Effect of Post Placement on the Restoration of Endodontically Treated Teeth: A Systematic Review

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Purpose: The aim of this study was to assess the effect of root canal post placement on the restoration of endodontically treated teeth. ***Materials and Methods:*** PubMed, the Cochrane Central Register of Controlled Trials (CENTRAL), Scopus, and two Chinese databases (China National Knowledge Internet and the Wan-fang database) were searched to identify randomized or quasi-randomized clinical trials related to post-and-core systems for the restoration of endodontically treated teeth. Studies published prior to August 2013, performed on humans, and written in English or Chinese were considered for inclusion. Two of the authors independently extracted data and assessed the quality of the selected studies. ***Results:*** Three studies involving 317 participants were included in the review. Meta-analysis revealed that the risk of overall failure was greater with nonpost (104/271) than with post (78/377) restorations, irrespective of the number of remaining coronal walls (risk ratio [RR] = 0.41; 95% confidence interval [CI], 0.23 to 0.74). The risk of catastrophic failure was greater with nonpost (24/227) than with post (4/329) restorations, irrespective of the remaining coronal walls in restored teeth (RR = 0.11; 95% CI, 0.04 to 0.31). When three or four coronal walls remained, no catastrophic failure occurred in either the post group or the nonpost group. The difference in noncatastrophic failure between the two groups had no statistical significance no matter how many coronal walls remained ($P > .05$). ***Conclusions:*** Post placement appears to have a significant influence on reducing the catastrophic failure rate of endodontically treated teeth. When three or four coronal walls remain, post placement seems to have no influence on the restoration of endodontically treated teeth. *Int J Prosthodont 2015;28:475–483. doi: 10.11607/ijp.4120*

The restoration of endodontically treated teeth remains controversial in many respects, despite having been extensively studied.[1] Many factors influence the prognosis of endodontically treated teeth: periapical status, tooth position, number of adjacent teeth, occlusal contacts, remaining tooth structure, collagen degradation and intermolecular cross linking of the root dentin, type of coronal restoration, type of post (if needed), and core material used.[2]

Many studies support the hypothesis that changes in structural integrity associated with site preparation and preexisting tooth defects,[3,4] rather than physical or chemical changes in tooth tissue,[5,6] increase the incidence of fracture in teeth treated with root canal versus vital teeth. A post is usually placed to provide retention for the core in a tooth with extensive loss of coronal structure.[7] Post placement does not strengthen or reinforce the tooth; the strength of the tooth and its resistance to fracture are derived from the residual tooth structure and surrounding alveolar bone.[8] The placement of a post may increase the incidence of root fracture, especially in the case of an oversized root canal.[1,9]

In vitro studies that have evaluated the effects of post placement on the fracture strength of root-filled teeth have reported different results. For example, some[10,11] have reported that the amount of remaining tooth structure has a significant effect on the fracture strength of nonvital teeth, and post placement has no significant effect, whereas others[12,13] have

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Table 1 PubMed Search Strategy

Search term	Results
pulpless tooth	1569
pulpless teeth	1633
root filled tooth	1308
root filled teeth	1923
endodontically treated tooth	2156
endodontically treated teeth	2446
devital teeth	21
devital tooth	15
tooth nonvital	1438
1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9	4480
dowel	639
endodontic post	1054
root canal post	2425
fibre post	1628
fiber post	3777
stainless post	605
cast post	1334
post and core	9984
11 or 12 or 13 or 14 or 15 or 16 or 17 or 18	16,809
core restoration	1911
non-post	51
post free	29,153
no post	539,506
20 or 21 or 22 or 23	540,211
10 and 19 and 24	1259

Table 2 Cochrane Central Register of Controlled Trials Search Strategy

Search term	Results
pulpless tooth	8
pulpless teeth	0
root filled tooth	1
root filled teeth	18
endodontically treated tooth	4
endodontically treated teeth	72
devital teeth	2
devital tooth	0
tooth nonvital	118
1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 and post	80

found that post placement significantly increases the fracture resistance of endodontically treated teeth. In 2011, Mangold and Kern[14] conducted an in vitro study to evaluate the effect of glass-fiber post placement on the fracture resistance of endodontically treated premolars with varying degrees of tooth defect and found that the post significantly increased fracture resistance when fewer than two cavity walls were present but had no significant effect when two or three walls remained. These contradictory results may be due to the different tooth types examined in the respective studies.

