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Clinical evaluation of root filled teeth restored with or without post-and-core systems in a specialist practice setting

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Abstract

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Aim To assess survival rates and complications of root-filled teeth restored with or without post-and-core systems over a mean observation period of ≥4 years.

Methodology A total of 325 single- and multirooted teeth in 183 subjects treated in a private practice were root filled and restored with either a cast post-and-core or with a prefabricated titanium post and composite core. Root-filled teeth without post-retained restorations served as controls. The restored teeth served as abutments for single unit metal-ceramic or composite crowns or fixed bridges. Teeth supporting cantilever bridges, overdentures or telescopic crowns were excluded.

Results Seventeen teeth in 17 subjects were lost to follow-up (17/325: 5.2%). The mean observation period was 5.2 ± 1.8 (SD) years for restorations with titanium posts, 6.2 ± 2.0 (SD) years for cast post-and-cores and 4.4 ± 1.7 (SD) years for teeth without posts. Overall, 54% of build-ups included the incorporation of a titanium post and 26.5% the cementation of a cast post-and-core. The remaining 19.5% of the teeth were restored without intraradicular retention. The adjusted 5-year tooth survival rate amounted to 92.5% for teeth restored with titanium posts, to 97.1% for teeth restored with cast post-and-cores and to 94.3% for teeth without post restorations, respectively. The most frequent complications included root fracture (6.2%), recurrent caries (1.9%), post-treatment periradicular disease (1.6%) and loss of retention (1.3%).

Conclusion Provided that high-quality root canal treatment and restorative protocols are implemented, high survival and low complication rates of single- and multirooted root-filled teeth used as abutments for fixed restorations can be expected after a mean observation period of ≥4 years.

Keywords: post, post-and-core, restoration, root canal treatment, root filling, root fracture.

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Introduction

Loss of pulp vitality leading to root canal treatment is frequently the consequence of caries, pre-existing restorations or trauma. The loss of a considerable portion of the clinical crown hinders sufficient retention of restorations from the remaining tooth structure. Thus, in such situations, a root canal-retained restoration is advocated (Morgano & Brackett 1999). In molar teeth, the need for post-retained cores may be necessary or sufficient retention of the restoration within the dentine walls of the pulp chamber is often possible. For single-rooted teeth, however, the cast post-and-core procedure has been advocated as one of several restorative options (Landolt & Lang 1988). Additional materials such as the use of prefabricated titanium, stainless steel, zirconia and carbon- or glass-fibre reinforced posts have been recommended for the restoration of root-filled teeth (Schwartz & Robbins 2004, Cheung 2005). Several laboratory studies

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related to material and technical aspects of post-and-core restorations have been conducted. Few studies, however, have investigated the long-term survival and complication rates of clinically meaningful restorative approaches. A meta-analysis and a systematic review on the success rates of post-and-core restorations have attempted to shed some light on this issue (Creugers *et al.* 1993, Heydecke & Peters 2002). Unfortunately, no randomized controlled trials were available for analysis. It is, therefore, difficult to justify a preference for cast or direct post-and-core restorations based exclusively on laboratory experiments. *Ex vivo* and clinical findings have shown that posts do not reinforce root-filled teeth and preparation designs such as incorporation of a dentine ferrule may increase tooth fracture resistance (Sorensen & Martinoff 1984, Trope *et al.* 1985, Sorensen & Engelman 1990, Gegauff 2000, Tan *et al.* 2005). Moreover, the assumption that root-filled teeth undergo biological changes by loosing moisture content and becoming more brittle compared with teeth with a vital pulp has been disproved (Sedgley & Messer 1992, Papa *et al.* 1994).

Several luting materials, such as zinc phosphate, polycarboxylate, glass–ionomer, resin-modified glass–ionomer, compomer and resins, are used to cement posts into the root canal (Ricketts *et al.* 2005). Properties such as compressive strength, tensile strength and cement adhesion, are commonly described as predictors for success of a cemented post. Additional factors, such as potential for plastic deformation, microleakage, behaviour of the luting agent during the setting process and handling characteristics, may also influence the longevity of restorations (Ricketts *et al.* 2005).

