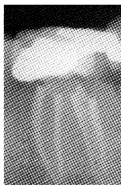

CLINICAL ARTICLE

A clinical report of 85 fractured metallic post-retained crowns

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Abstract

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Aim To determine any patient, technique or material factors that were significantly associated with post fracture in metallic post systems.

Summary Eighty-five fractured metal posts were retrieved over a 5-year period from a total of 84 patients who attended a dental hospital for treatment. A record was kept of the patient's dentition to identify the tooth with the fractured post, the number of teeth present, the excursive guidance scheme and the likely post design and material. Radiographs of 67 of these teeth were available. The presence or absence of a periapical lesion was noted as was the quality of the root filling. Maxillary lateral incisors, followed by maxillary centrals were associated with most of the fractured posts. The median survival to fracture was 36 months. The number of teeth in the dentition had a mode of 28. The most commonly fractured post design was a serrated and parallel design with an average diameter of 1.2 mm at the site of fracture. Apical lesions were found in 67% of the teeth with radiographs. Only 12% of teeth with a 'good' apical filling as opposed to 55% with a 'poor' apical filling had apical lesions.

Key learning points

- Maxillary lateral incisors, followed by maxillary central incisors are at greatest risk of having a fractured metallic post.
- Having a large number of teeth in the dentition or an adequate length of post was not protective against metallic post fracture.
- Teeth with fractured post-retained crowns had a high incidence of apical lesions.

Keywords: crowns, endodontics, failure, post-retained core.

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Introduction

The use of a post-retained core and subsequent crown to restore a badly broken down tooth has been a recognized treatment modality for over 150 years (Shillingburg & Kessler

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1982). The use of the technique has responded to various fashions within Operative Dentistry and has undergone various incarnations as a reinforcement for root filled teeth (Guzy & Nichols 1979), a desirable method of realigning misplaced anterior teeth (Shillingburg & Kessler 1982) or more recently simply as a method to gain retention for a core in the absence of sufficient coronal tissue (Baraban 1988, Robbins 2002). The use of bonding techniques and resin-based post systems are again being hypothesized as a means of gaining root reinforcement (El-Mowafy & Milenkovic 1994), however, the majority of post and core restorations currently in place within the population are still the 'traditional' metallic post systems retained with a conventional (rather than composite resin-based) cement.

Most of the metallic-based post and core systems can be categorized by the fabrication method (i.e. prefabricated wrought or cast metal alloy), by the post morphology (tapered or parallel) or by the post design (e.g. threaded, serrated, smooth, vented or unvented) (Caputo & Standlee 1976, Halpern 1985, Stokes 1987, Hunter & Flood 1989). The 'gold standard' has traditionally been accepted as the indirect fabrication of a cast post and core using a custom direct intra-oral pattern build-up (Kantor & Pines 1977), an impression of the post channel preparation or a matched post reamer and impression post system. The relative performance of these various systems are usually assessed *in vitro* where a single mechanical parameter such as retention (Standlee *et al.* 1978, Standlee & Caputo 1993), tensile (Ricker *et al.* 1986) or fracture strength of a post (McDonald *et al.* 1990, Fernandes & Dessai 2001) can be investigated.

Conversely, clinical studies on failure of post and core restorations often report the incidence of root fracture (Creugers *et al.* 1993, Torbjörner *et al.* 1995) or biological consequences of post and core placement (Eckerbom *et al.* 1991, Leempoel *et al.* 1995). There have been relatively few studies that have systematically examined the factors leading to the fracture of metallic post and core restorations *in vivo*. This is important as the consequences of fracture can leave both the patient and clinician in a difficult situation. If it can be assumed that the dowel length originally chosen was the best obtainable, the fractured portion has almost always to be removed to ensure that a subsequent suboptimal restoration is avoided. The methods to remove fractured posts have been reviewed (Abbott 2002) but none of these are without clinical risks either through dentinal microcracking with ultrasonics (Altshul *et al.* 1997), root perforation with trepans or root fracture with 'post-pulling' instruments (Machtou *et al.* 1989).

As identification of clinical risk factors may suggest situations where metallic post-retained crowns are contraindicated, an attempt to recognize these factors was considered appropriate to reduce the incidence of post fracture.

Materials and methods

Aims of study

A longitudinal case study was undertaken to determine any patient, technique or material factors that were significantly associated with post fracture in metallic post systems.