Although in vitro studies provide valuable information for the prediction of clinical outcomes of restorative materials and techniques, clinical trials, especially randomized controlled trials (RCTs), produce the most reliable evidence. Different failure rates have been reported for post-retained restorations in various clinical trials.

An RCT conducted in 2011[15] evaluated 3-year outcomes of glass fiber posts and composite cores versus gold alloy-based posts and cores in the restoration of endodontically treated teeth. The success and survival probabilities for all restorations were 91.7% and 97.2%, respectively. Both cast gold and composite post and core systems performed well clinically. A previous RCT in 2008[16] assessed whether the amount of residual coronal dentin and the placement of a prefabricated or a customized fiber post had a significant influence on the 3-year survival of endodontically treated premolars. Post placement and the amount of residual coronal dentin significantly affected survival. In another clinical trial,[17] the failure rate of post-endodontic restorations after 3 years of follow-up was 6.42%.

Although a few RCTs have been conducted, definite conclusions still cannot be drawn regarding the effect of post placement on the clinical behavior of endodontically treated teeth. The purpose of this systematic review is to provide a comprehensive overview of the effect of post placement on the restoration of endodontically treated teeth.

Methods

Search Strategy

The National Library of Medicine, Washington, DC (MEDLINE–PubMed); the Cochrane Central Register of Controlled Trials; Scopus; and two Chinese databases (China National Knowledge Internet [CNKI] and the Wan-fang database) were searched for papers satisfying the inclusion criteria (Tables 1 and 2). The search strategy and search terms used in Scopus were as follows: (ALL [tooth nonvital] OR ALL [devital teeth OR devital tooth] OR ALL [root filled teeth OR root filled tooth] OR ALL [pulpless teeth OR pulpless tooth] OR ALL [endodontically treated teeth OR endodontically treated tooth] AND ALL [post AND core OR cast post OR stainless post OR fiber post OR fibre post OR root canal post OR dowel OR endodontic

post] AND ALL [no post OR post free OR non-post OR core restoration]). The keywords used for the two Chinese databases were as follows: post-and-core crown, cast post, fiber (fibre) post, root canal post, and endodontic treatment.

Eligibility Criteria

Types of studies. RCTs and quasi-RCTs with a parallel group or split-mouth design were included. The minimum duration for the studies was 6 months.

Types of participants. Participants of any age or sex who had permanent teeth that had undergone endodontic treatment were included. The selected teeth were required to be in occlusal function and symptom-free, with a minimum apical seal of 4 mm.

Types of interventions. Studies comparing post restoration (regardless of the material of the post) with nonpost restoration were included. The final coronal restoration was required to be a single full crown.

Types of outcome measures. The failure rates of post versus nonpost restorations were assessed by clinical and radiographic examinations. The following events were considered failure: post debonding, post fracture, vertical or horizontal root fracture, failure of the core portion necessitating a new coronal restoration, crown displacement, and endodontic or periradicular conditions requiring endodontic retreatment. We categorized the failures into two failure modes:

1. Catastrophic failure: root fractures or nonreparable fractures of the post/core restoration leading to tooth extraction.
2. Noncatastrophic failure: loss of post-and-core or crown retention, or reparable fractures of the restorations; the tooth can be saved with further treatment.

Study selection and data extraction. Two reviewers (Z-FZ and SH) independently screened the titles and abstracts of papers selected by the electronic search. Full-text papers identified in the first selection phase were screened for eligibility based on the inclusion criteria. Any disagreement between the two reviewers was resolved by discussion with a third reviewer. If several articles had been published regarding the same study, only the most recent was considered for inclusion. Authors were contacted for additional information if necessary.

