Remaining Coronal Dentin and Risk of Fiber-Reinforced Composite Post-Core Restoration Failure: A Meta-analysis

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Purpose: The amount of coronal residual structure has been recognized as critical to the survival probability of pulpless teeth. The aim of this study was to analyze whether and how coronal dentin loss would affect the failure rate of fiber-reinforced composite (FRC) post-core restorations. ***Materials and Methods:*** Eligible studies were searched in PubMed, Cochrane Library, Embase, and China National Knowledge Infrastructure databases from their inception through April 2014. The risk ratio with 95% confidence interval (CI) was estimated using the Mantel and Haenszel method. ***Results:*** Five studies were included in this meta-analysis. The risk ratio for coronal wall absence was 2.73 (95% CI: 1.48–5.03). The risk ratio for ferrule absence was 1.94 (95% CI: 0.57–6.54). ***Conclusions:*** This meta-analysis of the limited studies available suggested that coronal wall absence might increase the risk of FRC post-core restoration failure, while the role of ferrule effect is still not entirely understood. *Int J Prosthodont 2015;28:258–264. doi: 10.11607/ijp.4157*

Endodontically treated teeth often suffer from extensive structural defects because of access cavity preparation, caries, prior restoration, and trauma. To restore these teeth, post-and-core techniques are widely used and have proven to be effective.[1]

Fiber-reinforced composite (FRC) posts, an alternative to traditional cast or prefabricated metallic posts, were introduced in the 1990s and became popular from then on.[2] Compared with cast metal posts, FRC posts present similar mechanical properties to those of dentin and can distribute stresses to the root more uniformly and decrease the occurrence of root fracture[3–5]; however, they can also increase stress concentration in cervical dentin and the margin of the restoration.[6] In addition, FRC posts are esthetic, handy, and removable.[7]

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Several clinical trials reported different failure rates for postendodontic restorations, which suggests that the amount of coronal residual structure as critical to the survival probability of pulpless teeth.[8–13] Moreover, preservation of "ferrule," a circumferential dentin collar of at least 2 mm in height, has been emphasized as the critical condition for the success of post-core restoration. Some in vitro and in vivo studies have shown that the ferrule might have a positive effect on the fracture resistance of the abutment tooth, the retention of the post-core, and the functioning of post endodontic restorations.[14–17]

The aim of this meta-analysis was to investigate whether and how coronal dentin loss would affect the failure risk of FRC post-core restorations. By taking root canal–treated teeth with structural loss in varying degrees and restoring them with FRC post-core restorations as research objectives, this study compared the failure rate of those teeth without coronal walls or ferrule with those teeth with more than one coronal wall or ferrule. Meta-analysis, which is a reliable method of synthesizing published information and providing direct evidence to clinical practice,[18] was conducted to assess the inconsistent results from related published studies.

Materials and Methods

Literature Search and Inclusion Criteria

PubMed, Cochrane Library, Embase, and China National Knowledge Infrastructure databases (from

their inception to April 2014) were searched to identify relevant studies that compared different failure rates of FRC post-core restorations with coronal dentin/ferrules (present and absent). Complying with the participant, intervention, comparison, outcome, study design (PICOS) principle, teeth restored with FRC post-core were considered to be the participants, teeth without coronal dentin wall/ferrule were considered to be the intervention, teeth with more than one coronal dentin wall/ferrule were used as comparison, restoration failure was taken as outcome, and cohort studies or randomized clinical trials (RCTs) and nonrandomized controlled clinical trials (CCTs) were considered to be the study design. Thus, the search themes were combined as "(fiber OR fibre) AND (post OR dowel) AND (tooth OR restoration OR crown) AND (coronal OR wall OR ferrule) AND (failure OR success OR survival)," with language restricted to English. Reference lists of reviews identified in the literature search were hand searched for additional studies. If duplicated data were presented in several studies, only the most recent or most complete study was included.

Two reviewers independently assessed and selected the studies on the basis of the following inclusion criteria: *(1)* investigating failure rates of FRC post-core restoration with coronal dentin/ferrule present and absent, *(2)* using coronal dentin loss as a controlled variable in cohort studies or RCTs and CCTs, and *(3)* providing the detailed data of each group and subgroup. Studies were excluded if they were *(1)* in vitro studies; *(2)* not using FRC post-core; *(3)* not related to coronal wall or ferrule effect; *(4)* studies with no detailed data of each group or subgroup; *(5)* case reports, reviews, or abstracts.

Data Extraction

Two reviewers independently extracted the data for each study, including the name of the first author, year of publication, location, study design, number of patients and restorations, patients' gender and age, number of failures, tooth type, restoration type, and follow-up time. Newcastle-Ottawa Scale (NOS)[19] was applied to estimate the quality of the included studies.