Patient selection

Eighty-four patients attending a dental teaching hospital over a 5-year period were recruited; local Ethical Committee approval and individual patient consent was gained. The great majority of those who entered the study (70%), were referred by their General Dental Practitioner for removal of the fractured post. The remaining cases (30%) were those who were attending the teaching hospital at the time for their treatment.

Eighty-five fractured posts were obtained. The posts were removed by the member of clinical staff treating the patient or by a student under supervision. The posts were removed as per normal clinical practice using ultrasonic vibration and/or Masserann trepan instrumentation (Medidenta International Inc., Woodside, NY, USA). Efforts were made to limit damage to the fracture surface during removal although in many cases this proved difficult. The retrieved posts were numbered and retained for further analysis (Fig. 1). Where the coronal portion of the post crown was available this was also retained. Finally, the teeth were temporarily restored as appropriate and arrangements were made for a permanent restoration. Each patient was assigned a number and his or her clinical details were recorded where possible.

These included:

- Date of post removal
- Tooth number (FDI)
- Whether there was a history of trauma to the tooth following post placement
- Length of time since the post was fitted (to the nearest month). This information, where available, was gained from the patient's notes, referring dentist or the patient themselves
- Number of teeth in the dentition
- Excursive occlusal scheme (e.g. incisal guidance, canine guidance, group function)
- Visible identification of type of post if possible (i.e. wrought versus cast, tapered versus parallel, serrated versus smooth)
- Evidence of a fractured root.

All posts (and coronal restorations where available) were disinfected in 1% Virkon (Antec International Ltd, Sudbury, UK) and then cleaned in an ultrasonic bath containing a surfactant of 3% Decon Neutracon (Decon Laboratories Ltd, Hove, UK) followed by rinsing with deionized water. The posts were subsequently dried on a paper towel and placed in numbered vials according to the patient number.

The length of each retrieved post was measured using a digimatic calliper (Mitutoyo UK Ltd, Andover, UK) to the nearest 0.01 mm. Each post was measured three times on separate occasions without reference to previous measurements. A mean of the three readings was then calculated.

Radiographic examination

If available, preoperative radiographs were examined and where possible the following information recorded:

1. Whether a root filling was present or not.
2. If present, what material the root filling appeared to consist of, e.g. gutta-percha, silver point or paste.
3. If the root filling was considered good or poor. This was determined against a set of criteria based on Ray & Trope (1995) and De Cleen (1993).
   Good apical root filling – 4 mm or more of apical root filling
   - Within 2 mm of the apex and not through the apex
   - No detectable voids

   Poor apical root filling
   - Greater than 2 mm from the apex or through the apex
   - Voids detected
4. Presence or absence of periradicular pathology.
5. Whether a gap between the apical extent of the post and the coronal extent of the root filling was greater than 1 mm.
6. Presence of root fractures or perforations.