Hence, the aim of this prospective clinical study was to compare survival rates and complications of root-filled teeth restored with different post-and-core systems after a mean observation period of ≥4 years and to compare them to root-filled teeth without post-and-core restorations.

Materials and methods

Subjects

This study was designed and conducted as a prospective evaluation of root-filled and restored teeth in 183 subjects. The root canal and restorative procedures were carried out by one specialist clinician in a private practice in the City of Berne, Switzerland. A strict protocol was followed to optimize clinical procedures for the respective materials used. The study was conducted observing the Guidelines for Clinical Research in the Declaration of Helsinki.

The subject's inclusion criteria required absence of relevant medical conditions and the completion of a comprehensive periodontal treatment with a full-mouth plaque score (FMPS) of ≤30% and a full-mouth bleeding score (FMBS) of ≤30% followed by regular attendance of a supportive periodontal therapy (SPT) programme. Subjects with untreated periodontitis were excluded. At each recall appointment, all restored abutment teeth were checked with respect to technical (i.e. loss of retention, post fracture and root fracture) and/or biological (i.e. recurrent caries, recurrent periodontitis and post-treatment periradicular disease) complications.

Endodontic and restorative treatment procedures

Root canal treatment or retreatment with routine rubber dam (Ivory®; Heraeus Kulzer GmbH, Hanau, Germany) application and standardized chemical (i.e. multiple irrigations with 0.5% NaOCl) and mechanical (i.e. FlexoFiles®, Dentsply Maillefer, Ballaigues, Switzerland) disinfection and filling technique (i.e. lateral condensation) with gutta-percha points and a root canal sealer (AH Plus™; Dentsply DeTrey GmbH, Konstanz, Germany) was carried out on all teeth. The use of an additional light source as well as magnifying loupes (3.5×) (Zeiss, Feldbach, Switzerland) or a microscope (Global Surgical™ Corporation, St Louis, MO, USA) was part of the standardized procedure. To minimize the risk of coronal bacterial leakage, the time interval between root canal treatment and post cementation was kept to a minimum (i.e. within 2 weeks). Single- and multirooted teeth were restored with either a cast gold alloy post-and-core or with a prefabricated cylindrical–conical titanium alloy post (Cytco®; Dentsply Maillefer, Ballaigues, Switzerland) adapted to the diameter and length of the root canal. Direct cast restorations were prepared by means of a prefabricated cylindrical–conical gold alloy post (Cendres & Métaux, Biel, Switzerland) and a self-curing resin pattern (Dura Lay, Reliance, Dental Mfg Co., Worth, IL, USA). All direct cast restorations were fabricated by the same dental laboratory. Between direct cast post-and-core preparation and cementation, the post space was filled with a calcium hydroxide paste (Ultra Cal™ XS™; Ultradent Products, Inc., South Jordan, UT, USA) and the access cavity was sealed with a zinc oxide eugenol provisional filling material (IRM®; Dentsply DeTrey GmbH, Konstanz, Germany). A light-curing composite