The same two reviewers independently extracted data using a data extraction form. Any disagreement was discussed, and additional reviewers (X-YD and Lei Jin) were consulted when necessary. The following details were extracted if available:

1. Trial methods: (a) method of random sequence generation, (b) method of allocation concealment, and (c) blinding of participants or trial investigator.
2. Participants: (a) inclusion and exclusion criteria, (b) study setting, (c) sample size, (d) age, (e) sex, (f) location and type of the restored teeth, and (g) volume of residual tooth structures.
3. Intervention: (a) materials and techniques of the post and core, (b) method of the final coronal restoration, and (c) duration of follow-up.
4. Control: (a) method of coronal restoration and (b) duration of follow-up.
5. Outcomes: (a) the number of failed restorations and total randomized restorations in the intervention and control groups and (b) the number of participants lost to follow-up.

Assessment of heterogeneity. Heterogeneity was evaluated using the following factors: design of the study; characteristics of the participants such as sample size, age range, and sex; and interventions and outcomes as specified in the criteria for included studies. Statistical heterogeneity was assessed using a chi-square test, with $P < .10$ considered to be statistically significant.[18]

Quality of assessment. The risk of bias in the included trials was independently assessed by two reviewers (Z-FZ, SH) using the Cochrane Collaboration tool for assessing risk of bias as described in the *Cochrane Handbook for Systematic Reviews of Interventions*.[18] Any disagreement was resolved by discussion. The following domains were assessed as having low, high, or unclear risk of bias:

1. Random sequence generation (selection bias)
2. Allocation concealment (selection bias)
3. Blinding of outcome assessment (detection bias)
4. Incomplete outcome data (attrition bias)
5. Selective reporting (reporting bias)
6. Other bias

The final overall risk of bias for each study was classified as follows:

1. Low risk of bias (plausible bias unlikely to seriously alter the results): All domains were assessed as having low risk of bias.
2. Unclear risk of bias (plausible bias that raises some doubt about the results): One or more domains were assessed as having unclear risk of bias.
3. High risk of bias (plausible bias that seriously weakens confidence in the results): One or more domains were assessed as having high risk of bias.

Table 3 Characteristics of Included Studies*

	Bitter et al[19]	Ferrari et al[20]	Ferrari et al[21]
No. of subjects	91	345	210
Mean age (y)	58	58	54
Age range (y)	24–80	18–76	18–76
Control group (no post used)	Composite core + crown	Composite core + crown	Composite core + crown
Test group (post was used)	DT Light Post + composite core + crown	Prefabricated or customized fiber post + composite core + crown	Fiber post + composite core + crown
Study duration (mo)	32	72	24
Overall failure rate of no post group	6/44 (13.63%)	62/107 (57.94%)	36/120 (30.00%)
Overall failure rate of post group	3/48 (6.25%)	66/209 (31.58%)	9/120 (7.50%)

*Ordered by study ID.

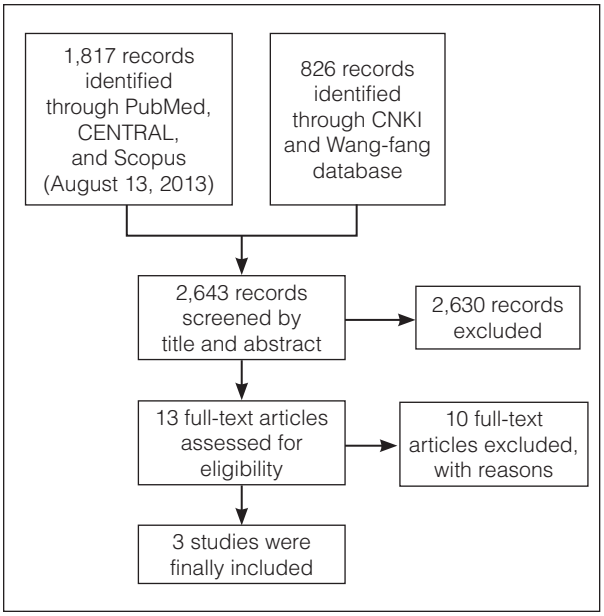

Fig 1 Study flow diagram.