Meta-analysis

The meta-analysis was performed using Revman 5.2.6 software provided by the Cochrane Collaboration. Dichotomous data were expected for the numbers of failures of the restorations. I^2 statistics, a quantitative measure of inconsistency across studies, were calculated to quantify the proportion of the total variation due to heterogeneity.[20] The risk ratio, with a 95% confidence interval (CI), was estimated using the Mantel and Haenszel method.[21] In the presence of substantial heterogeneity (> 50%, based on I^2 results), the random effect model (REM) was adopted as the pooling method, along with a 95% CI. Forest plots were created, which show the effect estimate, level of variability around that estimate for each study, and the weight given to each study in the meta-analysis, along with the overall pooled result. The level of statistical significance was set at 0.05 and a 95% CI was quoted throughout. Funnel plots were created to show the publication bias visually, while Begg and Egger's unweighted regression tests were carried out with STATA version 12.0 (Stata) to evaluate the publication bias statistically.[22,23]

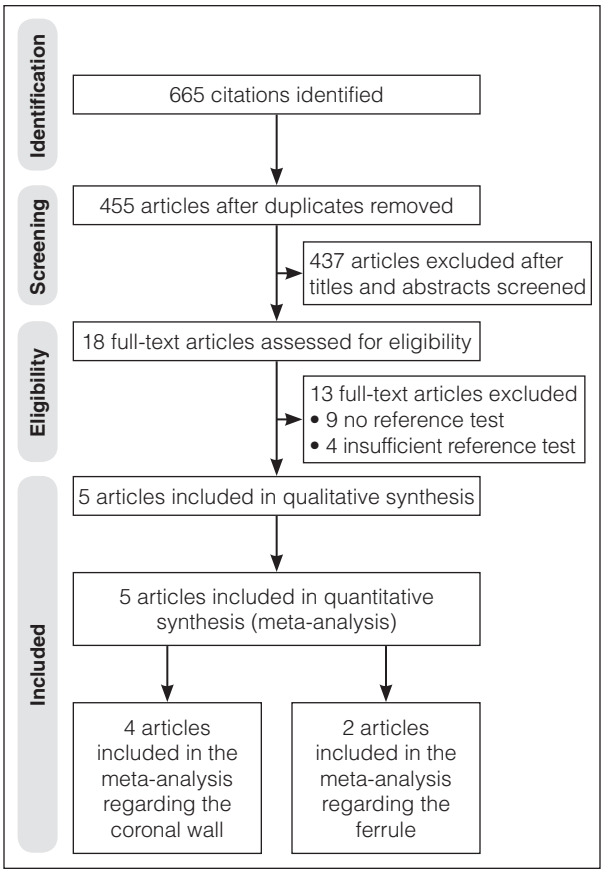

Fig 1 Flowchart of selection of studies for inclusion in meta-analysis.

Results

Identification of Eligible Studies

The literature search identified 665 citations, of which 18 were selected after reviewing titles and abstracts; others were excluded mainly because they were in

Table 1 Characteristics of Studies Included in This Meta-analysis

Study	Location	Study design	Sample size (no. of patients/ no. of teeth)	Sex (M/F)	Average age (y) (range)	Tooth type	Restoration type	Mean or median follow-up time
Ferrari et al[24]	Italy	RCT	345/360	NA	58 (18–76)	Premolar	Single-unit porcelain-fused-to-metal crowns	6 y
Signore et al[25]	Italy	CS	144/164	63/81	56 (18–72)	Premolar	All-ceramic crowns	42 mo
Naumann et al[26]	Germany	CS	119/149	52/67	53 (15–98)	63 anterior, 86 posterior	Single crowns, fixed partial dentures, combined fixed and removable partial dentures	105 mo
Bitter et al[27]	Germany	RCT	90/120	41/49	50 (20–80)	25 anterior, 95 posterior	Direct composite restorations, partial crowns, full crowns	32 mo
Mancebo et al[28]	Spain	CS	87/87	32/55	53 (23–78)	46 anterior, 41 posterior	Metal-ceramic or all-ceramic crowns	3 y

M = male; F = female; RCT = randomized controlled trial; CS = cohort study; NA = not available.

Table 2 Newcastle-Ottawa Scale Scores for Assessment of the Quality of the Included Studies

Study	Selection	Comparability	Outcome	Total
Ferrari et al[24]	3	0	3	6
Signore et al[25]	4	0	3	7
Naumann et al[26]	4	0	3	7
Bitter et al[27]	4	0	3	7
Mancebo et al[28]	4	0	3	7

vitro studies or not relevant to this analysis. After full-text reviewing, 5 studies meeting the inclusion criteria were included in the meta-analysis.[24–28] A detailed flowchart of the selection process is shown in Fig 1.