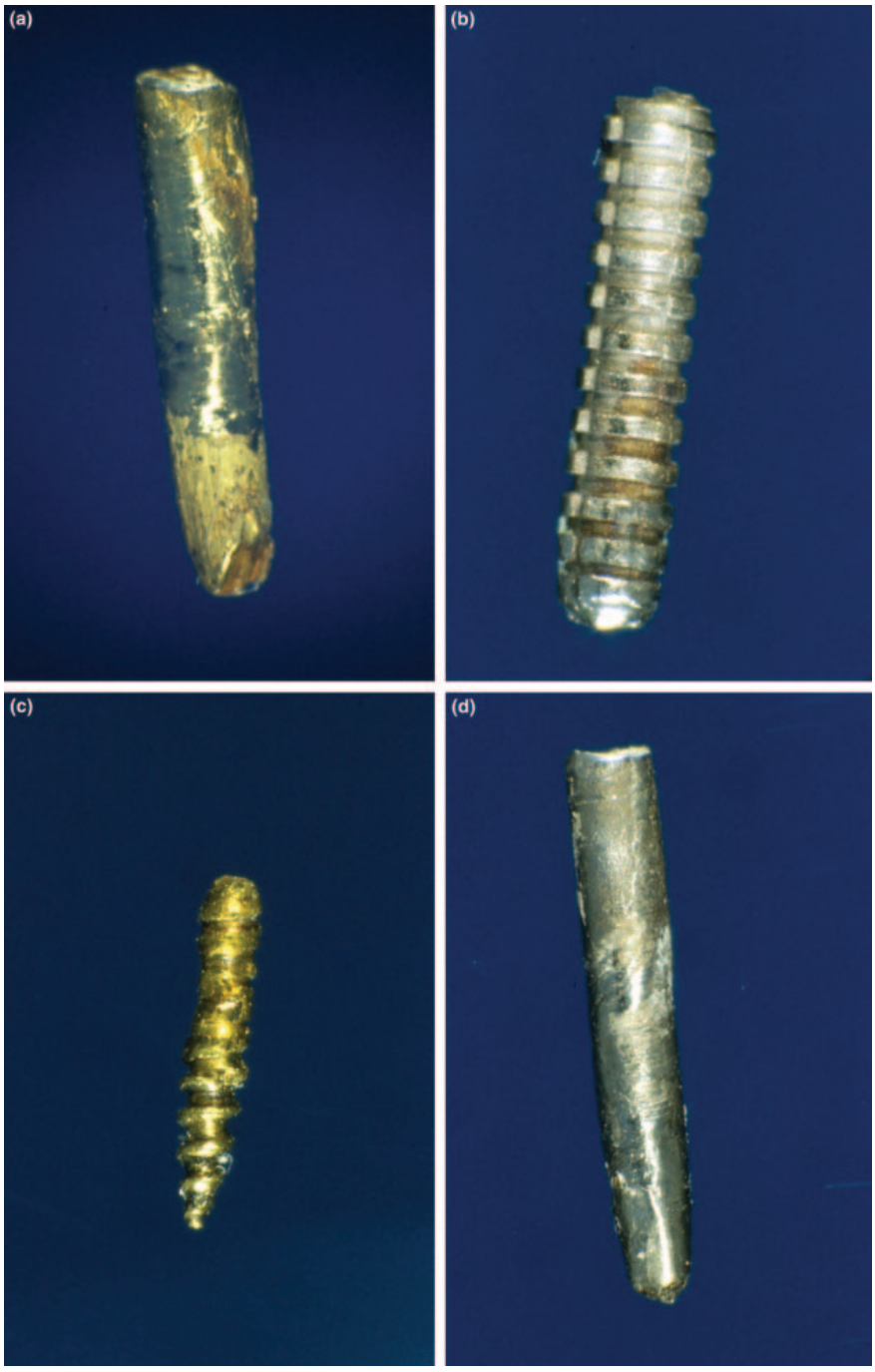

Figure 1 Examples of different materials and morphologies of retrieved posts.

7. Radiographic length of the fractured portion of post *in situ* and the position of fracture, i.e. the distance between the most coronal dentine and the coronal extent of the fractured post. Addition of the two values together gave the overall radiographic length of the pre-fractured post.
8. Diameter of the post at the site of fracture.

The radiographic length and diameter of the post, and the position of the fracture were measured using the calibrated calliper. Three measurements were again taken to the nearest 0.01 mm, and the average of the 3 was recorded.

Results

The fractured posts were predominantly retrieved from maxillary incisor and canine teeth with 40 (47%) being from maxillary lateral incisors. Mandibular anterior and maxillary and mandibular premolar teeth were also involved (Table 1).

History of trauma

The majority of fractured posts occurred during normal function although a history of recent trauma was reported in one case.

The details regarding the length of time since the posts were fitted to the time of fracture were recorded in 68 of the 85 posts and ranged from 1 to 240 months (20 years). The mean time was 58 months (4.8 years) but due to the skewed distribution the median was only 36 months (3 years). Overall, 47% of the fractures occurred within the first 2 years, 72% within 5 years and 87% within 10 years (Fig. 2).

Number of teeth in dentition

The number of teeth in the dentition was noted in 75 cases (88%) and ranged from 12 to 32 teeth with a mode of 28 (Table 2).

Table 1 Distribution of teeth from which fractured posts were removed

Tooth type	Number of fractured posts
Maxillary centrals	30
Maxillary laterals	40
Maxillary canines	8
Maxillary second premolars	1
Mandibular centrals	1
Mandibular laterals	2
Mandibular canines	1
Mandibular first premolars	1
Mandibular second premolars	1

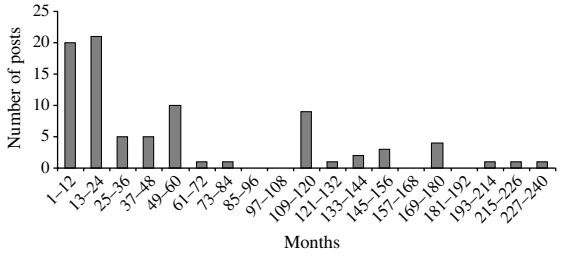

Figure 2 Length of time from post fitting to fracture.

