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SYSTEMATIC REVIEW

# Do anterior and posterior teeth treated with post-and-core restorations have similar failure rates? A systematic review and meta-analysis

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## ABSTRACT

**Statement of problem.** The association between tooth type, location in the dental arch, and selection of a post-and-core system for endodontically treated teeth is unclear. Information on the influence of these parameters on the failure rate of teeth treated with post-and-core restorations is needed.

**Purpose.** The purpose of this systematic review and meta-analysis was to assess the available evidence on the failure rates of anterior and posterior teeth treated with post-and-core restorations.

**Material and methods.** A search was performed in PubMed, Scopus, Web of Science, Latin American and Caribbean Health Sciences Literature database, Brazilian Library in Dentistry, Cochrane Library, and Gray literature for randomized clinical trials comparing the failure rates of anterior and posterior teeth treated with post-and-core restorations. The risk of bias tool from the Cochrane Collaboration was used for quality assessment of the studies.

**Results.** The search strategy identified 2526 articles, and 6 studies were included in the meta-analysis. No difference in the failure rate of post-and-core restorations placed in anterior and posterior teeth was found in most studies. The risk ratio for anterior versus posterior teeth was 1.06 (95% confidence interval [CI], 0.69-1.64; $P$=.79). The risk ratio for incisors versus canines was 3.08 (95% CI, 0.56-17.04; $P$=.20) and that for premolars versus molars was 0.45 (95% CI, 0.12-1.74; $P$=.25). The risk ratio for prefabricated glass fiber posts on anterior versus posterior teeth was 1.13 (95% CI, 0.61-2.09; $P$=.70) and that for metal posts was 1.10 (95% CI, 0.64-1.91; $P$=.72).

**Conclusions.** The failure rates in anterior and posterior teeth treated with post-and-core restorations were similar at short- to medium-term follow-up. More well-designed clinical trials comparing the survival and failure rates of anterior and posterior teeth treated with post-and-core restorations with longer follow-up times are needed. (J Prosthet Dent 2019;121:887-94)

The restoration of endodontically treated teeth with post-and-core restorations has been extensively studied in the last 20 years.[1-4] Nonvital teeth have been considered vulnerable and more susceptible to fracture than vital teeth[5] because they are generally associated with a substantial loss of coronal and radicular tooth structure which causes a significant reduction in their capacity to withstand functional loads.[5-7] Traditionally, cast metal post and cores are used to provide the required retention for the prosthetic crown. However, prefabricated glass fiber posts adhesively cemented to the root dentin have been increasingly used for improved esthetics. However, in situations where prefabricated posts do not adapt well to the root canal walls, custom glass fiber posts have been proposed because they exhibit thinner and more uniform resin cement layers, particularly in the coronal and middle thirds.[8-13]

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## Clinical Implications

Similar failure rates were observed for anterior and posterior teeth treated with post-and-core restorations. Both prefabricated glass fiber posts and metal posts were considered acceptable options and presented good clinical success rates at short- to medium-term follow-up.

Retrospective studies have reported a relationship between successful post-and-core restorations and factors such as the number of proximal contacts,[14] occlusal contacts,[6] type of definitive restoration,[15] and position of the tooth in the dental arch with respect to the occlusal forces.[3,6,16] The association between tooth type and position in the dental arch and selection of the post-and-core system used in the restoration of endodontically treated teeth is controversial.[17] Anterior teeth treated with post-and-core restorations have a fracture rate 3 times higher than that of posterior teeth.[18] This difference can be partially explained by the greater horizontal forces present in anterior teeth. Posterior teeth are subjected to a more perpendicular compression force vector.[17]

Fatigue fractures are caused by tensile stresses rather than by compression stresses. Therefore, the anterior region of the maxilla can be considered an area of high fracture risk.[17,18] However, a retrospective study reported that maxillary premolars and molars have the highest incidence of fractures[19] and that the nonfunctional cusps are the most affected (because of horizontal masticatory loads), with a ratio of 3:2 for maxillary teeth and 3:1 for mandibular teeth.[20,21] Because of the controversial results and lack of clear information, the purpose of this systematic review and meta-analysis was to answer the focused question: Do anterior and posterior teeth treated teeth with post-and-core restorations have similar failure rates?

## MATERIAL AND METHODS

This study followed the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement for the report of this systematic review[22] and was registered in the PROSPERO database (CRD42017075645). The controlled vocabulary (Medical Subject Headings terms) and free keywords used in the search strategy were defined according to the following PICOS terms: population (P), post-and-core restorations; intervention (I), anterior teeth; comparison/control (C), posterior teeth; outcome (O), failure rate; study design (S), randomized clinical trial.

The electronic databases MEDLINE via PubMed, Scopus, Web of Science, the Latin American and Caribbean Health Sciences Literature database, the Brazilian Library in Dentistry, and the Cochrane Library were selected (Supplemental Table 1). The search strategy was established firstly for PubMed and then modified for the other databases to identify eligible studies.

The reference lists of all primary studies were handsearched for supplementary relevant publications. Also, the related article links for each primary study in the PubMed database were examined. There were no restrictions on publication date or language.

Abstracts of the annual session of the International Association for Dental Research and its regional divisions (1990-2017) were explored. The gray literature was searched using the database System for Information on Gray Literature in Europe. Dissertations and theses were examined using the ProQuest Dissertations and Theses Full-Text databases and the Periódicos Capes Theses database. Clinical trials registries were searched to locate unpublished and ongoing trials (Current Controlled Trials [www.controlled-trials.com], International Clinical Trials Registry Platform [http://apps.who.int/trialsearch/], ClinicalTrials.gov [www.clinicaltrials.gov], ReBEC [Brazilian Clinical Trials Registry, www.rebec.gov.br], and European Union Clinical Trials Register [https://www.clinicaltrialsregister.eu]).

Randomized clinical trials (RCTs) were included that reported the failure rate of anterior and posterior teeth with post-and-core restorations. The failure rate of teeth was the primary outcome of the study. All the articles (full-text versions) that met the eligibility criteria were obtained and saved for data extraction.

