5-Year Follow-up of a Prospective Clinical Study on Various Types of Core Restorations

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Purpose: This study tested whether: *(1)* the survival rate of cast post-and-core restorations is better than the survival of direct post-and-core restorations and post-free all-composite cores; and *(2)* the survival of these buildup restorations is influenced by the remaining dentin height after preparation. ***Materials and Methods:*** In a clinical trial, 18 operators made 319 core restorations in 249 patients. The restorations involved were: *(1)* cast post-and-core restorations; *(2)* direct post and composite core restorations; and *(3)* post-free all-composite cores. All restorations were made under single porcelain-fused-to-metal crowns. Treatments were allocated after dentin height assessment using balanced drawing. Failures were registered during a 5-year period. ***Results:*** Fifteen restorations failed during the follow-up period. Five failures occurred during the first month; they were considered to be independent from clinical aging and excluded from further survival assessments. The overall survival was 96% ± 2%. No difference was found between the survivals of the different types of restorations. The factor "remaining dentin height" appeared to have a significant effect on the survival of post-and-core restorations (98% ± 2% survival for "substantial dentin height" vs 93% ± 3% for "minimal dentin height"). ***Conclusion:*** The type of post and core was not relevant with respect to survival. The amount of remaining dentin height after preparation influenced the longevity of a post-and-core restoration. *Int J Prosthodont 2005;18:34–39.*

The traditional and most accepted method to restore a structurally compromised tooth that is endodontically treated is to construct a cast post-and-core restoration that may act as a foundation for a covering artificial crown. Amalgam cores also serve as buildup restorations for premolars and molars; however, this restoration has always been considered a second choice. Since the early 1970s, the application of resin composite in combination with prefabricated posts has been considered an alternative.[1,2] This direct method of fabrication of the restoration has since been described extensively in the dental literature.[3] Initially, the prefabricated posts were made from gold-plated brass or stainless steel; later, titanium alloys became popular, and today ceramic and fiber-reinforced materials are used. Direct post-and-core systems offer clinicians the possibility to use posts without the necessity to remove tooth material for elimination of undercuts in the pulp chamber. Operative procedures are biologically friendly (tooth material can be saved), and they save chair time. The direct post-and-core restoration reduces costs to the patient while providing satisfactory results.[4]

Post-and-core restorations have been made to strengthen weakened teeth. Today, textbooks still promote the post-and-core restoration as a preventive

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Table 1 Details of Investigated Restorations

Restoration	Specifications	No.	No. per trial*
Cast post and core	Post: Cendres et Métaux prefabricated cast-on post Core: palladium alloy	127	Trial S: 69 Trial M: 58
Direct post and core	Post: Radix or RS prefabricated post (Maillefer) Core: Clearfil Core resin composite (Kuraray)	150	Trial S: 90 Trial M: 60
Post-free all-composite core	Post: none Core: Clearfil Core resin composite	42	Trial S: 42

*Trial S = comparing cast posts and cores, direct posts and cores, and all-composite cores under the condition "substantial dentin height"; trial M = comparing only cast and direct posts and cores under the condition "minimal dentin height."

measure against fracture of endodontically treated teeth, and many clinicians follow this as a rule.[5] However, in vitro studies demonstrate that post space preparation weakens the root of a tooth and does not reinforce endodontically treated teeth.[4,6–9] Together with the experiences of many clinicians that failures of post-and-core restorations are frequently dramatic, often leaving extraction as the only option, this has led to the opinion that posts are not always necessary to support the core. Apart from the post space preparation, the amount of remaining coronal tooth structure seems to be of importance for the performance of the post-and-core restoration.[10–16]

Although the matters above are the subject of many investigations, there is still no consensus on the treatment of preference. A recently published review comparing cast and direct post-and-core restorations for single-rooted teeth could not show which system provides the best clinical service.[17] This is due to the enormous variety in experimental designs used in scientific studies and to a lack of comparative clinical studies.[18,19]

The present clinical study aimed to compare some of the factors thought to be of relevance in the survival of buildup restorations. It included indirect (cast) and direct post-and-core restorations, as well as post-free restorations. Besides these post-and-core systems, the effect of the remaining tooth structure on the survival of these restorations was studied. The hypotheses tested in this study were: *(1)* there is no difference between the 5-year survival of indirect (cast), direct post, and post-free core restorations; and *(2)* the remaining dentin height after preparation does not influence the functional survival of these restorations.