(Brilliant Esthetic Line Dentine; Coltène Whaledent, Altstätten, Switzerland) core or full crown was built up in conjunction with the Cytco® post. Enamel etching was performed with 38% phosphoric acid (Blue Etch, La Maison Dentaire SA, Balzers, Fürstentum Liechtenstein) for 60 s followed by 60 s of thorough water rinsing. Dentine was not etched with phosphoric acid. After priming of dentine for 30 s and bonding (A.R.T. Bond; Coltène Whaledent, Altstätten, Switzerland), incremental composite layers were light cured (Translux® CL; Heraeus Kulzer, GmbH, Hanau, Germany) for 40 s each until completion of the build-up. During post space preparation, care was taken to leave ≥3 mm of filling material apically. In all cases, the post length was equal or longer than that of the crown. Direct cast post-and-core preparation included an anti-rotation cavity. The prefabricated titanium post had mechanical retention (i.e. threads) in the cylindrical part and displayed a retaining head resting on a circular dentine shoulder. The access cavity and root canal were cleaned thoroughly by means of a rotating brush (Curaden, Kriens, Switzerland) and a chelating solution (Tubulicid®, Dental Therapeutics AB, Saltsjö-Boo, Sweden), rinsed with 70% ethanol and dried with sterile paper points before post cementation. Cementation was performed under aseptic conditions with a glass–ionomer luting agent (Ketac® Cem, 3M ESPE AG, Seefeld, Germany). A thin layer of cement was applied into the root canal by means of a lentulo spiral (Dentsply Maillefer, Ballaigues, Switzerland) and on the post before insertion. A circular band of dentine coronal to the crown margin (i.e. a dentine ferrule) was incorporated in the preparation of abutment teeth. All restored teeth served as abutments for either a single-unit metal-ceramic crown, a fixed bridge or a direct composite crown. No post was used for tooth restoration provided that at least 2/3 of the remaining height of the clinical crown were still available. Direct cast post-and-cores were used to restore incisors and canines whereas prefabricated titanium posts were used in maxillary and mandibular molars.

A minimum observation period of ≥2 years was required for all abutment teeth to be included in the analysis. To provide a homogeneous group of teeth with respect to restorative procedures, root-filled abutment teeth incorporated in removable partial dentures (RPDs) with ball anchors or bar retention, in telescopic crowns or in bridges with cantilever(s) were excluded.

Statistical analysis

The tooth was regarded as the statistical unit. Descriptive statistics are presented as mean ± standard deviations (SD) and ranges with interval. The chi-square test was applied to detect statistically significant differences between groups. The level of statistical significance was set at $\alpha = 0.05$.

Results

Over the entire observation period, 17 out of 325 teeth (i.e. 5.2%) in 17 subjects were lost to follow-up. The reasons for drop-out were change of dental practice (six), relocation (five), death of patient (four), unavailability at follow-up (one) and tooth extraction (one) in one subject requesting extraction of all root-filled teeth.

As shown in Table 1, 166 teeth (54%) were restored with a prefabricated titanium post and either a composite core and metal-ceramic crown or a direct composite crown, 82 (26.5%) with a cast post-and-core and 60 teeth (19.5%) were restored without intraradicular retention and either a metal-ceramic crown or a direct composite crown. Out of 166 teeth restored with a prefabricated titanium post, 93 included direct composite crowns whereas the remaining 73 served as abutment teeth for single-unit crowns or bridges. The mean observation period was 5.2 ± 1.8 (SD) years for build-ups with prefabricated titanium posts (range 2.1–10.0 years), 6.2 ± 2.0 (SD) years for cast post-and-cores (range 2.9–11.5 years) and 4.4 ± 1.7 (SD) years for teeth without a post (range 2.2–9.4 years).

The frequency distribution of post-and-core build-ups with respect to tooth type is summarized in Table 2. The majority of teeth (i.e. 88.5%) restored with a prefabricated titanium post and composite included maxillary and mandibular molars. No incisors and

Table 1 Mean observation period ± standard deviation (SD) and range of single- and multirooted root filled teeth restored with either a cylindrical–conical prefabricated titanium alloy post (Cytco®; Maillefer, Baillagues, Switzerland), a cast post-and-core or without post

	Prefabricated titanium post	Cast post-and-core	No post	All abutment teeth
n (%)	166 (54)	82 (26.5)	60 (19.5)	308 (100)
Mean ± SD (years)	5.2 ± 1.8	6.2 ± 2.0	4.4 + 1.7	5.3 + 1.9
Range (years)	2.1–10.0	2.9–11.5	2.2–9.4	2.1–11.5

canines were restored using prefabricated titanium posts. On the other hand, 89% of teeth restored with a cast post-and-core included incisors, canines and premolars. Restorations without the use of a post were distributed equally amongst incisors, premolars and maxillary and mandibular molars.