Noncontrolled clinical trials, editorial letters, historical reviews, in vitro studies, cohort, observational studies, and descriptive studies such as case reports and case series were excluded. RCT studies were excluded if they were observational studies, studies that did not present results for anterior and posterior teeth, studies that did not separate their data on anterior and posterior teeth, studies in which post-and-core restorations were not used, or studies that presented the same population.

The studies were selected by title and abstract according to the eligibility criteria. Articles appearing in more than 1 database were considered only once. Where there was insufficient information in the title and abstract to reach a definitive decision, full-text versions of the articles were retrieved.

The full-text articles were read, and 2 reviewers (P.P.G., C.C.G.) extracted all the relevant information about study design, participants, interventions, and outcomes using a custom extraction form (Supplemental Table 2). This custom extraction form had been previously prepared by 3 authors (P.P.G., C.C.G., G.M.C.) and was pilot tested using a sample of 4 studies to ensure that

the data were consistent with the specific research question. To avoid overlapping, when multiple reports of the same study with different follow-up periods were identified, data from all reports were extracted directly into a single form.

Two independent reviewers (P.P.G., C.C.G.) performed the quality assessments of the selected trials using the Cochrane Collaboration's tool for assessing risk of bias in randomized trials.[23] The assessment criteria comprised sequence generation, allocation concealment, blinding, incomplete outcome data and selective outcome reporting, and other possible sources of bias. During quality assessment and data collection, disagreements between the 2 reviewers were resolved through discussion, and a third reviewer (J.L.G. or L.M.W.) was consulted if needed.

For each of the quality assessment items, the risk of bias was classified according to the recommendations described in the Cochrane Handbook for Systematic Reviews of Interventions 5.1.0 (http://handbook.cochrane.org). Each item was evaluated, and the decision consisted of scoring "no" (high risk of bias), "yes" (low risk of bias), or "unclear" (either insufficient information or uncertainty over the potential for bias).

Two of the 5 domains in the Cochrane risk of bias tool were considered as key domains for the present study: sequence generation and allocation concealment. Studies were classified as low risk of bias if the key domains were judged to be at "low risk." When 1 or 2 key domains were classified as at unclear risk of bias, the study was, as a whole, considered to be at "unclear risk," and if at least 1 key domain was classified to be at high risk of bias, the entire study was judged to be at "high risk."

Data from eligible studies were dichotomous (failure rate of anterior and posterior teeth with post-and-core restorations). Only studies judged in the key domains as "low risk" or "unclear risk" of bias were included in the meta-analysis. For each study, the risk ratio (RR) and the 95% confidence interval (CI) were calculated. For statistical analyses, the random-effects models were used. Cochran Q test and $I^2$ statistics were used to assess statistical heterogeneity. All analyses were performed using a software program (Review Manager, v5.3; The Cochrane Collaboration). Subgroup analyses were performed considering anterior teeth (incisors versus canines), posterior teeth (premolars versus molars), and type of posts (prefabricated glass fiber post and metal posts).

## RESULTS

After the database screening and removal of duplicates, 2526 studies were identified (Fig. 1). After title and abstract screening, 26 studies remained. This number was reduced to 6 after their full texts had been assessed to evaluate eligibility.

Among them, 20 were excluded because they were observational studies,[3,5,14,18] studies that did not present results for anterior and posterior teeth,[7,15,24-27] studies that did not separate data on anterior and posterior teeth,[1,28-32] studies in which post-and-core restorations were not used,[33,34] and studies that presented the same population.[35,36]

The characteristics of the 6 studies selected are listed in Supplemental Table 2. The smallest sample size of teeth per group was 52,[37] and the largest sample size was 297.[38] The mean age of participants ranged from 36 to 54.1 years (overall mean of 47.8 years). The number of participants in the trials varied from 42 to 257.[6,37-41] The percentage of female participants in the studies ranged from 49.4% to 88.4%, with overall mean of 62.2%.[6,37-41]

Two studies reported 1 post per participant.[39,40] Three of 6 studies did not report the number of posts placed,[37,38,41] whereas 1 study reported between 1 and 5 restorations per participant.[6] Three studies included only prefabricated posts,[37-40] and 3 studies included prefabricated and custom posts.[6,38,41] The type of post included were cast metal posts,[38,41] prefabricated metal posts,[6,38,40] prefabricated glass fiber posts,[6,39-41] carbon fiber posts,[37] and custom-made glass fiber posts.[6]

Two studies cemented all posts with self-adhesive resin cement,[39,40] 2 studies used dual-polymerizing resin cement,[6,37] 1 study used both types of resin cement,[41] and 1 study did not report the type of cement.[38] The core foundation materials reported by 4 studies were composite resin,[6,38-40] whereas 2 studies did not report the foundation material.[37,41] All studies reported the type of coronal restoration that included metal crowns,[38] metal-ceramic crowns,[37-41] and ceramic crowns.[6,39]

Two studies reported a post length of 19 mm[39] and 9 mm.[40] Four of 6 studies did not report this information.[6,37,38,41] The same 2 studies[39,40] reported an apical seal of at least 4 mm. None of the studies have reported the type of sealant used in endodontic therapy, and only 2 studies described the technique used for endodontic treatment.[39,41]

Dentists[6,37,39] and dental students[40,41] were responsible for the restorations. One of 6 studies did not report this information.[38] The evaluation of the restorations was performed by the dentists monitoring the patients' oral health,[38] 1 previously trained examiner,[39] 1 blinded dentist who was briefed by 1 operator,[40] the author of 1 of the studies,[37] 2 calibrated independent examiners,[41] and 1 blinded operator.[6] The evaluated outcome in all the studies was failure rate.[6,37-41]

The follow-up period ranged from 3[39,41] to 9 years.[38] Three studies reported higher failure rates for posterior teeth.[37,39,41] One study reported higher failure rates in anterior teeth,[6] but 2 studies had similar failure rates in both anterior and posterior teeth for certain types of post.[38,40] The failure reasons were fracture (core, root,