Occlusal scheme

In 76 of the 85 cases (89%) the right and left excursive guidance schemes were noted. It can be seen from Table 3 that canine guidance was the predominant occlusal scheme on the left-hand side but on the right this was more evenly distributed between canine guidance and group function.

Design of post

The design of posts used in restoring the root filled tooth varied enormously. However, they could all be classified into two basic shapes, parallel and tapered. Overall, 66 of the 85 posts were parallel and 19 were tapered. Of the 66 parallel posts 48 were serrated, 10 were smooth and eight were threaded. Of the 19 tapered posts 13 were smooth, three were serrated and three were threaded (Table 4). The most common fractured post was the parallel serrated post (56%).

With regard to the composition of the fractured posts, 64 posts were cast in metal alloys whilst 21 posts were wrought.

Evidence of root fracture

Clinically, out of the 85 cases of fractured posts there was only one case where there was also a root fracture that was noted following the removal of the fractured post and consequently extraction of the tooth was required.

Table 2 Distribution of fractured posts according to number of teeth in the dentition

Number of teeth in dentition	Number of fractured posts
<10	0
10–14	4
15–19	10
20–24	25
24–29	35
>30	1

Table 3 Excursive occlusal schemes in patients associated with fractured posts

Excursive guidance	Number of posts from right side	Number of posts from left side
Canine guidance	12	24
Posterior group function	17	7
Incisal guidance	5	11

Table 4 Distribution of fractured posts according to surface design

Design of post	Number of fractured posts
Parallel serrated	48
Parallel smooth	10
Parallel threaded	8
Tapered smooth	13
Tapered serrated	3
Tapered smooth	3

Radiographic study

Sixty-seven of the 85 (79%) posts had radiographs available for analysis. These were viewed on a light box under ×2 magnification. One investigator examined all radiographs on three separate occasions without reference to the previous results. If any variability occurred the radiographs were examined by a second investigator and an agreement reached.

Root fillings

In 63 of the 67 radiographs available, root fillings were visible; in four cases no root filling was present. As may have been expected 61 of the 63 (97%) root fillings were gutta-percha. The remaining two (3%) teeth were filled with sectional silver points.

Apical root filling

Of the 67 radiographs examined 24 (36%) had a good apical root filling and 43 (64%) had a poor apical root filling.

Apical lesions

Forty-five teeth (67%) demonstrated the presence of apical lesions. The effect of other factors on the presence of apical lesions, such as the presence or absence of a root filling, the quality of the apical seal and the size of gap between the root filling and the post, was analysed.

The majority of teeth 63 (94%) had a root filling present. However of these, apical lesions were evident in 41 (65%). All four teeth with no root fillings had apical lesions (Table 5).

Only eight (12%) of the teeth with a good apical root filling had evidence of apical lesions. However, 37 (55%) teeth with a poor apical root filling had apical lesions (Table 6).

Accuracy of fit between post and root filling

The distance between the apical end of the fractured post and the start of the root filling was measured. In 22 (33%) of the 63 teeth with root fillings, this distance was greater than 1 mm in length resulting in incomplete filling of the canal. Table 7 shows the relationship between the accuracy of fit of the post and the presence of apical lesions.

Length of fractured post

Eighty-one of the 85 fractured posts were available for measuring. In the remaining four cases only the coronal segments of the post crown had been returned. Both the actual length of each of the apical portions of the fractured posts removed and where available

Table 5 Apical lesions in relation to the presence or absence of a root filling

Root filling	Apical lesion	Number of teeth
Present	No	22
Present	Yes	41
Absent	No	0
Absent	Yes	4

Table 6 Apical lesion and quality of the apical filling

Quality of apical filling	Apical lesion	Number of teeth
Good	No	16
Good	Yes	8
Poor	No	6
Poor	Yes	37

Table 7 Apical lesions and gap between the root filling and the post

Gap between the root filling and the post >1 mm	Apical lesion	Number of teeth
Yes	No	8
Yes	Yes	14
No	No	14
No	Yes	27

the preoperative radiographic lengths were measured. The mean length of the portion of fractured post removed was 6.17 mm (SD 1.95 mm).