As shown in Table 3, 274 restored teeth (89%) remained free of any biological and/or technical complications over the observation period, 4.8% were affected by technical and/or biological complications and 6.2% of abutment teeth were lost. The overall survival rate of root-filled and restored single- and multirooted teeth amounted to 93.8% (289/308). No statistically significant difference ($P > 0.05$) was observed comparing the survival rate (93.5%) of teeth restored with the use of intraradicular retention (i.e. prefabricated titanium post or cast post-and-core) with that of teeth restored without the use of a post (95%).

Table 4 shows the frequency distribution of presence/absence of biological and/or technical complications as well as abutment tooth loss with respect to tooth type. No statistically significant differences ($P > 0.05$) were observed amongst tooth types. Abutment tooth loss occurred at the highest rate in mandibular molars (3.6%).

The frequency distribution of presence/absence of biological and/or technical complications as well as abutment tooth loss with respect to type of prosthetic restoration is summarized in Table 5. No statistically significant difference ($P > 0.05$) was observed when comparing the survival rate of teeth restored with single-unit metal-ceramic crowns (93.7%) to that of teeth restored with direct composite crowns (93.2%).

Table 6 illustrates the incidence of biological and technical complications occurring on abutment teeth restored with or without the use of a post. Root perforations were not observed and, therefore, are not reported. Post-treatment periradicular disease with 1.6% and recurrent caries with 1.9% were recorded as biological complications. With respect to technical

Table 2 Frequency distribution of restorations with prefabricated titanium post, post-and-core and without post according to tooth type

	Incisors	Canines	Premolars	Maxillary molars	Mandibular molars	Total
Prefabricated titanium post	0 (0)	0 (0)	19 (6.2)	75 (24.4)	72 (23.4)	166 (54)
Cast post-and-core	19 (6.2)	7 (2.2)	47 (15.2)	5 (1.6)	4 (1.3)	82 (26.5)
No post	21 (6.8)	1 (0.3)	15 (4.9)	13 (4.2)	10 (3.3)	60 (19.5)
Total	40 (13)	8 (2.5)	81 (26.3)	93 (30.2)	86 (28)	308 (100)

Values in parenthesis are percentages.

Table 3 Frequency distribution of abutment teeth without any complications, with technical and/or biological complications and abutment tooth loss according to post type

	Abutment teeth without any complications	Abutment teeth with technical and/or biological complications	Abutment tooth loss	Total
Prefabricated titanium post	147 (47.8)	6 (2)	13 (4.2)	166 (54)
Cast post-and-core	74 (24)	5 (1.6)	3 (1)	82 (26.5)
No post	53 (17)	4 (1.3)	3 (1)	60 (19.5)
Total	274 (89)	15 (4.8)	19 (6.2)	308 (100)

Values in parenthesis are percentages.

Table 4 Frequency distribution of abutment teeth without any complications, with technical and/or biological complications and abutment tooth loss according to tooth type

	Abutment teeth without any complications	Abutment teeth with technical and/or biological complications	Abutment tooth loss	Total
Incisors	38 (12.4)	2 (0.6)	0 (0)	40 (13)
Canines	7 (2.2)	1 (0.3)	0 (0)	8 (2.5)
Premolars	72 (23.4)	4 (1.3)	5 (1.6)	81 (26.3)
Maxillary molars	87 (28.2)	3 (1)	3 (1)	93 (30.2)
Mandibular molars	70 (22.8)	5 (1.6)	11 (3.6)	86 (28)
Total	274 (89)	15 (4.8)	19 (6.2)	308 (100)

Values in parenthesis are percentages.