Materials and Methods

Study Design and Sample

This study was a combination of two randomized clinical trials in which the clinical behavior of direct post-and-core restorations with covering crowns was the central theme. The study was organized as a multipractice clinical trial. Some of the restorations were made in the clinic of the College of Dental Sciences of the University Medical Centre Nijmegen, The Netherlands, and some were made in 17 general practices in the Nijmegen area. Consequently, the team of operators was established by 17 general practitioners on one hand and the principal investigator on the other hand. All operators were instructed to adhere strictly to the protocols. Operative procedures were taught in special courses including both theoretic and practical instructions, and restorative protocols were provided with the materials to be used. The study protocol was screened and approved on its ethical acceptability by the Committee on Experimental Research on Man of the University of Nijmegen.

A strict selection guide was provided to the operators to aid the selection of patients from the populations in their clinics. It was aimed to select patients who had one or more endodontically treated teeth that were in need of treatment with single crowns. The teeth had to be in good periodontal condition (no pockets deeper than 4 mm; physiologic mobility) and should have antagonistic contact with either natural teeth or a partial denture. During the intake period, which was fixed at 2 years, 249 patients (97 males, 152 females, aged 17 to 71 years) were included. Before entering the study, patients were informed about the study protocol, and those who agreed signed an informed consent form. The 177 patients selected in the practices received 213 restorations; the 72 patients from the university dental clinic received 106 restorations.

Restorations

Three types of restorations were under investigation: *(1)* cast post-and-core restorations; *(2)* direct metal post and resin composite core restorations; and *(3)* post-free all-composite core restorations. The materials for the posts and cores are described in Table 1. The metal alloys for the crowns were not prescribed in the treatment

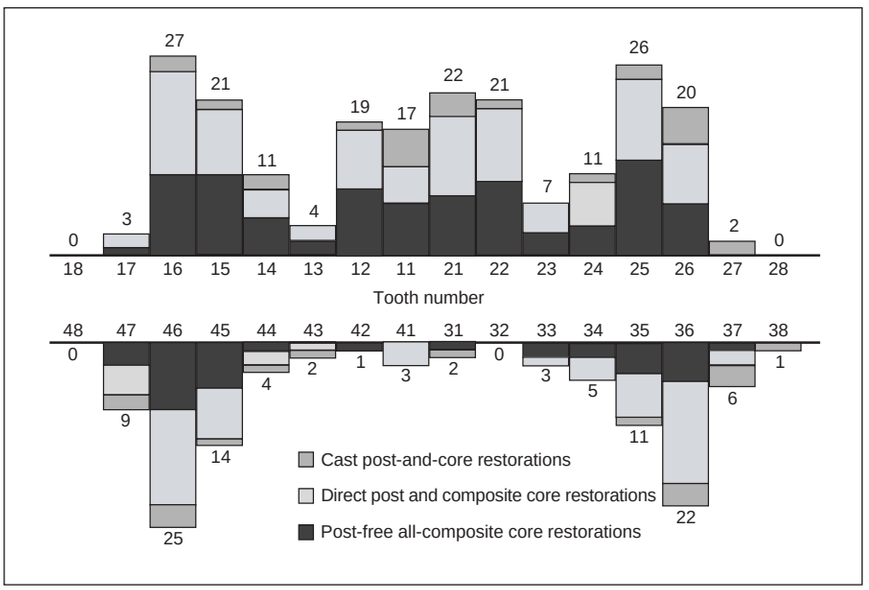

Fig 1 Distribution of restorations according to tooth number (Fédération Dentaire Internationale system).

protocol, nor was the porcelain. The cement to be used could be either zinc phosphate or glass-ionomer, depending on the preference of the operator. The composite core material was bonded to the tooth material with conventional enamel bonding. Laboratory procedures were carried out following the manufacturers' instructions. All cast restorations were made by one dental laboratory.

Treatment Allocation and Experimental Comparisons

Before randomization, the recipient tooth was categorized according to expected dentin height after tooth preparation. A tooth was assessed to have one of two expected dentin height levels:

1. "Substantial dentin height": $>$ 75% of circumferential dentin wall of minimum 1-mm thickness has at least a height of 1 mm above gingival level; less than 25% of the circumference has less than 1 mm above the gingiva, but a collar of 1 to 2 mm could be achieved.
2. "Minimal dentin height": $<$ 75% of circumferential dentin wall has at least 1 mm above gingival level; more than 25% of the circumference has less than 1 mm above the gingiva, or no collar of 1 to 2 mm could be achieved.