Data synthesis. Meta-analyses were performed if studies were sufficiently homogenous. If heterogeneity between the studies was not significant, fixed-effects meta-analysis was used. If heterogeneity between the studies was significant, the factors causing the heterogeneity were examined, and then subgroup analyses or random-effects meta-analyses were performed. If the response was a dichotomous outcome, risk ratios (RRs) were used and the uncertainty was expressed using 95% confidence intervals (CIs).

Results

Search Results

The search yielded 2,643 records. After titles and abstracts were screened, 13 records seemed to fulfill the inclusion criteria; the full texts of these studies were evaluated. After each text was read in full, 10 articles were excluded for not fulfilling the inclusion criteria and 3 studies were finally included in our systematic review. These 3 studies proceeded to data extraction (Fig 1).

Characteristics of Included Studies

One RCT by Bitter et al in Germany[19] and two by Ferrari et al in Italy[20,21] were included. The total combined sample size of the three studies was 648. In the Ferrari studies, 556 premolars were included; these were divided into six groups based on remaining tooth structure. Within the six groups, subjects were randomly divided into two subgroups: 329 root-filled teeth in subgroup one that received a fiber post core system, and 227 endodontically treated teeth in subgroup two that did not receive any endocanal retention. The final restoration of each tooth was a single-unit metal-ceramic crown. In the Bitter et al study, 92 teeth were divided into two groups: 48 teeth in group one received fiber post core crowns, and 44 teeth in group two received core crowns only. The detailed data are listed in Table 3. Tables 4 and 5 display the catastrophic failure rate and the noncatastrophic failure rate, respectively.

Characteristics of Excluded Studies

The characteristics of the excluded studies and the reasons for exclusion are listed in Table 6.

Assessment of Quality

Allocation. The generation of randomization sequences in Ferrari et al[21] (tossing a coin) and in Bitter et al[19] (according to a random number list) was judged as having a low risk of bias. For Ferrari et al,[20] this factor was judged as having an unclear risk of bias

Table 4 Catastrophic Failure Rate of the Post Group and the Nonpost Group in the Included Studies*

Group	Ferrari et al[20]	Ferrari et al[21]
Nonpost	15/107 (14.02%)	9/120 (7.50%)
Post	4/209 (1.91%)	0/120

*Bitter et al[19] was excluded.

Table 5 Noncatastrophic Failure Rate of the Post Group and Nonpost Group in the Included Studies*

Group	Ferrari et al[20]	Ferrari et al[21]
Nonpost	47/107 (43.93%)	27/120 (22.50%)
Post	62/209 (29.67%)	9/120 (7.50%)

*Bitter et al[19] was excluded.

Table 6 Characteristics of Excluded Studies

Study	Reason for exclusion
Fokkinga et al[22]	The teeth were not covered by an artificial crown.
King et al[23]	This study reports a prospective clinical trial comparing a carbon fiber reinforced carbon endodontic post with a conventional prefabricated post.
Mannocci et al[24]	The teeth were not covered by an artificial crown.
Monticelli et al[25]	This study prospectively evaluated the clinical performance of three types of translucent posts.
Naumann et al[26]	This randomized parallel-group clinical pilot study aimed to compare the clinical outcome of prefabricated rigid titanium to glass-fiber endodontic posts.
Salvi et al[27]	The final restorations were unit metal-ceramic or composite crowns or fixed partial dentures.
Schmitter et al[28]	This randomized controlled trial was designed to assess the survival rate of two different post systems.
Sterzenbach et al[29]	This study compared glass fiber–reinforced epoxy resin posts with titanium posts.
Sun et al[30]	This study evaluated the effect of two types of post and core on the restoration of endodontically treated teeth.
Zicari et al[15]	Although the study fulfilled the inclusion criteria, some key data for the post and nonpost groups could not be obtained.