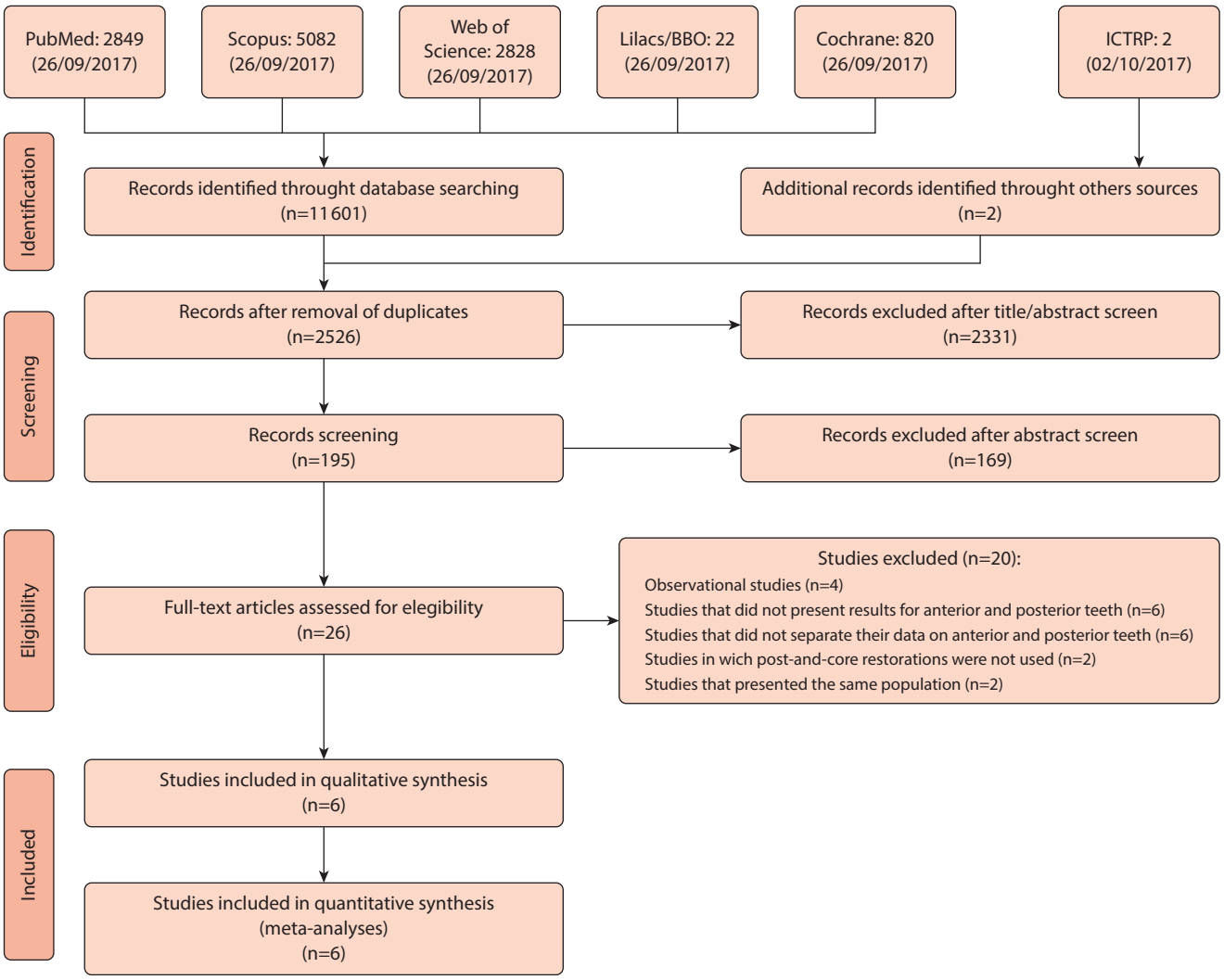



**Figure 1.** Study design. BBO, Brazilian Library in Dentistry; LILACS, Latin American and Caribbean Health Sciences Literature database; ICTRP, International Clinical Trials Registry Platform.

or post),[6,37-41] dislodgement of post-and-core or crown,[6,37-39,41] caries,[6,37-39] periodontal failure,[6,37,39,40] and endodontic failure.[6,37,39,40]

The assessment of the risk of bias of the included studies is presented in Figure 2. Some studies did not report the method of randomization and how the allocation concealment was performed. These 2 items were the key domains of the current systematic review. In the key domains of the Cochrane risk of bias tool, 2 of these studies were judged as at "low" risk of bias, and 4 studies were considered to be at "unclear" risk of bias.

The meta-analysis initially included only the 2 studies classified as "low risk" of bias in the key domains (data not shown). In a second analysis, all 6 studies ("low risk" and "unclear risk" of bias in the key domains) were included. Because no statistical difference was observed, the authors chose to include all the studies in the meta-analyses.

The analysis of anterior versus posterior teeth was based on 6 studies.[6,37-41] The RR calculated between groups was 1.06, with a 95% CI of 0.69 to 1.64 ($P$=.79). Based on these studies, no statistically significant difference between the groups was identified (Fig. 3). Data were homogeneous (chi-square test, $P$=.28; $I^2$=20%), indicating that all studies included in the analysis shared a common effect size.

The analysis of types of teeth was based on 2 studies.[39,40] Comparing incisors versus canines, the RR between groups was 3.08, with a 95% CI of 0.56 to 17.04 ($P$=.20). Based on these studies, no statistical significant difference between the groups was observed (Fig. 4A). Data were homogeneous (chi-square test, $P$=.43; $I^2$=0%). For premolars versus molars, the RR was 0.45, with a 95% CI of 0.12 to 1.74 ($P$=.25). Based on these studies, a significant statistical difference between the groups was observed (Fig. 4B). Data were homogeneous (chi-square test, $P$=.91; $I^2$=0%). In both comparisons, all studies included in the analysis shared a common effect size.