Radiographically, it was possible to determine 63 post lengths from the 67 radiographs available. The remaining four radiographs had been taken with the crown still *in situ* so it was impossible to determine exactly where the fracture had occurred. The results measured from the radiographs showed a mean length of apical fractured post of 6.42 mm (SD 1.67 mm).

Position of the fracture

From the radiographs the distance from the most cervical point of dentine to the fractured post was measured. This was possible to determine in 60 of the 67 radiographs. The remaining seven were obscured due to radiographic positioning or the presence of a coronal temporary restoration. The mean cervical length to fracture was 2.83 mm (SD 1.41 mm).

Diameter of post at fracture site

In contrast to length determination, it was possible to determine the diameter of the posts at the fracture site from radiographs in 66 of the 67 cases. The length of the post to the full coronal extent of the fracture could not always be measured where the crown was still present (due to the radio-opacity of the post material). However, the horizontal position of the fracture could often be identified and the diameter at this position measured. The mean diameter at this point was 1.20 mm (SD 0.25 mm).

Discussion

Many *ex vivo* studies have investigated the mechanical properties of post and cores (Hoag & Dwyer 1982, Assif *et al.* 1993, Huysmans *et al.* 1993, Cohen *et al.* 1994, Heydecke *et al.* 2002). However, as yet there is no data regarding fractured post and cores *in vivo*. As post fractures are not the most common reason for failure of restorations involving post and cores it took 5 years to gain a large enough sample to study. General dental practitioners placed the majority of posts and as a result there was a large variation in the materials and designs of posts used. Although the authors retrieved the largest number of posts, in order to include as many samples as possible some posts were removed by

other clinicians. In these cases the clinical staff were requested to supply as much clinical information as possible.

The fractured posts were found to be predominantly from maxillary lateral incisors possibly due to, first, the fact that post crowns are more commonly placed in maxillary anterior teeth and, secondly, the lateral incisor has the smallest root and therefore the diameter of the post will tend to be narrow.

The length of time since the posts were fitted varied from 1 month to 20 years. This tends to suggest that the reason for failure may not be the same for all fractured posts. However, it is not possible to determine the cause of early or late failure. Turner (1982) in a survey of 100 failed post crowns showed that failures, for whatever reason, could occur at any time and that there was no correlation between type of failure and length of time *in situ*. The mean time to failure was found to be 4.8 years although the median was only 3 years. This is in accordance with Lewis & Smith (1988) who stated that the mean life span of a post crown was only 4.2 years and that the bulk of failures occurred within the first 3 years. These findings should be taken into consideration when planning long-term restorative treatment for patients.

Although lack of posterior support is widely considered to be a cause of fracture of post crowns in anterior teeth, the majority of patients in this study had a full dentition (28 teeth). Therefore it cannot be assumed that a complete dentition has a protective effect against the risk of fracture of a post, rather it suggests an occlusal analysis should be undertaken for each patient. The cause of the fracture was related to trauma in only one case with the remaining fractures occurring during normal function. However, it is not known if there was an increased level of parafunction in these patients. With regard to their occlusal scheme patients were recorded as either canine guidance, group function or incisal guidance. However this may have been skewed where the fractured post crown had been a canine as the patient would then have probably have been recorded as having group function on that side.

There was a large variation in the designs of the fractured posts. The predominant type was the parallel-serrated design. However, as this is the design currently most favoured (Ibbetson 1997), it is not possible to suggest this as a cause of fracture rather it is implied that the use of this design is not a protective factor against post fracture. With regard to composition there were more fractured cast than wrought posts. This may be due to the fact that, for the same diameter, wrought posts tend to be stronger than cast posts and do not have the problems of incorporated casting defects (Harty 1972). However, if the modulus of elasticity is very different to that of the dentine the risk of root fracture is increased. The use of fibre-reinforced resin posts has become more popular in an attempt to overcome this problem (Stewardson 2001).

Although prior to post removal all patients were warned regarding the possibility of a fractured root, this was only noted following removal of the post in one case and it is not possible to say whether the fracture occurred prior to, or during, post removal. However, when removing the fractured post, further dentine tends to be removed around the post and therefore the likelihood of a later root fracture is increased (Castrisos & Abbott 2002).

Radiographic study

The general dental practitioners or the dental hospital, prior to the removal of the fractured posts, radiographed all teeth. In all, 79% of the radiographs were available for later analysis, the remainder had been returned to the practitioners prior to copying and were thus unavailable. With regard to standardization of the radiographs there are several limitations. The radiographs were taken with a range of machines and by a variety of clinicians with different techniques. All the radiographs within the dental hospital were

taken by the paralleling technique using a film holder and any radiographs that were sent with the patient that were not clinically acceptable were retaken.