*Ordered by study ID.

because there was no description of the exact randomization method. No information was provided concerning allocation concealment in any of the three trials, so this domain was assessed as having an unclear risk of bias for all studies.

Blinding. As the interventions in this study did not permit blinding of the participants or trial investigators, none of the three studies adopted the blinding method. However, the outcomes of the studies were not affected and this domain was considered to have low risk of bias.

Incomplete outcome data. All of the included studies provided adequate information regarding participant withdrawal. As the dropout rate in each included study was $< 20\%$, this domain was considered to have low risk of bias.

Selective reporting. The three studies reported all of the outcomes specified in our inclusion criteria, and this domain was considered to have low risk of bias.

Other bias. There were no concerns of other biases (Table 7).

Effects of interventions (results of meta-analyses). Meta-analyses demonstrated that the risk of the overall failure (irrespective of the catastrophic or noncatastrophic failure) was greater with nonpost (104/271) than with post (78/377) restorations, regardless of the remaining coronal walls in restored teeth (RR = 0.41; 95% CI, 0.23 to 0.74) (Fig 2).

Table 7 Assessment of Quality of the Included Studies

Study factor assessed for risk of bias	Ferrari et al[20]	Bitter et al[19]	Ferrari et al[21]
Random sequence generation	Unclear risk	Low risk	Low risk
Allocation concealment	Unclear risk	Unclear risk	Unclear risk
Blinding of outcome assessment	Low risk	Low risk	Low risk
Incomplete outcome data	Low risk	Low risk	Low risk
Selective reporting	Low risk	Low risk	Low risk
Other bias	Low risk	Low risk	Low risk
Overall risk of bias	Unclear risk	Unclear risk	Unclear risk

Catastrophic failure leading directly to tooth extraction. Meta-analyses demonstrated that the risk of catastrophic failure was greater with nonpost (24/227) than with post (4/329) restorations, irrespective of the remaining coronal walls in restored teeth (RR = 0.11; 95% CI, 0.04–0.31) (Fig 3).

The results of subgroup analysis grouped by remaining coronal wall are listed in Fig 4. When fewer

Study or subgroup	Post Events	Post Total	Nonpost Events	Nonpost Total	Weight	Risk ratio M-H, random, 95% CI
Bitter et al[19]	3	48	6	44	14.8%	0.46 (0.12, 1.72)
Ferrari et al[21]	9	120	36	120	32.7%	0.25 (0.13, 0.50)
Ferrari et al[20]	66	209	62	107	52.5%	0.54 (0.42, 0.70)
Total (95% CI)		377		271	100.0%	0.41 (0.23, 0.74)
Total events	78		104			
Heterogeneity: $Tau^2 = 0.16$; $Chi^2 = 4.83$, $df = 2$ ($P = .09$); $I^2 = 59\%$						
Test for overall effect: $Z = 2.94$ ($P = .003$)						

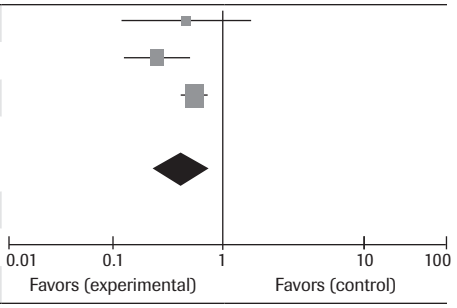

Fig 2 Forest plot showing the relationship between one post and nonpost (regardless of the residual coronal wall); outcome: 1.1 the number of failed restorations or teeth.