Table 5 Frequency distribution of abutment teeth without any complications, with technical and/or biological complications and abutment tooth loss according to type of prosthetic reconstruction

	Abutment teeth without any complications	Abutment teeth with technical and/or biological complications	Abutment tooth loss	Total
FPD with ≥1 abutment tooth with titanium post or post-and-core	11 (3.6)	1 (0.3)	1 (0.3)	13 (4.2)
3-unit FPD	24 (7.8)	0 (0)	1 (0.3)	25 (8.1)
≥4-unit FPD	10 (3.3)	0 (0)	0 (0)	10 (3.3)
Single unit metal- ceramic crown	96 (31.1)	9 (2.9)	7 (2.3)	112 (36.3)
Direct composite crown	133 (43.2)	5 (1.6)	10 (3.3)	148 (48.1)
Total	274 (89)	15 (4.8)	19 (6.2)	308 (100)

FPD = fixed partial denture. Values in parenthesis are percentages.

Table 6 Frequency distribution of abutment teeth without any complications and with biological (i.e. endodontic failure and recurrent decay) and technical (i.e. loss of retention and root fracture) complications according to type of post used

	Abutment teeth without any complications	Endodontic failure	Recurrent decay	Loss of retention	Root fracture	Total
Prefabricated titanium post	147 (47.8)	2 (0.6)	4 (1.3)	0 (0)	13 (4.2)	166 (54)
Cast post-and-core	74 (24)	1 (0.3)	0 (0)	4 (1.3)	3 (1)	82 (26.5)
No post	53 (17.2)	2 (0.6)	2 (0.6)	0 (0)	3 (1)	60 (19.5)
Total	274 (89)	5 (1.6)	6 (1.9)	4 (1.3)	19 (6.2)	308 (100)

Values in parenthesis are percentages.

complications, loss of retention occurred in 1.3% and root fracture in 6.2% of abutment teeth, respectively. Out of the 13 mandibular molars restored with a post, 11 (84.6%) presented with a fracture of the mesial root without post.

Discussion

The present prospective clinical study compared cast post-and-core restorations with prefabricated post-and-core and post-free restorations. The findings showed that adherence to strict and standardized endodontic and restorative protocols yielded high survival and low complication rates of single- and multirooted root-filled teeth used as abutments for fixed reconstructions after a mean observation period of ≥4 years.

The findings of the present study compare favourably with several recent reports (Ellner *et al.* 2003, Creugers *et al.* 2005a,b).

Complete adherence to the standardized clinical protocols and lack of operator variability were maintained throughout the study because all endodontic and restorative procedures were performed by the same specialist clinician. Optimal aseptic conditions including the routine use of rubber dam, thorough chemomechanical disinfection and provisional restorations of short duration were routinely applied during root canal treatment. Hence, the risk of bacterial coronal leakage between root canal treatment and final restoration was minimized. Moreover, emphasis was placed on a dense filling technique (i.e. lateral condensation) and maintenance of a ≥3 mm length of apical gutta-percha after post space preparation (Goodacre & Spolnik 1995). In this context, crowned teeth with high-quality root filling and an optimal morphology of the post-and-core were shown to have a similar survival rate as crowned teeth with a vital pulp over an observation period of 25 years (Valderhaug *et al.* 1997). In this study, however, deterioration of the periapical status of root-filled teeth could not be related to the density, the apical location or the length of remaining filling material (Valderhaug *et al.* 1997). How much root filling material should remain apically to the post (3–5 mm) is still a matter of debate (Goodacre & Spolnik 1995). Nevertheless, the high-quality standards of root filling provided in the present study yielded a rate of post-treatment periradicular lesions of 1.6% after a mean observation period of ≥4 years. Furthermore, it should be pointed out that additional care was taken to avoid a void between the apical end of the post and the gutta-percha. The presence of such a void has been shown to be associated with an increased incidence of post-treatment periradicular disease in teeth restored with a post-and-core (Moshonov *et al.* 2005).