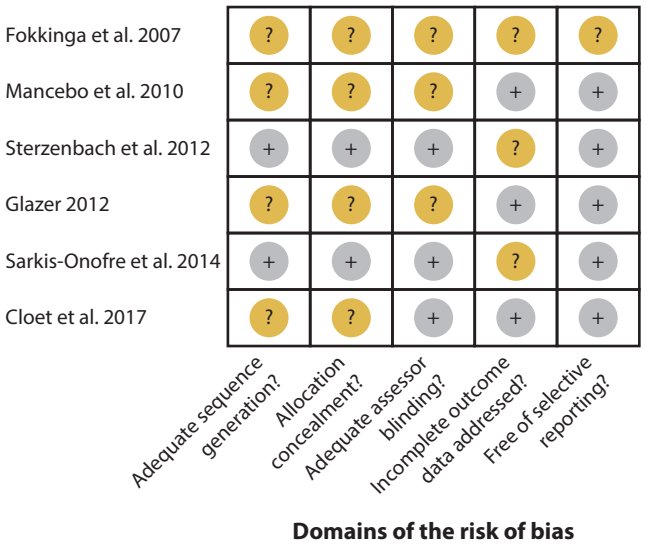



**Figure 2.** Summary of risk of bias assessment according to Cochrane Collaboration tool.

The analysis of types of posts was based on 5 studies.[6,37,39-41] Comparing prefabricated glass fiber posts on anterior and posterior teeth, the RR between groups was 1.13, with a 95% CI of 0.61 to 2.09 ($P$=.71). Based on these studies, no statistical significant difference between the groups was observed (Fig. 5A). Data were homogeneous (chi-square test, $P$=.53; $I^2$=0%). As for metal posts on anterior and posterior teeth, the RR was 0.10, with a 95% CI of 0.64 to 1.91 ($P$=.72). Based on these studies, no significant statistical difference between the groups was observed (Fig. 5B). Data were homogeneous (chi-square test, $P$=.38; $I^2$=2%). For both comparisons, all studies included in the analysis shared a common effect size.

Because statistical homogeneity was observed for all cases, sensitivity analysis was performed considering only the follow-up times of the selected studies. Three analyses were performed: the first considered all 6 studies, another considered only studies with follow-up times of 3 to 6 years (short- to medium-term follow-up), and the last considered only studies with follow-up times of up to 3 years (short follow-up periods).

## DISCUSSION

In this systematic review, RCTs comparing post-and-core restorations on anterior and posterior teeth were analyzed. Randomization and allocation concealment were the key domains used in this review. They were chosen because they were considered as the most critical factors for the clinical studies selected to answer the specific question that guided this systematic review. Randomization is important because it increases the validity of the study by avoiding any selection bias, which is one of the criteria for evaluating the internal quality of the studies.[42] Other criteria such as type of study, identification and treatment of confounding factors, reliability and validity of methods of data collection, allocation, and blinding of researchers and participants were also evaluated to assess the quality of the studies. For the present work, blinding of all the parties involved was assessed in the selected studies but was not considered a key domain because it could not be adequately performed in the clinical trials (operators and evaluators could not always be blinded for type of tooth or during post placement and follow-up evaluations) and would not influence the results.

The restoration of endodontically treated teeth with post-and-core restorations is a relatively complex procedure indicated when there is a substantial loss of coronary dentin to promote retention and stability for the definitive restoration.[31] Cloet et al[6] showed a greater number of failures in anterior teeth than posterior teeth. This finding has been corroborated by other studies[18,26] in which an increase in the frequency of fractures in anterior teeth was also reported. These fractures are generally related to occlusal forces. A higher incidence of horizontal forces responsible for tensile and shear stresses occurs in anterior teeth,[3,17] which, along with the premolars, are subjected to lateral forces.[39] In molars, vertical compression forces are more frequent.[14,17,39] However, some studies reported a higher frequency of fractures in posterior teeth.[37,39,41] This result can be explained by the absence of remaining walls on the treated teeth.

All studies included in this systematic review and meta-analysis emphasized the importance of a conservative preparation during endodontic treatment. The quality and quantity of remaining dentin and the coronal preservation of the walls have also been reported as decisive factors in obtaining a positive prognosis regarding the restoration of endodontically treated teeth with post-and-core restorations.[6,37-41] The importance of a ferule and the preservation of coronal tooth structure have been emphasized to increase survival rates of teeth with post-and-core restorations.[15,28]

Posts are available of different materials and composition, including metal, ceramic, and fiber-reinforced materials (including carbon fiber, quartz fiber, and glass fiber). Each of these materials has specific characteristics and mechanical properties.[43] The first analysis of this systematic review included all 6 selected studies, irrespective of the type of post used. In subgroup analysis, the type of post was considered, and metal posts were separated from prefabricated fiber posts. In both the cases, no statistically significant difference was found in the failure rates of anterior and posterior teeth.

Different clinical trials comparing the survival rate of glass fiber posts and metal posts placed in endodontically treated teeth (either with no remaining coronal wall or with a ferrule) showed similar clinical performance after a follow-up period of 6 months to 5 years.[6,7,40,41] However,

| Study or Subgroup | Anterior Teeth Events | Anterior Teeth Total | Posterior Teeth Events | Posterior Teeth Total | Weight | Risk Ratio M-H, Random, 95% CI |
|---|---|---|---|---|---|---|
| Cloet et al. 2017 | 16 | 56 | 21 | 109 | 34.6% | 1.48 (0.84, 2.61) |
| Fokkinga et al. 2007 | 13 | 75 | 40 | 183 | 34.6% | 0.79 (0.45, 1.40) |
| Glazer et al. 2012 | 1 | 29 | 3 | 23 | 3.7% | 0.26 (0.03, 2.38) |
| Mancebo et al. 2010 | 9 | 46 | 5 | 41 | 15.2% | 1.60 (0.58, 4.40) |
| Sarkis-Onofre et al. 2014 | 1 | 40 | 3 | 32 | 3.7% | 0.27 (0.03, 2.44) |
| Sterzenbach et al. 2012 | 4 | 42 | 3 | 45 | 8.2% | 1.43 (0.34, 6.01) |
| **Total (95% CI)** | | **288** | | **433** | **100.0%** | **1.06 (0.69, 1.64)** |
| Total events | 44 | | 75 | | | |

Heterogeneity: $\tau^2$=0.06; $\chi^2$=6.26, *df*=5 (*P*=.28); $I^2$=20%
Test for overall effect: Z=0.27 (*P*=.79)