Study or subgroup	Post Events	Post Total	Nonpost Events	Nonpost Total	Weight	Risk ratio M-H, fixed, 95% CI
Ferrari et al[21]	0	120	9	120	32.4%	0.05 (0.00, 0.89)
Ferrari et al[20]	4	209	15	107	67.6%	0.14 (0.05, 0.40)
Total (95% CI)		329		227	100.0%	0.11 (0.04, 0.31)
Total events	4		24			
Heterogeneity: $Chi^2 = 0.42$, $df = 1$ ($P = .52$); $I^2 = 0\%$						
Test for overall effect: $Z = 4.20$ ($P < .0001$)						

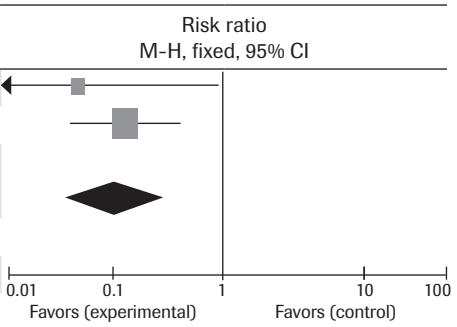

Fig 3 Forest plot showing the relationship between one post and nonpost (regardless of the remaining coronal walls); outcome: 1.1 catastrophic failure.

Study or subgroup	Post Events	Post Total	Nonpost Events	Nonpost Total	Weight	Risk ratio M-H, fixed, 95% CI
Ferrari et al[21]	0	80	9	80	32.5%	0.05 (0.00, 0.89)
Ferrari et al[20]	4	139	15	72	67.5%	0.14 (0.05, 0.40)
Total (95% CI)		219		152	100.0%	0.11 (0.04, 0.31)
Total events	4		24			
Heterogeneity: $Chi^2 = 0.43$, $df = 1$ ($P = .51$); $I^2 = 0\%$						
Test for overall effect: $Z = 4.22$ ($P < .0001$)						

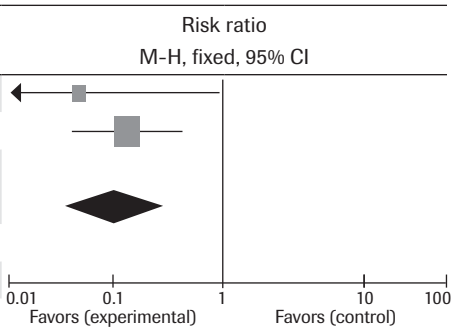

Fig 4 Forest plot showing the relationship between two post and nonpost (fewer than three remaining coronal walls); outcome; 2.1 catastrophic failure.

than three coronal walls (zero, one, or two coronal walls) of the restored teeth remained, the risk of catastrophic failure was greater with nonpost (24/152) than post (4/219) restorations (RR = 0.11; CI, 0.04 to 0.31) (Fig 4). However, when three or four coronal walls of the restored teeth remained, no catastrophic failure leading to tooth extraction occurred in either the post group or the nonpost group.

Noncatastrophic failure of the restoration requiring further treatment. Meta-analyses demonstrated that the risk of noncatastrophic failure was greater with nonpost (74/227) than with post (71/329) restorations, irrespective of the remaining coronal walls in restored teeth, but the difference had no statistical significance (RR = 0.51; 95% CI, 0.25 to 1.02) (Fig 5).

The results of subgroup analysis grouped by remaining coronal wall are listed in Figs 6 and 7. When fewer than three coronal walls of the restored teeth remained, the risk of noncatastrophic failure was greater with nonpost (66/152) than post (66/219) restorations (RR = 0.55; CI, 0.27 to 1.09) (Fig 6). When

Study or subgroup	Post Events	Post Total	Nonpost Events	Nonpost Total	Weight	Risk ratio M-H, random, 95% CI
Ferrari et al[21]	9	120	27	120	39.7%	0.33 (0.16, 0.68)
Ferrari et al[20]	62	209	47	107	60.3%	0.68 (0.50, 0.91)
Total (95% CI)		329		227	100.0%	0.51 (0.25, 1.02)
Total events	71		74			
Heterogeneity: $Tai^2 = 0.19$; $Chi^2 = 3.41$, $df = 1$ ($P = .06$) $I^2 = 71\%$						
Test for overall effect: $Z = 1.89$ ($P = .06$)						