Study Characteristics

The characteristics of the five included studies were reported individually in Table 1. These studies were published between 2009 and 2012. Among these studies, three were cohort studies and two were RCTs using coronal dentin loss as a controlled variable. Meanwhile, three of five studies investigated coronal wall effect, one study investigated ferrule effect, and one investigated both. The NOS scores assessing the quality of the included studies are shown in Table 2.

Coronal Wall and Risk of Restoration Failure

A total of 573 restorations were included in the four studies investigating the relationship between coronal wall and risk of restoration failure. These four studies were heterogeneous (Tau^2 = 0.19, Chi^2 = 7.49, degrees of freedom = 3, P = .06, I^2 = 60%). Since substantial heterogeneity was observed, the REM was used for combining study estimates. The total risk ratio was 2.73 (95% CI: 1.48–5.03). The test of overall effect showed the risk of restoration failure was significantly higher for teeth without a coronal wall than teeth with more than one coronal wall (P = .001; Fig 2).

Ferrule and Risk of Restoration Failure

A total of 156 restorations were included in the two studies investigating the relationship between ferrule and risk of restoration failure. As these two studies were heterogeneous (Tau^2 = 0.59, Chi^2 = 3.83, degrees of freedom = 1, P = .05, I^2 = 74%), REM was used for combining study estimates. The total risk ratio was 1.94 (95% CI: 0.57–6.54). The test of overall effect showed no significant difference between the risk of restoration failure for teeth with ferrule and that for teeth without ferrule (P = .29; Fig 3).

Publication Bias

Funnel plots for the four studies about coronal wall and risk of restoration failure were created to show the publication bias visually (Fig 4). The funnel plot was almost symmetric. Meanwhile, both Begg's and Egger's tests in the meta-analysis indicated no significant publication bias (Begg's test, P = .734; Egger's test, P = .948). Because there were only two studies about the ferrule and risk of restoration failure, no funnel plot was created.

Discussion

Level of Evidence

Three of the included studies were prospective cohort studies, grouping the participants according to the degree of coronal dentin loss. The other two studies

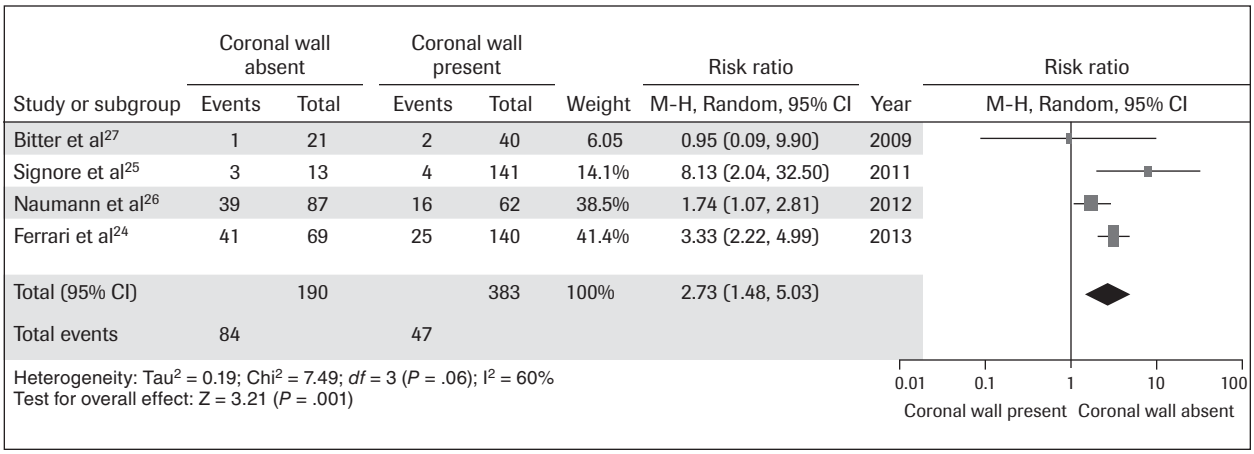

Fig 2 Forest plot showing the relationship between coronal wall and risk of restoration failure.

