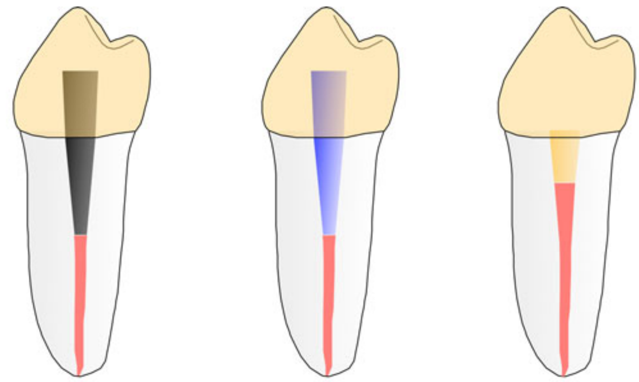
After post space preparation and treatment, all specimens were restored with standardised direct composite crowns. Because no dentin adhesive was used in group 1 for post cementation, a dual-cure adhesive (Excite DSC) was applied to the coronal tooth surface according to the manufacturer's instructions.

For the fabrication of direct crowns, transparent moulds (Pella crowns, Odus, Dietikon, Switzerland) with anatomically formed occlusal surfaces were filled with Multicore flow and adapted to the tooth surface. Each post was occlusally covered with approximately 1.5 mm of resin composite. After light curing for 40 s from four sides, any excess of the composite resin was removed at the restoration margins using fine diamond burs.

### Thermo-mechanical loading

The roots were coated with a thin 0.3-mm layer of polyvinylsiloxane (President light body, Coltène-Whaledent AG, Altstaetten, Switzerland) to simulate the periodontal ligament [11]. The roots were subsequently embedded in self-curing acrylic resin (Demotec 20, Demotec Siegfried Demel, Nidderau, Germany) such that the restoration margins were situated approximately 2 mm above the feigned bone level [12].

**Fig. 1** Experimental groups



| | Group 1 (Ti) | Group 2 (FRC) | Group 3 (Comp) |
|---|---|---|---|
| Intracanal anchorage, depth | Titanium post, 6 mm | FRC post, 6 mm | Composite, 3 mm |
| Luting material | Zinc Phosphate Cement | Excite DSC / Multicore Flow | Excite DSC / Multicore Flow |
| Build-up | Multicore Flow | Multicore Flow | Multicore Flow |

Clinical conditions were simulated by thermal cycling and mechanical loading using a computer-controlled masticator (CoCoM 2, PPK, Zurich, Switzerland). This fatigue test comprised 3,000 thermal cycles between 5 and 50 °C and 1.2 million vertical loads of 49 N from human cusps at 1.7 Hz [13].

Fracture resistance

After thermo-mechanical loading (TML), a linear compressive load was applied (cross-head speed=0.5 mm/min) to all specimens in a universal loading device (Zwick, Ulm, Germany) at an angle of 45° in the direction of the buccal cusp until failure. A tin foil (0.5-mm thick) was positioned between the steel sphere and the crown to avoid excessive stress concentrations on the composite resin crown surface. The maximum load capability was recorded in Newtons (N).

To obtain a more detailed failure analysis, all specimens were examined meticulously under the stereomicroscope (Wild-Heerbrugg AG, Heerbrugg, Switzerland) at a magnification of ×16. The main fracture mode of each specimen was identified and categorised into four patterns: (1) fracture solely within the restoration, (2) fracture at or near the interface restoration/tooth but intact post, (3) fracture at or near the interface restoration/tooth and fractured or bent post and (4) fracture of the root below the feigned bone level within the embedding material. The latter failure type was judged as non-restorable, while categories 1–3 were deemed to be restorable fracture modes. Each specimen was investigated from four sides (buccal, lingual, mesial and distal), while any visible fracture line or crack was illustrated on a scheme according to its direction and position (Fig. 3).

Statistical analysis

Statistical analysis was performed using JMP (SAS Institute, Cary, NC, USA). The level of significance was set at $\alpha=0.05$. The primary outcome variable was failure during TML (fatigue testing). For tooth specimens not surviving TML, the load capability of these teeth was set at 49 N for further analysis. After confirming that the data met assumptions of normality (Shapiro–Wilk test), the maximum load capabilities of the experimental groups were compared with one-way ANOVA followed by Tukey's post hoc test.