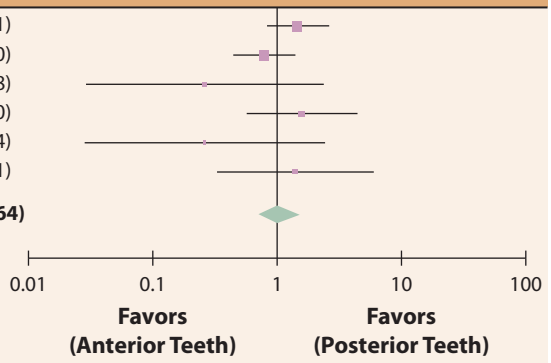
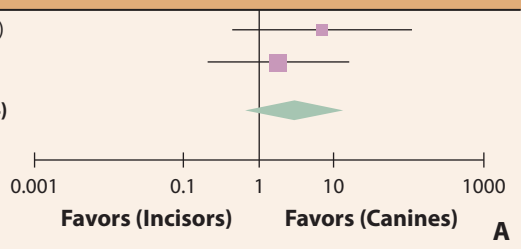



**Figure 3.** Forest plots of failure rates for anterior versus posterior teeth. CI, confidence interval.

| Study or Subgroup | Incisors Events | Incisors Total | Canines Events | Canines Total | Weight | Risk Ratio M-H, Random, 95% CI |
|---|---|---|---|---|---|---|
| Mancebo et al. 2010 | 9 | 34 | 0 | 12 | 38.1% | 7.06 (0.44, 112.81) |
| Sterzenbach et al. 2012 | 3 | 26 | 1 | 16 | 61.9% | 1.85 (0.21, 16.26) |
| **Total (95% CI)** | | **60** | | **28** | **100.0%** | **3.08 (0.56, 17.04)** |
| Total events | 12 | | 1 | | | |

Heterogeneity. $\tau^2$=0.00; $\chi^2$=0.61, *df*=1 (*P*=.43); $I^2$=0%
Test for overall effect: Z=1.29 (*P*=.20)




| Study or Subgroup | Premolars Events | Premolars Total | Molars Events | Molars Total | Weight | Risk Ratio M-H, Random, 95% CI |
|---|---|---|---|---|---|---|
| Mancebo et al. 2010 | 2 | 25 | 3 | 16 | 65.1% | 0.43 (0.08, 2.28) |
| Sterzenbach et al. 2012 | 2 | 36 | 1 | 9 | 34.9% | 0.50 (0.05, 4.92) |
| **Total (95% CI)** | | **61** | | **25** | **100.0%** | **0.45 (0.12, 1.74)** |
| Total events | 4 | | 4 | | | |

Heterogeneity. $\tau^2$=0.00; $\chi^2$=0.01, *df*=1 (*P*=.91); $I^2$=0%
Test for overall effect: Z=1.15 (*P*=.25)

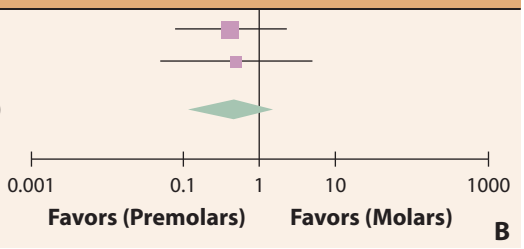



**Figure 4.** Forest plots of failure rates for types of teeth. A, Incisor versus canines. B, Premolars versus molars. CI, confidence interval.

a few studies have reported that glass fiber-reinforced posts performed better than metal screw posts in short-term clinical follow-up (mean of 13 months).[26]

Custom posts have been used[8-10,12,13] to better adapt the with the root canal walls (especially in the coronal and middle thirds) and achieve a thinner and more uniform resin cement layer.[11] Few clinical studies have been conducted with customized posts.[6] Among the studies included in the present review, only 1 trial[6] included a group of customized glass fiber posts (in addition to a group of prefabricated posts). In the first meta-analysis performed, the data of the 2 groups (prefabricated and customized) were pooled. The heterogeneity was high, and the cause was sought during the sensitivity analysis. The experimental design of each included study was reviewed, and it was determined that the inclusion of customized posts could be the reason. These data were removed, and only studies and groups with prefabricated posts were maintained. The data presented in Figures 3-5 are only for prefabricated posts.

The results of this systematic review may be limited by false-positive information. Only 2 studies were classified as low risk of bias,[40,41] and 4 studies had an unclear risk of bias.[6,37-39] Considering that studies with a low risk of bias are more reliable, future clinical studies should be more careful about methodological parameters to reduce the risk of polarization and to properly inform the nature of the study and its methodology. However, in the

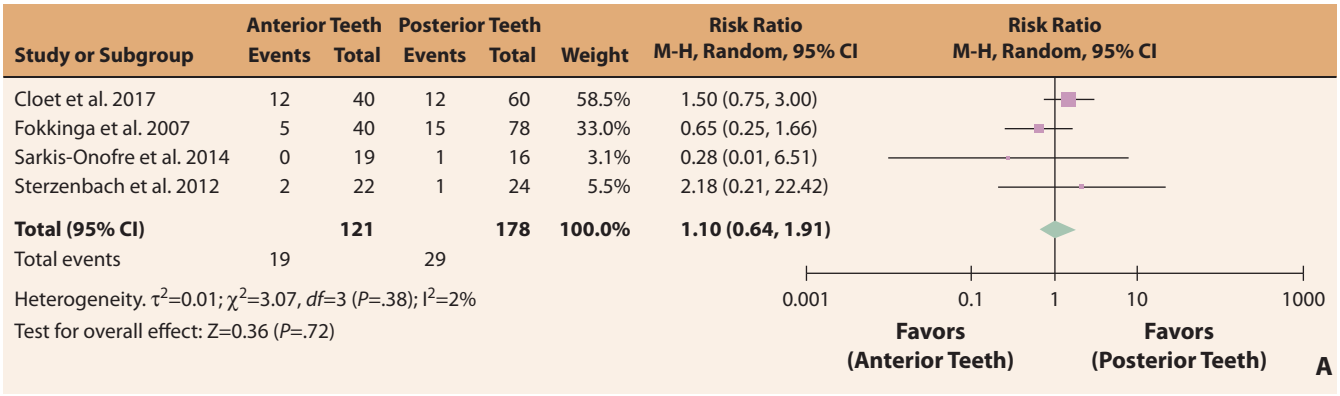



**Figure 5.** Forest plots of failure rates for anterior versus posterior teeth, considering types of posts. A, Prefabricated glass fiber posts. B, Metal posts. CI, confidence interval.

present study, the same result (no difference between anterior and posterior teeth) was obtained using only the 2 studies with low bias risk or when all 6 studies (low risk and unclear risk) were included. Another limitation of this review is the restricted follow-up period in most of the included studies. Well-designed RCTs with longer follow-up times are needed to provide more information on the clinical performance and failure modes of endodontically treated teeth with post-and-core restorations.