This criterion was in fact a prediction for the remaining dentin height after preparation, made by the operator. To check for the operators' prediction of the remaining dentin height, additional impressions were made after the preparations were completed. The principal investigator assessed the dentin heights of the remaining tooth structures in the casts. Comparison with the operators' clinical assessments showed 100% agreement.

As a result, 201 teeth were assigned to trial S (comparing cast posts and cores, direct posts and cores, and all-composite cores under the condition "substantial dentin height"), and 118 teeth were assigned to trial M (comparing only cast and direct posts and cores under the condition "minimal dentin height"). Within each trial, the type of restoration to be made was assigned by balanced drawing (Table 1). Balancing criteria were patient age and gender, antagonistic teeth (natural or artificial), and the presence of teeth adjacent to the tooth included in the study. Sixty-six percent (n = 211) of the restorations were made in the maxilla, and 34% (n = 108) were in the mandible (Fig 1). Most restorations were made in premolars and molars.

Evaluation and Statistics

All patients were regular attendees of the local clinics and were reviewed approximately every 6 months. The patients were instructed to visit their dentists or contact the principal investigator if they had or suspected a problem with the restored teeth. The operators were instructed to contact the principal investigator the moment problems or failures occurred. Failures were categorized as: A = dislodgment of the

Table 2 Details of Failed Restorations

Failure	Lifetime (y)	Tooth*	Type of buildup restoration	Failure characteristic†	Trial‡
1	0.01	21	Cast post and core	E	S
2	0.01	11	Post-free composite core	E	S
3	0.02	41	Direct post and core	E	S
4	0.02	31	Cast post and core	E	S
5	0.08	45	Direct post and core	E	M
6	0.83	26	Cast post and core	E	S
7	1.49	22	Direct post and core	B	M
8	2.03	25	Cast post and core	A	M
9	2.07	13	Cast post and core	A	M
10	2.17	46	Post-free composite core	F	S
11	2.59	15	Direct post and core	B	M
12	3.13	25	Direct post and core	B	M
13	3.95	23	Cast post and core	B	M
14	4.15	14	Cast post and core	E	S
15	4.72	47	Direct post and core	F	M

*Fédération Dentaire Internationale tooth-numbering system.
†A = dislodgment; B = dislodgment, with loss of remaining tooth material; E = root fracture; F = tooth loss. Categories C (core fracture) and D (post fracture) were not observed.
‡Trial S = comparing cast posts and cores, direct posts and cores, and all-composite cores under the condition "substantial dentin height"; trial M = comparing only cast and direct posts and cores under the condition "minimal dentin height."

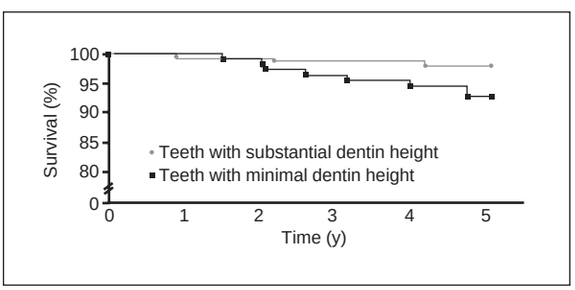

Fig 2 Survival of restorations made on teeth with "substantial dentin height" (n = 197) and "minimal dentin height" (n = 117); early failures excluded.

restoration; B = dislodgment, with loss of tooth material; C = core fracture; D = post fracture; E = root fracture; or F = tooth loss (for unspecified reasons).

A patient was recorded as "lost to follow-up" if they were not seen by any of the operators for a period longer than 1 year before the date set for this analysis. Reasons to discontinue the study were extraction of the tooth (following root fracture), or failure resulting in replacement of the restoration.

To audit the collected data, the principal investigator visited 12 randomly selected practices and checked the restorations by using the patient records. At the end of the evaluation period, the principal investigator evaluated 50 randomly selected patients clinically and compared the findings with the data received from the operators. The data appeared to be reliable, and no further checks were required. The minimum follow-up period was 5 years.

Life tables were constructed, and log-rank and Wilcoxon tests were used to test the variables "remaining dentin height" and "type of restoration" for their influence on restoration longevity, with a cutoff value of $P = .05$.

Results

Fifteen restorations failed during the 5-year study (Table 2). Five failures (33% of all failures) occurred within 1 month after insertion. These failures were "early" failures and were related either to problems during the clinical procedures or misjudgments by the operators on the suitability of the teeth to receive the restorations. These early failures included different types of restorations, all were root fractures, and all originated from two operators. Although true failures, they were independent of clinical aging and fatigue processes. Therefore, they were excluded from further survival assessments.