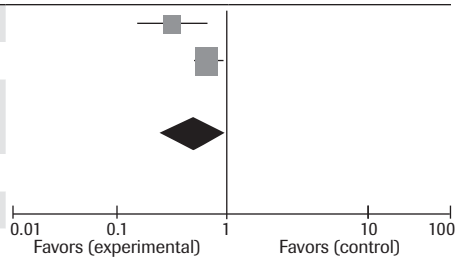

Fig 5 Forest plot showing the relationship between one post and nonpost (regardless of the remaining coronal walls); outcome: 1.1 noncatastrophic failure.

Study or subgroup	Post Events	Post Total	Nonpost Events	Nonpost Total	Weight	Risk ratio M-H, random, 95% CI
Ferrari et al[21]	9	80	25	80	40.0%	0.36 (0.18, 0.72)
Ferrari et al[20]	57	139	41	72	60.0%	0.72 (0.54, 0.96)
Total (95% CI)		219		152	100.0%	0.55 (0.27, 1.09)
Total events	66		66			
Heterogeneity: $Tau^2 = 0.19$; $Chi^2 = 3.58$, $df = 1$ ($P = .06$) $I^2 = 72\%$						
Test for overall effect: $Z = 1.71$ ($P = .09$)						

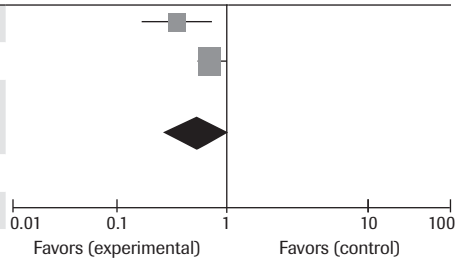

Fig 6 Forest plot showing the relationship between two post and nonpost (fewer than three coronal walls remaining); outcome: 2.1 noncatastrophic failure.

Study or subgroup	Post Events	Post Total	Nonpost Events	Nonpost Total	Weight	Risk ratio M-H, fixed, 95% CI
Ferrari et al[21]	0	40	2	40	23.8%	0.20 (0.01, 4.04)
Ferrari et al[20]	5	70	6	35	76.2%	0.42 (0.14, 1.27)
Total (95% CI)		110		75	100.0%	0.37 (0.13, 1.04)
Total events	5		8			
Heterogeneity: $Chi^2 = 0.21$, $df = 1$ ($P = .65$); $I^2 = 0\%$						
Test for overall effect: $Z = 1.88$ ($P = .06$)						

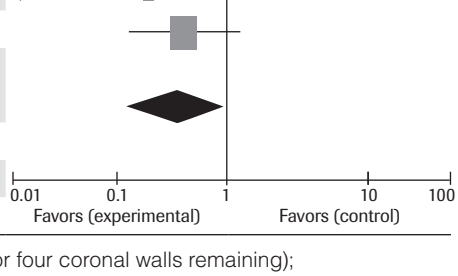

Fig 7 Forest plot showing the relationship between three post and nonpost (three or four coronal walls remaining); outcome: 3.1 noncatastrophic failure.

three or four coronal walls of the restored teeth remained, the risk of catastrophic failure was greater with nonpost (8/75) than post (5/110) restorations (RR = 0.37; CI, 0.13 to 1.04) (Fig 7). The difference in the subgroup analysis had no statistical significance.

Discussion

In the last decade, many in vitro and in vivo studies have been published regarding post-and-core restoration, and many types of post systems are available for restoration of endodontically treated teeth. Systematic reviews differ from traditional reviews in that they are usually confined to a single focused question that provides the basis for systematic searches and the selection and clinical evaluation of relevant research.[31] RCTs and systematic reviews provide strong scientific clinical evidence regarding the effect of post placement on the restoration of endodontically treated teeth.