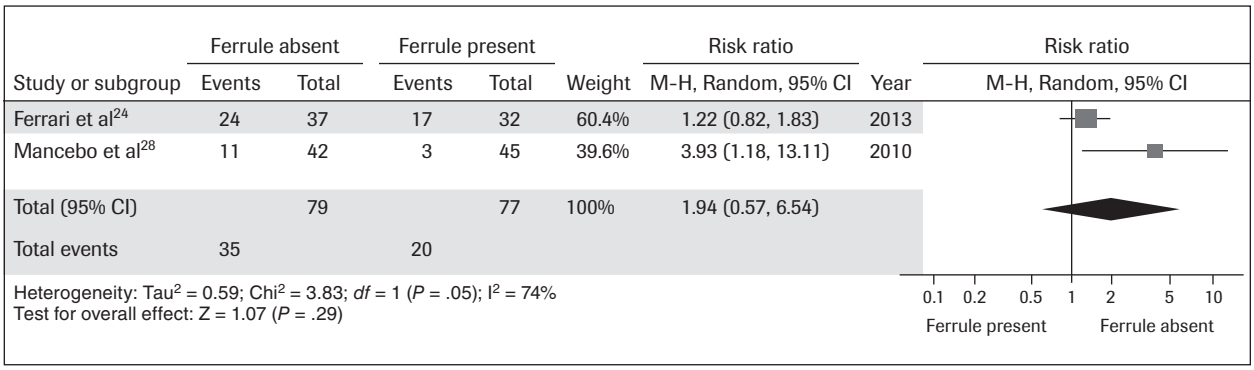

Fig 3 Forest plot showing the relationship between ferrule and risk of restoration failure.

were RCTs, in which participants were divided into treatment group (FRC post-core and crown restored) and control group (no post-core, directly crown restored) in a randomized manner. Meanwhile, the degree of coronal dentin loss was used as a control variable to divide patients into different subgroups. The NOS score of the included studies ranged from 6 to 7 (of a total of 9), which indicated that the quality of the included studies was acceptable, but all of the studies scored 0 in "comparability," showing the lack of controls for confounding factors.

Heterogeneity

The forest plot (Figs 2 and 3) showed the heterogeneity between the included studies. In Fig 2, there was one study showing opposite results from the others. After investigating this study,[27] a distinct difference from other studies was found in the design. For instance, the definition of "coronal wall" used in this study[27] applied "coronal wall exceeding 2 mm above the gingival level" as the criterion, whereas the other three studies used the whole coronal wall as the criterion. This might be a possible reason for the higher failure rate among the group with coronal walls present in this study and may have led to results being different from other studies.

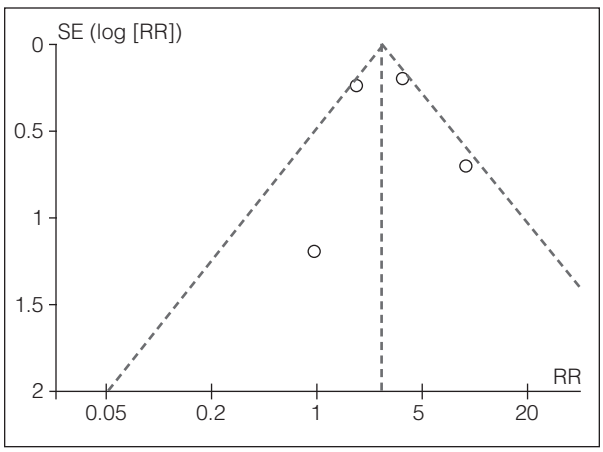

Fig 4 Funnel plot with 95% confidence interval of coronal wall studies for assessment of publication bias. RR = risk ratio.

Publication Bias

Publication bias is the tendency that studies with positive results are more likely to be published than those with negative results, which could falsely skew the conclusion of meta-analysis in either direction. Funnel plots are a common way to test whether publication bias exists. Since only four of the included studies were analyzed, no obvious bias could be observed from the funnel plot. Meanwhile, both Begg's and Egger's tests in the meta-analysis indicated no significant publication bias ($P > .05$). In this meta-analysis, only published clinical trials were included, which may have increased the risk of publication bias by neglecting unpublished studies. Moreover, the searching limitation and the language restriction also might increase the publication bias.

The Relationship Between Coronal Wall and FRC Post-Core Restoration Failure

Although many in vivo and in vitro studies have investigated the effect of coronal walls on FRC post-core restorations, a comprehensive and quantitative summary on this topic is still lacking.