In this manner, 10 failures in 314 restorations (3%) were observed. No statistical differences were found between the survivals of the three types of restorations (early failures excluded). The restorations survived better in teeth with substantial dentin height (98% ± 2%) than in teeth with minimal dentin height (93% ± 3%) (Fig 2; log-rank and Wilcoxon tests $P = .04$).

Failure mode analysis revealed six dislodged restorations (Table 2), of which four showed additional loss of remaining tooth tissue; seven root fractures, of which

Table 3 Reported Success in Clinical Studies on Different Types of Post-and-Core Restorations

Study	Follow-up (y)	No. of patients	Post type(s)	No. of posts	Posts in anterior teeth (%)	Success (%)
Ellner et al[20]	10	31	Indirect cast	27	63	100
			Direct prefabricated	23	52	92
Kerschbaum and Imm[21]	5	199	Indirect cast	245	69	88
Bergman et al[22]	6	53	Indirect cast	96	41	91
Mentink et al[23]	4.8	283	Indirect cast	516	40	92
Torbjörner et al[24]	> 6	638	Indirect cast	456	± 35*	85
			Direct prefabricated	332		92
Fredriksson et al[25]	2.7	236	Carbon fiber	236	23	100

*Estimated for both groups.

five were early failures; and two extractions for unspecified reasons. Of the failed restorations included in the survival analysis, four were made at the university clinic and six were from the general practitioners.

Discussion

The present study compared indirect cast post-and-core restorations with direct post-and-core and post-free buildup restorations. To our knowledge, this is the second prospective clinical study in which different techniques were compared. A relatively recent report covers 10 years of follow-up but includes only 50 restorations.[20] Although the follow-up period was limited, the present study provided useful information because of the high number of restorations.

By using a mixed design regarding the research location, this study aimed to combine the advantages of the general dental practice in terms of external validity and those of the university clinic in terms of internal validity. First, the involved general practices provide a strong indication that the results can be inferred to daily (dental) life, which can be stronger than results from a study performed in a purely academic setting. Second, adherence to the protocols may be most secured by the involvement of the academic clinic. This internal validity is not warranted in general practice because of uncontrollable external influences such as time pressure. Daily monitoring, therefore, is almost impossible.

From post hoc evaluation, two shortcomings of the treatment allocation procedure appeared. First, noncompliance of operators was prevalent for 23 restorations. Those restorations were assigned to be post-free core restorations but turned out to include posts. The reason for this noncompliance might be an apparent lack of confidence of some of the operators with regard to post-free core restorations and the unwillingness to bear risk, including the financial implications, for failures in these cases. The effect is overestimation of the survival of the post-free core restorations (98%) because "high-risk teeth" (according to the operators' opinions) are underrepresented in this group. Direct comparison between core restorations with and without posts is thus biased and therefore not allowed.

Second, there is a lack of insight into the patient selection procedure of each operator. Although the operators were provided with a strict selection guide, it is unknown how many patients were not included. While the reasons for excluding are not known, it is difficult to make investigations into this item. It is possible that operators excluded high-risk patients (as judged by themselves) in an attempt to produce "good" results or results that might verify their own ideas about the quality of (post and) core restorations.

The overall survival found in the present study is within the range reported in the dental literature (Table 3).[20–25] The number of failures was too small to allow statistical analyses with respect to failure characteristics or influence of tooth type and other experimental variables. However, the consequences of the failures could be assessed and resembled previously reported results.[9,26,27] Apart from biologic variations such as tooth and root size differences, the failures in the present study may also be related to inadequate clinical handling in preparing the roots and inserting the posts. This is substantiated by the observations that all of these cases were seen in core restorations with posts and that five failures were early failures.

Post-and-core restorations made on teeth with substantial dentin height performed significantly better than those on teeth with less remaining tooth structure. It is unlikely that the allocation shifts described above have confounded this finding, as the allocation shifts were seen only in trial S. Therefore, this finding stresses the importance of the so-called "ferrule rule." The ferrule is the clinical guideline to provide an extension of at least 1.5 to 2 mm of the definitive cast restoration apical to the junction of the core and remaining tooth structure.[28] To our knowledge, this guideline has never been confirmed in a clinical experimental setup before. The current study revealed that the remaining dentin

height seems to be of more importance than the design of the core restoration.

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