An aseptic technique was strictly maintained during post space preparation and cementation (Wu

et al. 1998). It may be speculated that the consistent preparation of an anti-rotation cavity for cast post-and-cores or a circular dentine shoulder for the retaining head of the prefabricated titanium post may have reduced the transmission of vertical forces to the root thereby minimizing the risk of root fracture. Furthermore, the tapered effect of the apical portion of the prefabricated titanium and gold alloy posts allowed adaptation to the root canal anatomy thereby reducing the risk of perforations (Landolt & Lang 1988). In fact, no root perforations were observed in the present study. However, 11 out of 13 (84.6%) mandibular molar teeth restored with a prefabricated titanium post and extracted because of root fracture, presented with a fracture of the mesial root without the post. It cannot be excluded that, despite the use of magnifying loupes or a microscope and an additional light source, incomplete root fractures were already present, but remained undetected at the time of root canal treatment. In this context, it should be noted that laboratory studies investigating fracture resistance of root-filled teeth are usually performed on intact or minimally compromised teeth and do not account for the presence of an incomplete tooth fracture.

In the present study, remaining dentine coronal to the crown margin was routinely incorporated in the preparation of the abutment tooth. This type of preparation, also known as a ferrule, has been shown to substantially increase fracture resistance of root-filled teeth *ex vivo* (Sorensen & Engelman 1990, Gegauff 2000, Tan *et al.* 2005). Although the remaining thickness and height of the dentine walls were not recorded in millimetres, it may be assumed that the presence of a dentine ferrule of variable dimensions contributed to the low incidence (6.2%) of abutment tooth fractures observed in the present study over a mean observation period of ≥4 years. Clinical findings corroborating the importance of a dentine ferrule have been published by several research groups (Torbjörner *et al.* 1995, Ellner *et al.* 2003, Creugers *et al.* 2005b). A 5-year prospective study evaluated the effect of remaining circular dentine walls on various types of core restorations (Creugers *et al.* 2005b). The findings of that study showed that, independently of the type of post-and-core used, a substantial amount of remaining dentine height after preparation positively influenced the survival rate of the restorations (Creugers *et al.* 2005b).

In the present study, no post was used for tooth restoration provided that at least two-thirds of the remaining height of the clinical crown were still available. Direct cast post-and-cores were exclusively used for the restoration of incisors and canines whereas maxillary and mandibular molars were predominantly restored by means of a prefabricated titanium post. Moreover, restoration of a root-filled tooth with a single unit full crown was often not considered because of financial limits and a direct composite crown was built up.

Findings from a recent *ex vivo* investigation showed that root-filled maxillary premolars restored with direct composite crowns without the use of a post yielded similar fracture resistance compared with that with the use of metal or glass fibre posts (Fokkinga *et al.* 2005). Based on the hypothesis that posts are not necessarily required to restore root-filled teeth, a prospective 5-year clinical trial on the survival rate of direct composite crowns with or without the use of a post was conducted (Creugers *et al.* 2005a). The findings of that trial showed that anterior and posterior teeth restored with post-free direct composite crowns yielded a 100% survival rate, whereas a survival rate of 96% was observed for comparable restorations with a post (Creugers *et al.* 2005a). Fractures were the reason of abutment tooth loss. Similar survival rates over a comparable mean observation period of ≥4 years were observed in the present study for teeth restored with the use of a post (i.e. 92–96%) and without a post (i.e. 95%), respectively.

Conclusion

Implementation of high-quality endodontic and restorative protocols as well as regular attendance of a maintenance care programme yielded high survival and low complication rates of single- and multirooted root-filled teeth used as abutments for fixed reconstructions over a mean observation period of ≥4 years. Furthermore, building up the clinical crown with the use of a precision titanium anchor system yielded similarly favourable results than using cast post-and-core alloy build-ups. Finally, high survival and low complication rates were identified in root-filled and built up teeth when compared with such teeth without build-ups.

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