## CONCLUSIONS

Based on the short- and medium-term RCTs analyzed in this study, the following conclusions were drawn:

1. The failure rates in anterior and posterior teeth treated with post-and-core restorations are similar.
2. More well-designed clinical trials evaluating the survival and failure rates of anterior and posterior teeth treated with post-and-core restorations with longer follow-up times are needed.

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**Supplemental Table 1.** Electronic databases and search strategy

| | | |
|---|---|---|
| PubMed=2849 (26/September/2017) | | |
| #1 (((tooth, nonvital[MeSH Terms] OR post and core technique[MeSH Terms] OR tooth preparation, prosthodontic[MeSH Terms] OR dental prosthesis retention[MeSH Terms] OR fiberglass[Supplementary Concept] OR "tooth, nonvital"[Title/Abstract] OR "post and core technique"[Title/Abstract] OR "tooth preparation, prosthodontic"[Title/Abstract] OR "dental prosthesis retention"[Title/Abstract] OR fiberglass[Title/Abstract] OR "devitalized teeth"[Title/Abstract] OR "pulpless teeth"[Title/Abstract] OR "endodontically treated teeth"[Title/Abstract] OR "fiber posts"[Title/Abstract] OR "fiber posts"[Title/Abstract] OR "glass fiber posts"[Title/Abstract] OR "cast core"[Title/Abstract] OR "cast post"[Title/Abstract] OR "endodontic posts"[Title/Abstract] OR "prefabricated posts"[Title/Abstract] OR "customized post"[Title/Abstract] OR "anatomical post"[Title/Abstract]))) #1 AND#2 AND#3 | #2 (((tooth[MeSH Terms] OR permanent dentition[MeSH Terms] OR tooth[Title/Abstract] OR teeth[Title/Abstract] OR "permanent dentition"[Title/Abstract] OR "posterior teeth"[Title/Abstract] OR "anterior teeth"[Title/Abstract])))) | #3 (randomized controlled trial[pt] OR controlled clinical trial[pt] OR randomized controlled trials[mh] OR random allocation [mh] OR double-blind method[mh] OR single-blind method[mh] OR clinical trial [pt] OR clinical trials[mh] OR ("clinical trial"[tw]) OR ((singl*[tw] OR doubl*[tw] OR trebl*[tw] OR tripl*[tw]) AND (mask*[tw] OR blind*[tw])) OR (placebos[mh] OR placebo* [tw] OR random*[tw] OR research design [mh:noexp] OR comparative study[pt] OR evaluation studies as topic[mh] OR follow-up studies[mh] OR prospective studies[mh] OR control*[tw] OR prospective*[tw] OR volunteer*[tw]) NOT (animals[mh] NOT humans[mh])) |
| Scopus=5082 (26/September/2017) | | |
| #1 (TITLE-ABS-KEY ("nonvital tooth") OR TITLE-ABS-KEY ("post and core technique") OR TITLE-ABS-KEY ("dental prosthesis retention") OR TITLE-ABS-KEY (fiberglass) OR TITLE-ABS-KEY ("devitalized tooth") OR TITLE-ABS-KEY ("pulpless tooth") OR TITLE-ABS-KEY ("endodontically treated tooth") OR TITLE-ABS-KEY ("fiber post") OR TITLE-ABS-KEY ("glass fiber post") OR TITLE-ABS-KEY ("cast core") OR TITLE-ABS-KEY ("cast post") OR TITLE-ABS-KEY ("endodontic post") OR TITLE-ABS-KEY ("prefabricated post") OR TITLE-ABS-KEY ("customized post") OR TITLE-ABS-KEY ("anatomical post")) # 1 AND#2 | # 2 (TITLE-ABS-KEY (tooth) OR TITLE-ABS-KEY ("permanent dentition") OR TITLE-ABS-KEY ("dentition permanent") OR TITLE-ABS-KEY ("posterior tooth") OR TITLE-ABS-KEY ("anterior tooth")) | |
| Web of Science=2828 (26/September/2017) | | |
| #1 TOPIC ("nonvital t*th") OR TOPIC: ("post and core technique") OR TOPIC: ("tooth preparation prosthodontics") OR TOPIC: ("dental prosthesis retention") OR TOPIC: ("fiberglass") OR TOPIC: ("devitalized t*th") OR TOPIC: ("pulpless t*th") OR TOPIC: ("endodontically treated t*th") OR TOPIC: ("fiber post*") OR TOPIC: ("fiber post*") OR TOPIC: ("glass fiber post*") OR TOPIC: ("glass fiber post*") OR TOPIC: ("cast core*") OR TOPIC: ("cast post*") OR TOPIC: ("endodontic post*") OR TOPIC: ("prefabricated post*") OR TOPIC: ("customized post*") OR TOPIC: ("anatomical post*") #1 AND#2 | #2 TOPIC (t*th) OR TOPIC: ("permanent dentition") OR TOPIC: ("posterior t*th") OR TOPIC: ("anterior t*th") | |
| LILACS and BBO=22 (26/September/2017) | | |
| #1 ((MH:"tooth, nonvital" OR MH:"post and core technique" OR MH:"tooth preparation, prosthodontic" OR MH:"dental prosthesis retention" OR "nonvital teeth" OR fiberglass OR "fiberglass reinforced polymers" OR "devitalized teeth" OR "devitalized tooth" OR "pulpless teeth" OR "pulpless tooth" OR "endodontically treated teeth" OR "endodontically treated tooth" OR "fiber post" OR "fiber posts" OR "fiber post" OR "fiber posts" OR "glass fiber post" OR "glass fiber posts" OR "cast core" OR "cast cores" OR "cast post" OR "cast posts" OR "endodontic post" OR "endodontic posts" OR "prefabricated post" OR "prefabricated posts" OR "customized post" OR "customized posts" OR "anatomical post" OR "anatomical posts" OR "dentes não vitais" OR "dente não vital" OR "técnica de pino e núcleo" OR "técnicas de pino e núcleo" OR "preparo dentário" OR "preparos dentários" OR"fibra de vidro" OR "dente desvitalizado" OR "dentes desvitalizados" OR "dente despolpado" OR "dentes despolpados" OR "dente endodonticamente tratado" OR "dentes endodonticamente tratados" OR "dente tratado endodonticamente" OR "dentes tratados endodonticamente" OR "pino de fibra" OR "pinos de fibra" OR "pino de fibra de vidro" OR "pinos de fibra de vidro" OR "núcleo metálico fundido" OR "núcleos metálicos fundidos" OR "pino metálico" OR "pinos metálicos" OR "pino pré-fabricado" OR "pinos pré-fabricados" OR "pino personalizado" OR "pinos personalizados" OR "pino anatômico" OR "pinos anatômicos" OR "rententor intrarradicular" OR "rententores intrarradiculares" OR "dientes no vitales" OR "dente no vital" OR "técnica de pino y núcleo" OR "técnicas de pino y núcleo" OR "preparación dental" OR "preparaciones dentales" OR "fibra de vidrio" OR "diente desvitalizado" OR "dientes desvitalizados" OR "diente despolpado" OR "dientes despolpados" OR "diente endodónticamente tratado" OR "dientes endodónticamente tratados" OR "diente tratado endodónticamente" OR "dientes tratados endodónticamente" OR "poste de fibra" OR "postes de fibra" OR "poste de fibra de vidrio" OR "postes de fibra de vidrio" OR "núcleo metálico fundido" OR "núcleos metálicos fundidos" OR "poste metálico" OR "postes metálicos" OR "poste prefabricado" OR "postes prefabricados" OR "poste personalizado" OR "postes personalizados" OR "poste anatómico" OR "postes anatómicos" OR "rententor intrarradicular" OR "rententores intrarradiculares") #1 AND#2 | #2 (MH:"tooth" OR MH:"permanent dentition" OR teeth OR "posterior teeth" OR "anterior teeth" OR "posterior tooth" OR "anterior tooth" OR dente OR "dentição permanente" OR dentes OR "dentes posteriores" OR "dentes anteriores" OR "dente posterior" OR "dente anterior" OR diente OR "dentición permanente" OR dientes OR "dientes anteriores" OR "diente anterior" OR "diente posterior" OR "dientes posteriores") | |