## Results

Due to failures in technical handling (partial damage during mounting specimens in the chewing simulator), two specimens in group 1 and one specimen in group 3 failed before TML. All remaining specimens survived TML except one tooth in group 3, in which the composite crown was debonded. The median fracture load values (min–max) were as follows: 290 (126–486) in group 1, 408 (225–580) in group 2 and 234 (49–411) in group 3.

The results of fracture resistance are graphically displayed as box plots (Fig. 2). A one-way ANOVA demonstrated significant differences between the three groups ($p<.0001$). Post hoc analysis with Tukey's HSD test revealed that group 2 had significantly higher fracture resistance than did group 1 ($p=.0009$) and group 3 ($p<.0001$). Group 3 was not significantly different compared with group 1 ($p=.1417$). In all specimens restored with posts (groups 1 and 2), unfavourable failure modes dominated (mode 4), while in group 3, the majority of fractures were judged as being

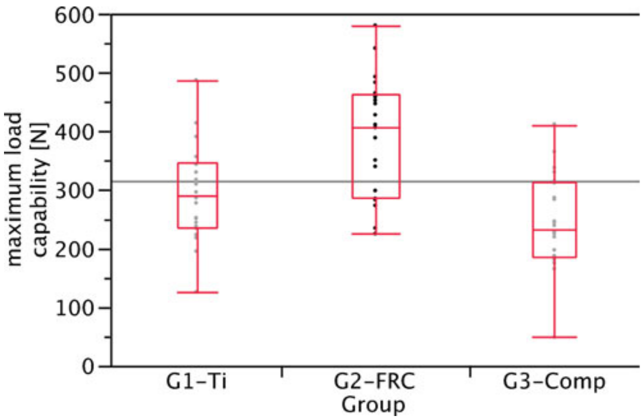



**Fig. 2** Box and whisker plots of fracture loads of the experimental groups. The median fracture load in group 2 is significantly higher than in groups 1 and 3 ($p<.05$)

restorable (mode 2 and 3, Table 1). In group 3, 5 out of the 22 teeth showed fractures at or near the restoration/tooth interface with intact posts (mode 2), while the majority of teeth had fractured radicular anchorage (mode 3). Fractures solely within the restoration (mode 1) were not evident in any group. Even in teeth with a restorable main fracture pattern (modes 2 and 3), additional cracks were frequently found under the stereomicroscope (Figs. 3 and 4). In summary, only 8 (three in group 2 and five in group 3) out of 23 teeth with a non-catastrophic fracture did not demonstrate any fractures or dentinal cracks below the simulated bone level.

## Discussion

The present study was conducted to evaluate the suitability of an intracanal composite anchorage as an alternative for metal and fibre posts in severely compromised premolars. The hypothesis that the use of posts does not affect the fracture resistance was rejected because the results from group 2 significantly exceeded the maximal load of the other groups.

The higher load capability of the FRC group (group 2) compared to group 1 with titanium posts is in contrast to the results of a previous study by Naumann et al. (2007), who reported no differences in fracture resistance

**Table 1** Distribution of the fracture patterns across the experimental groups

| Fracture pattern | Group 1 (Ti) | Group 2 (FRC) | Group 3 (composite) |
|---|---|---|---|
| Type 1 (restorable) | | | |
| Type 2 (restorable) | 1 | 3 | 5 |
| Type 3 (restorable) | | | 14 |
| Type 4 (non-restorable) | 22 | 21 | 3 |