The average position of fracture was noted from radiographs to be 2.83 mm below the cervical margin. This latter measurement is in agreement with common clinical observation. It could be speculated that this is related to the depth at which any anti-rotation groove terminates and that this may then act as a site of stress concentration predisposing the post to fracture. Another possible explanation may be that this is the site where the coronal flare of the canal is not fully filled by the core material allowing flexure of the post that is well supported more apically, especially where a matched post reamer system is used. However, further study, outside the remit of the current investigation, is required to test these hypotheses.

The measurement of diameter of the posts at the fracture site was undertaken using the preoperative radiograph. It was decided to measure these rather than the retrieved posts because during the removal process the diameter of the post was commonly reduced by the use of diamond burs, ultrasonic instrumentation or the Masserann trephines. The mean diameter was noted to be 1.2 mm, which is close to that of a red Parapost (1.25 mm). This, slightly narrow, post diameter may be have been used because the predominant tooth was the maxillary lateral incisor and this tooth has a relatively small root size. Shillingburg & Kessler (1982) have recommended a dowel diameter of 1.3 mm when using a post in the restoration of this tooth.

The most commonly used post design was the parallel serrated post. A red Parapost has 1.25 mm as its greatest diameter but the posts were observed to fracture between 'threads' where the diameter is slightly smaller. The serrations may actually act as stress concentrators leading to fracture through the narrower part of the post. Although it would appear that general guidelines were followed in post selection, post diameter is an important parameter of post strength and the narrowness of these posts may have been a factor in their fracture.

A further factor that may have influenced the fracture of the cast posts is the possibility of casting defects in the form of internal or external porosity. This can occur if the sprue is insufficient in size or the alloy or mould temperatures are too extreme causing rapid solidification. Evidence in the literature to show any connection between post fracture and casting porosities is lacking. However, Gapido *et al.* (2003), investigating the fatigue resistance of cast occlusal denture rests, noted that earlier failures had casting effects visible under SEM. Further work by the authors involving scanning electron microscopy of the fractured posts is being undertaken.

The majority of radiographs examined (94%) demonstrated the presence of a root filling however, somewhat disturbingly, 67% also showed evidence of apical lesions. This contrasts with observations of apical lesions in post crowned teeth of 47% (Grieve & McAndrew 1993), 41% (Eckerbom *et al.* 1991) and 55% (Turner 1982). The prevalence of apical lesions in the current study may have been due to the fracture of the post with subsequent loss of coronal seal and reinfection from this route. Those roots with a poor apical filling were much more likely to exhibit apical lesions than those with a good apical filling. Although this does not take into account the status of the coronal seal it does seem to imply that the quality of the apical filling is still an important factor in the success of endodontic treatment (Tronstad *et al.* 2000). This also reinforces the view that a total hermetic seal of the root canal is required to prevent microleakage and subsequent endodontic failure (Iqbal *et al.* 2003). The accuracy of fit between the post end and the root filling may also have an effect on the quality of overall filling of the canal. In this study it was noted that in one third of the samples this distance was over 1 mm and therefore leaving the tooth at risk of leaving a bacterial reservoir with resultant failure of the root canal treatment.

The radiographic preoperative length and the actual length of the retrieved post were recorded. As expected, the radiographic length was slightly longer than the actual length and this is probably because the surfaces of the posts were often damaged during removal. However, there may also have been some magnification of the radiographic images due to lack of standardization of the radiographic technique. In order to assess the average total post length prior to fracture, the length from the cervical margin to the position of fracture was measured on the radiographs. By adding the two radiographic measurements together the average length of post was found to be 9.25 mm. As the average length of the root of a maxillary central or lateral incisor is 13.00 mm (Berkovitz *et al.* 1992) this length of post fulfils one of the stated guidelines (Shillingburg & Kessler 1982) that the post should be over two-thirds the length of the root. Consequently an 'adequate' length of post does not seem to be a protective factor against post fracture.

Conclusions

- Maxillary lateral incisors, followed by maxillary central incisors were at greatest risk of having a fractured post.
- Having a large number of teeth in the dentition or an adequate length of post was not protective against fracture of the metallic posts.
- 'In this extended case study fractured posts were associated with a high incidence of apical lesions.

Disclaimer

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