(*continued on next page*)

**Supplemental Table 1.** (*Continued*) Electronic databases and search strategy

| Cochrane Libary=820 (26/September/2017) | |
|---|---|
| #1#1 MeSH descriptor: [Tooth, Nonvital] explode all trees | #1 MeSH descriptor: [Tooth] explode all trees |
| #2 MeSH descriptor: [Post and Core Technique] explode all trees | #2 MeSH descriptor: [Dentition, Permanent] explode all trees |
| #3 MeSH descriptor: [Tooth Preparation, Prosthodontic] explode all trees | #3#1 OR#2 |
| #4 MeSH descriptor: [Dental Prosthesis Retention] explode all trees | #4 teeth:ti,ab,kw or posterior t?? th:ti,ab,kw or anterior t?? th:ti,ab,kw (Word variations have been searched)#4 teeth:ti,ab,kw or posterior t??th:ti,ab,kw or anterior t??th:ti,ab,kw (Word variations have been searched) |
| #5#1 OR#2 OR#3 OR#4 | #5#3 OR#4 |
| #6 "teeth nonvital":ti,ab,kw or "fiberglass":ti,ab,kw or devitalized t??th:ti,ab,kw or pulpless t??th:ti,ab,kw or endodontically treated t??th:ti,ab,kw (Word variations have been searched) | |
| #7 fib?? post*:ti,ab,kw or glass fib?? post*:ti,ab,kw or cast core*: ti,ab,kw or cast post*: ti,ab,kw or endodontic post*: ti,ab,kw (Word variations have been searched) | |
| #8 prefabricated post*: ti,ab,kw or customized post*: ti,ab,kw or anatomical post*: ti,ab,kw (Word variations have been searched) | |
| #9#5 OR#6 OR#7 OR#8 | |
| #9 AND#5 | |

BBO, Brazilian Library in Dentistry; LILACS, Latin American and Caribbean Health Sciences Literature database; MeSH, Medical Subject Headings.