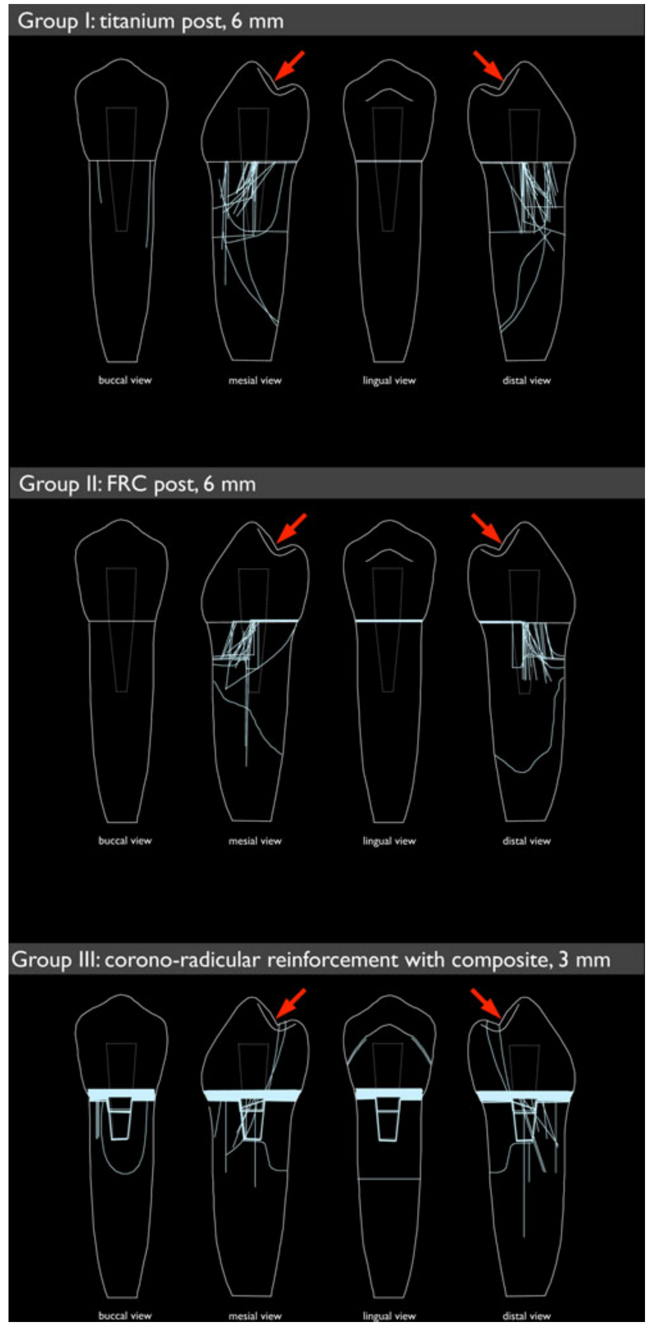



**Fig. 3** Detailed failure report of each experimental group summarising all of the main fractures and additional cracks in the dentine (direction of the applied force in the load-to-fracture test denoted by red arrows)

between titanium and fibre posts. In the aforementioned study, both types of posts were luted with a self-adhesive cement [14]. Therefore, the observed differences are rather attributed to the type of cementation than being caused by the post material. In this context, Naumann et al. (2008) demonstrated that conventional non-adhesive post cementation was less reliable in withstanding simulated functional forces than adhesive approaches [15].

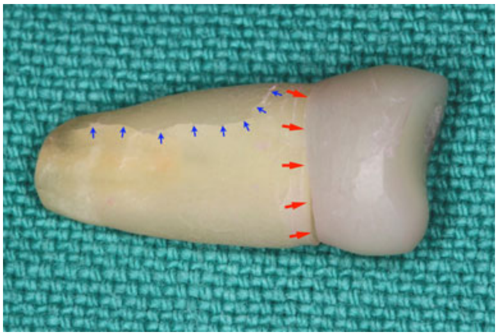


**Fig. 4** Example of a specimen with non-catastrophic failure (debonding of the crown as denoted by *red arrows*). Additional cracks can be clearly seen up to the apex of the root (as denoted by *blue arrows*)

The influence of post rigidity has been a matter of controversy since the market launch of fibre posts in the early 1990s. At that time, posts exhibiting a modulus closer to that of dentin were thought to constitute a more favourable biomimetic approach than existing techniques in the restoration of severely decayed teeth [16]. This was based on the idea that a more flexible post would distribute forces more evenly within the root, resulting in fewer root fractures [1]. A recent study revealed, however, that fibre posts positioned in the centre of the root did not contribute to load transfer as long as the bond between the tooth and composite core was intact [17]. Controversial results have been published regarding the in vitro fracture load of teeth restored with different post systems. Some studies have indeed demonstrated a reduced fracture resistance with the use of stiffer titanium, stainless steel or zirconia posts [18–20]. However, lower fracture strength of FRC posts compared with metal posts has been demonstrated in different in vitro studies [21, 22]. A recent study questioned the influence of post rigidity because no linear association was detected between failure load and the modulus of the posts [23]. Thus, when focusing on fracture mechanics, it may be concluded that there is no advantage in restoring teeth with either post type.