Laboratory and clinical studies have suggested that the amount of retained coronal tooth structure may influence the failure risk of postendodontic restorations. Several in vitro loading tests have focused on whether increasing the number of residual coronal walls could improve the fracture resistance of endodontically treated teeth restored with FRC post-core, and some of them found significant influence[29–31] while some did not.[32] Three-dimensional finite element analysis (3D FEA) also has been conducted to evaluate the effects of the amount of remaining coronal dentin on the biomechanical behavior of endodontically treated teeth, suggesting the presence of 2.0-mm coronal remnants decreased strains within the root.[33] Some clinical trials also showed that endodontically treated teeth without a coronal wall were more likely to suffer from post-core fracture and debonding than teeth with more than one coronal wall.[8–13] Two of these clinical trials showed that the survival rate was higher for teeth retaining more coronal walls than those with fewer coronal walls.[10,12] Another study about acrylic resin cores collected survival data of metal post and acrylic resin core restorations and found the absence of remaining coronal dentin was a significant risk factor for core failure.[11] There were also some other studies observing the clinical behavior of FRC posts and cores, which pointed out that mechanical failure of teeth restored with fiber posts often occurred in teeth that suffer from substantial coronal dentin loss.[8,9,13] On the other hand, there was an RCT that concluded that the degree of coronal dentin destruction did not influence the survival of FRC post-and-core restorations.[34]

The overall estimates of this meta-analysis provided evidence that coronal wall absence from the tooth was significantly associated with increased risk of FRC post-core restoration failure. The risk ratio value was 2.73, which suggested a moderate intensity of correlation between coronal wall absence and FRC post-core restoration failure.

Since there were only four studies included in this meta-analysis, conclusions based on these results should be interpreted with caution. However, despite the limitations, the findings of this study can be used for clinical decision making when integrated with the doctor's consideration of the patient's individual situation.[35] The FRC post-and-core method is getting more and more popular in treating defected teeth, especially for esthetic restorations on anterior teeth. FRC posts present a similar elastic modulus to that of dentin, which could be the most remarkable advantage, but in some ways the disadvantage. FEA analysis suggested that FRC posts could more uniformly distribute stresses to the root, especially when it comes to the weakened roots or curved roots, for which FRC posts could be a more suitable choice than metal posts.[36,37] On the other hand, FRC posts could increase stress concentration on cervical dentin and margins of the restoration.[6] Moreover, FRC posts actually could not strengthen the teeth,[38] while stiffer posts may increase the strength but introduce other problems like root fracture.[3,4] Thus, clinicians should seek a balance between FRC posts and metal posts when making clinical decisions. As a result of this study, FRC post-and-core restorations should be used with strict indications. When restoring teeth with extensive destruction, especially when all coronal walls are absent, the FRC post should be considered carefully before use. Furthermore, larger amounts of well-designed clinical studies are needed to confirm the present findings and clarify the relationship between the exact number of coronal walls and FRC post-core restoration failures.

The Relationship Between Ferrule and FRC Post-Core Restoration Failure

There were some in vitro studies focusing on the effect of ferrule on FRC post-core restorations, but clinical trials were few due to limitations such as difficulty to collect suitable cases and medical ethics principle.

Some laboratory studies have shown that the ferrule effect in the endodontically treated teeth positively affects the fracture strength of the fiber post restorations,[39–41] whereas some other studies drew

conflicting conclusions.[42–45] Meanwhile, a 3D FEA study revealed that ferrule effect in teeth restored with posts and cores has a critical influence on stress reduction in the root.[46]

The overall estimates of this meta-analysis provided no significant difference between the failure risk of FRC post-core restored teeth with ferrule and that of teeth without ferrule.

The two included studies had entirely different results. One of the included studies indicated that endodontically treated teeth restored with FRC post-core with ferrule present or absent showed different failure rates,[28] whereas the other one did not.[24] According to the researchers' explanation, the amount of coronal dentin left was estimated before abutment preparation; therefore, the amount of ferrule was probably overestimated in that study, which might cause the indiscrimination of the failure rates for these restorations.[28] Within the limitations of the two studies, no significant influence of ferrule was found, but no definite implication for practice could be made due to the small number of the included studies.

Although the importance of ferrule effect was highlighted in in vitro studies,[47] it has not been widely taken into account in clinical research. Besides the two included studies, research about the clinical performance of composite resin core restorations concluded that the preservation of ferrule seems to be critical to the long-term survival of endodontically treated crowned teeth.[48] In the future, more clinical trials should shed light on the protective role of the ferrule for FRC post-core–restored pulpless teeth.

Conclusions

Considerable research has been done to expound on the relationship between remaining coronal dentin and the risk of restoration failure; however, there is still a lack of well-designed clinical trials. This meta-analysis of the limited studies available suggested that coronal wall absence might increase the risk of FRC post-core restoration failure, while the role of ferrule effect is still not entirely understood. More clinical trials are needed to determine the effect of remaining coronal dentin on the risk of FRC post-core restoration failure.

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