**Supplemental Table 2.** Summary of studies selected for systematic review and meta-analysis

| Study ID | Fokkinga et al, 2007[38] | Mancebo et al, 2010[39] | Sterzenbach et al, 2012[40] | Glazer 2012[37] | Sarkis-Onofre et al, 2014[41] | Cloet et al, 2017[6] |
|---|---|---|---|---|---|---|
| Study design | Clinical trial | Clinical trial | Randomized controlled clinical trial | Prospective study | Randomized controlled trial | Controlled clinical trial |
| No. of teeth per group | N=297: anterior (n=85), premolars (n=99), molars (n=113) | N=87: incisors (n=34), canines (n=12), premolars (n=25), molars (n=16) | N=87—Glass fiber: incisor (n=14), canine (n=6), premolar (n=17), molar (n=4); Titanium: incisor (n=12), canine (n=10), premolar (n=19), molar (n=5) | N=52: anterior (n=29), premolars (n=23) | N=72—Glass Fiber (n=37): anterior (n=21), posterior (n= 16); Cast metal (n=35): anterior (n=19), posterior (n=16) | N=191—Cast gold alloy –based post and cores (n =100): anterior (n=40), posterior (n=60); Prefabricated glass fiber post (n=65): anterior (n=16), posterior (n=49); Custom-made glass fiber post (n=26): anterior (n=12), posterior (n=14) |
| Participants' age (range and mean ±SD) (in years) | 17-71 years/mean age 36 years | 23-78 years/average of 53 | Glass fiber: 49.2 ±14.8; Titanium: 52.3 ±14.2 | Mean of 54.1 | 42.7 ±11.2 | 18-80 years/47 ±8.7 |
| Participants | 257 | 87 | 87 | 42 | 54 | 131 |
| No. of male participants (%) | 38.13 | 36.78 | Glass fiber: 55.6; Titanium: 45.7 | 42.9 | 16.6 | 47 |
| No. of posts per participant | NR | 1 | 1 | NR | NR | 71% had 1 restoration only, whereas 18%, 8%, 2%, and 1% of the patients had 2, 3, 4, and 5 restorations, respectively |
| Type of post/ commercial brand | Cast post-and-core restoration: Cendres et Métaux prefabricated cast-on post; Prefabricated metal post: Radix or RS prefabricated post (Maillefer) | Zircon-rich glass fiber post: Snowpost (Carbotech) | Prefabricated glass fiber-reinforced epoxy resin: Fiberpoints Root Pins Glass (Schütz Dental Group); Prefabricated titanium post: Fiberpoints Root Pins Titanium (Schütz Dental Group) | Carbon fiber posts: Composipost (Recherches Techniques Dentaire, RTD) | Glass fiber: White Post DC (FGM); Cast metal: CoCr | Gold alloy–based wrought post with cast cores: ParaPost (Coltène) and Medior 3 (Cendres+Métaux); Prefabricated glass fiber post: ParaPost Fibrelux (Coltène); Custom-made glass fiber post: everStick (StickTech) |
| Customized or prefabricated | Customized/ prefabricated | Prefabricated | Prefabricated | Prefabricated | Customized/ prefabricated | Customized/prefabricated |
| Luting agent | NR | Self-adhesive resin cement (RelyX Unicem) | Self-adhesive resin cement (RelyX Unicem) | Dual-polymerizing resin cement (C&B Metabond) | Glass fiber posts: self-adhesive resin cement (RelyX U100) or dual-polymerizing resin cement (RelyX ARC) Cast metal posts: self-adhesive resin cement (RelyX U100) | Dual-polymerizing resin cement (Panavia F2.0) |
| Core build-up material | Cast core or composite core-restoration (Clearfil Core) | All-in-one light-polymerizing adhesive for enamel and dentin (Excite) and flowable resin composite (DentoCore Automix) | Direct composite cores using an etch-and-rinse adhesive (NewBond and Clearfil Core) | NR | NR | Direct composite cores (Clearfil AP-X) bonded with a self-etch adhesive system (Clearfil SE Bond) |
| Type of coronal restoration | Metal or metal-ceramic crowns | Metal-ceramic or ceramic crowns | Metal-ceramic crowns | Metal-ceramic crowns | Single metal-ceramics | Ceramic single crowns |
| Post length | NR | 19 mm | 9 mm | NR | NR | NR |
| Apical seal (root canal filling) | NR | At least 4 mm | At least 4 mm | NR | NR | NR |
| Type of cement | NR | NR | NR | NR | NR | NR |
| Endodontic therapy | NR | The walls of the root canals enlarged with low-speed burs provided by the manufacture. The root canal was treated with 5% sodium hypoclorite, and coronal dentin was etched with | NR | NR | Crown down technique and irrigation with 2.5% NaOCl solution | NR |

(*continued on next page*)

**Supplemental Table 2.** (*Continued*) Summary of studies selected for systematic review and meta-analysis

| Study ID | Fokkinga et al, 2007[38] | Mancebo et al, 2010[39] | Sterzenbach et al, 2012[40] | Glazer 2012[37] | Sarkis-Onofre et al, 2014[41] | Cloet et al, 2017[6] |
|---|---|---|---|---|---|---|
| | | 37% phosphoric acid for 15 seconds, rinsed with a water spray, and dried with air and papers point | | | | |
| Who made restorations | NR | One operator (with more than 15 years of experience) | Dental students of department of operative dentistry and periodontology | One investigator with over 30 years of clinical experience | Predoctoral and graduate students | 29 operators, all of whom were graduated dentists employed at the Unit of Prosthetic Dentistry |
| Who evaluated restorations | The current dentists monitoring the oral health of the patients | One previously trained examiner | 1 blinded dentist who was briefed by 1 operator | The author | Two calibrated independent examiners | Blinded operator |
| Evaluation criteria | Failure rate | Failure rate | Failure rate | Failure rate | Failure rate | Failure rate |
| Follow-up period | 9 years (mean: 8.8 years; range: 0.8-17 years) | 3 years | 5.9 years | 3.75 years | 3 years | 5 years (mean: 5.8 years; range: 0.5-7.2 years) |
| Failure rate (%) | Cast post-and-core: Ant 34.5% (5 failures of 40), Post 19.3% (15 failures of 78); Prefab metal post: Ant 22.86% (8 failures of 35), Post 23.8% (25 failures of 105) | Incisor 26.5% (9 failures of 34); canine 0% (0 failure of 12); premolar 8% (2 failures of 25); molar 18.8% (3 failures of 16) | Glass fiber: incisor 7.1% (1 failure of 14), canine 16.7% (1 failure of 6), premolar 11.8% (2 failures of 17), molar 0% (0 failure of 4); Titanium: incisor 16.7% (2 failures of 12), canine 0% (0 failure of 10), premolar 0% (0 failure of 19), molar 20% (1 failure of 5) | Anterior 3.45% (1 failure of 29), premolars 13.1% (3 failures of 23) | Glass fiber: anterior 4.8% (1 failure of 21), posterior 12.5% (2 failures of 16); Cast metal: anterior 0% (0 failure of 19), posterior 6.2% (1 failure of 16) | Cast gold alloy–based post and cores: 30% anterior (12 failures of 40), 20% posterior (12 failures of 60); Prefabricated glass fiber post: 25% anterior (4 failures of 16), 18.4% posterior (9 failures of 49); Custom-made glass fiber post: 41.7% anterior (5 failures of 12), 0% posterior (0 failure of 14) |
| Reasons for failure | Fracture, dislodgement of post-and-core and crown, caries at crown margin, crown replacement | Caries, crown decementation, post decementation, root fracture, post fracture, periapical lesion, marginal gap | Endodontic failure, root fracture, core fracture, tooth mobility | Biological (presence of pathology due to caries, periodontal disease, or endodontic failure); mechanical (debonding of any part of the tooth-post-core-crown complex or the presence of fracture) | Debonding, root fracture | Root fracture, post fracture into the root canal, caries, periodontal failure, loss of retention of the post, endodontic failure, and post fracture requiring post replacement |

ID, identification; SD, standard deviation; NR, not reported.