In this systematic review, three studies involving 317 participants were included and examined by meta-analyses. The results indicate that post placement

appears to have a significant influence only on reducing catastrophic failure of endodontically treated teeth. When three or four coronal walls remained, post placement seems to have no influence on the restoration of endodontically treated teeth.

In 2006, a nationwide survey[32] of dentists in Germany about treatment concepts for restoration of endodontically treated teeth suggested that 52% of the surveyed dentists consider post placement for almost every postendodontic restoration of endodontically treated teeth and the majority of dentists (54%) believe that a post can reinforce endodontically treated teeth. The belief that a post would reinforce an endodontically treated tooth might explain the high frequency of unnecessary post placements. As mentioned above, a post is usually placed to provide retention for the core rather than reinforcement of the tooth.[7,8] On the contrary, unnecessary post placements add a certain degree of risk of perforation and increase the chances of root fracture.[1,33–35] The results of our systematic review also indicate that post placement has no influence on the restoration of endodontically treated teeth when three or four coronal walls remain. When fewer than three coronal walls remain, endodontically treated teeth benefit from post placement with a significant risk reduction for catastrophic failure. However, as only three studies were included and the sample size of subgroup analysis became rather small, the evidence was not sufficient. Although the evidence was not strong, it was sufficiently meaningful to guide clinical application of post placement in endodontically treated teeth.

Risk of bias varied from low to unclear, as detailed in the results, indicating that all three studies provided robust results. The final assessment of the three included studies was judged as having an unclear risk of bias. This would pose a negative influence on the quality of the RCTs and weaken the reliability of the evidence.

Although meta-analysis is now a well-established method of reviewing evidence, sources of heterogeneity, particularly clinical differences between studies, are a common problem. Heterogeneity must be investigated to increase the clinical relevance of the conclusions drawn from meta-analyses.[36] In our systematic review, the results of the heterogeneity test indicated that heterogeneity was present among the three included studies ($P < .1$). Therefore, we used the random effects model to calculate the pooled effect of intervention in the three studies in some cases. We also conducted subgroup analyses of the included teeth according to the remaining coronal walls. The following possible sources of heterogeneity were identified: First, the position of selected teeth in the dental arch varied among the three studies. In Ferrari's studies, only premolars were selected, while there were no restrictions regarding tooth type in Bitter's study. Second, the amount of remaining tooth structure, which significantly affects the restoration of endodontically treated teeth, varied markedly among the studies. Other possible factors include different types of post and core systems, the quality of trial design, accuracy of outcome measures, study population, and length of follow-up.

In recent years, multiple clinical trials have been conducted regarding the effects of post restoration on the survival of root-filled teeth. The three RCTs included in this review suggest that post procedures could significantly increase the survival rates of endodontically treated teeth, especially those with severe tooth defects.

Fokkinga et al[22] collected up to 17 years of survival data of endodontically treated single teeth with or without a prefabricated metal post, and found that post placement had no influence on the survival probability of endodontically treated teeth. The results were confirmed in another study.[24] Our review results are not in agreement with these two RCTs, likely due to different tooth types and the different types of post and core used.

There are some limitations to this review. Only five databases were searched to identify RCTs, so not all relevant studies were included. In addition, only studies published in English or Chinese were reviewed. Future reviews should collect as many studies as possible. Future RCTs must be well designed and conducted to investigate the relative effects of different degrees of tooth loss and different tooth types on the restoration of endodontically treated teeth.

Conclusions

Post placement appears to have a significant influence on reducing catastrophic failure rate in endodontically treated teeth. When three or four coronal walls remain, post placement seems to have no influence on the restoration of endodontically treated teeth. As the evidence was not strong enough, more RCTs are needed to confirm whether and to what extent the degree of coronal tissue loss and the post placement have an influence on the clinical behavior of endodontically compromised teeth.

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