The fact that the fracture resistance provided by the composite anchorage in the present investigation was significantly lower compared with the FRC group can be interpreted as an underwhelming result. However, group 3 performed similarly compared to conventionally cemented titanium posts with 6-mm length. Despite clinical guidelines advocating an insertion depth of two-thirds of the root for conventional cementation [1, 3], a post length of 6 mm was chosen for both titanium and FRC posts to eliminate a possible influence of the post length. A previous study conducted on root filled maxillary premolars demonstrated that restored teeth with direct resin composite crowns without posts had fracture resistance levels similar to those with metal or glass fibre posts inserted to a depth of 8 mm [10]. Despite the use of comparable restoration with full composite crowns, the fracture values generated by Fokkinga and co-workers [10] following thermocycling were three- to fourfold higher than those in our study. This may be attributed to the extensive fatigue regimen with thermocycling and simultaneous cyclic occlusal loading, as well as to the lower loading angle of 45° in the present load to fracture test compared to 30° in the previous study.

The present results demonstrate that the proportion of favourable fractures increased with the use of only composite in intraradicular anchorage. Thus, the second part of the null hypothesis was rejected. It is striking that a meticulous inspection of the roots by stereomicroscopy revealed a high level of additional cracks.

These cracks were detected even in two-thirds of all specimens that experienced a restorable main fracture. To date, no report in the literature has reported similar findings. Thus, it may be doubted whether a tooth with a repairable failure in a clinical situation that undergoes re-restoration is indeed able to survive over the long term. Prognosis may not be influenced solely by a subgingival fracture, which is difficult to treat; instead, it may also depend on dentinal cracks, which may propagate and lead to subsequent fractures. From a clinical standpoint, additional studies that evaluate the prognoses of fractured post-treated and re-restored teeth are warranted.

Because the inspection of the roots could only be performed as soon as the specimens were removed from the embedding material after the load to fracture test, it was not feasible to evaluate the exact time of crack formation and propagation. Mechanical fatigue alone was not identified to be capable of inducing dentinal defects under the experimental conditions [24]. However, there is evidence that pre-existing flaws in normal dentin may be caused by preparation procedures. These defects may propagate or grow to catastrophic size during the fatigue test even with application of small cyclic loads [25, 26]. Thus, studies including thermocycling and mechanical loading before the loading to fracture may provide more reliable information regarding the fracture behaviour of the specimens [27]. To improve clinical relevance of the fatigue testing, a periodontal ligament was simulated by a thin layer of impression material. President was chosen as it proved to be the material of choice for this purpose in a recent laboratory test [11].

Severely destroyed premolars without ferrule were simulated for the current experiment by amputation of the clinical crown. A ferrule preparation was omitted in order to assess the real impact of the corono-radicular reinforcement on the fracture behaviour. A sufficient ferrule was shown to attenuate the effect of the post in laboratory studies [6–9, 28]. From a clinical perspective, however, the results have to be interpreted with care since a circumferential ferrule is considered mandatory in cases with no coronal structure [28, 29].

Even though this study suggests that intracoronal anchorage with composite may be regarded as a valuable time-saving alternative for non-adhesive post cementation, caution is advised in transferring these laboratory findings to clinical practice. In a recent clinical study, post placement resulted in a significant reduction in failure risk for endodontically treated premolars especially for those lacking all coronal walls [30]. However, the fact that the groups without posts did not receive any additional corono-radicular reinforcement may have considerably influenced the results.

## Conclusions

Within the limitations of this study, the following can be concluded in severely decayed premolars:

- Adhesively cemented fibre posts are more reliable in terms of fracture resistance than conventionally cemented titanium posts with the same length.
- Adhesive intracanal anchorage to a depth of 3 mm using resin composite alone had a comparable fracture resistance as titanium posts.
- In contrast to the FRC and the titanium post group, repairable fractures were more common in the specimens with composite as a corono-radicular reinforcement.
- Even teeth with repairable main fractures exhibited additional dentinal cracks on the root surface, which can impact their longevity.

**Conflict of interest** The authors have no conflict of interest.

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