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Review Article

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Survival rates against fracture of endodontically treated posterior teeth restored with full-coverage crowns or resin composite restorations: a systematic review

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No potential conflict of interest relevant to this article was reported.

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ABSTRACT

This systematic review aims to summarize the current clinical studies that investigated survival rates against fracture of endodontically treated posterior teeth restored with crowns or resin composite restorations. Literature search were performed using keywords. Publications from 1980 to 2016 were searched in PubMed, ScienceDirect, ISI Web of SCIENCE, MEDLINE, and SCOPUS. Included studies were selected based on inclusion and exclusion criteria. Three clinical studies were included: 1 randomized controlled trial and 1 prospective and 1 retrospective cohort studies. Pooled survival rates ranged from 94%–100% and 91.9%–100% for crowns and resin composite, respectively. The majority of teeth had no more than 3 surface loss of tooth structure. The studies included were heterogeneous, and were not appropriate for further meta-analysis. Current evidence suggested that the survival rates against the fracture of endodontically treated posterior teeth restored with crowns or resin composites were not significantly different in the teeth with minimum to moderate loss of tooth structure.

Keywords: Composite resins; Crown, dental; Survival rate; Tooth, non-vital; Tooth fractures

INTRODUCTION

Endodontically treated tooth (ETT) is primarily weakened due to dental caries, trauma, or pre-existing restorations [1-3]. Tooth fracture usually occurs when the ETT is not immediately or properly restored, which leads to unrestorable fracture or root canal retreatment due to coronal leakage [4]. Success rate in ETT with immediate permanent restorations is higher than those with long-term provisional restorations, especially in the posterior teeth with excessive loss of tooth structure [5,6].

For posterior ETT, a post-endodontic restoration with cuspal protection is traditionally recommended to reduce the potential of tooth fracture [7,8]. Incidence of tooth fracture after endodontic treatment was lower in posterior teeth with cuspal protection; cuspal-coverage restoration significantly improves clinical success in posterior ETT [9-11].

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Recently, it has been proposed that posterior ETT with minimum to moderate loss of tooth structure may be successfully restored with adhesive resin composite restoration [12]. Similar clinical success rates between crown and resin composite restorations in premolar ETTs with loss of 1 or 2 marginal ridges were reported [13]. However, the clinical implication of this concept is still controversial.

In the evidence-based medicine, a systematic review collects and critically analyzes all relevant research studies in order to gather a summary of the specific subject. From Cochrane Database of Systematic Review, there is a current systematic review that reported the effects of post-endodontic restorations, crowns, and direct resin composites, on the outcome of ETT [14]. Due to the strict criteria for the study selection, the result was only summarized from one randomized controlled trial that investigated in the premolars with no more than 3 surfaces loss [13]. The study reported similar success rate between the ETT restored with resin composites and crown restorations at 3 years.

Clinical decision making for selection of a final restoration in posterior ETT is mainly based on the limited current clinical evidence [9,11,13]. Systematic reviews generally include only randomized controlled trials in the analysis [14]. However, randomized controlled trial needs time and budget to establish, so the number of study is sometimes rare in a specific topic such as for post-endodontic restoration. In such circumstances, a high-quality retrospective or prospective cohort study could be included to increase the number of selected studies and provide more information in systematic review. Therefore, the purpose of this systematic review was to summarize the current available clinical studies on the survival rates against fracture of posterior ETT using a systematic approach.

MATERIALS AND METHODS

Research question

For the systematic review, a research question was firstly set based on the PICO model:

P (population): endodontically treated posterior permanent teeth (with mature root formation).
I (intervention): post-endodontic restoration with non-cuspal coverage, direct resin composite.
C (comparison): post-endodontic restoration with full-coverage crown.
O (outcome): survival rate against fracture.

Therefore, the research question was "Are survival rates against fracture of endodontically treated posterior teeth restored with non-cuspal coverage direct resin composite similar to those restored with full-coverage crown?".

Literature search

Literature electronic search was performed in PubMed, ISI Web of SCIENCE, ScienceDirect, SCOPUS, and MEDLINE from the period of 1980 to 2016. The search was limited to clinical studies in the English language. Based on the question, the 17 keywords and MeSH terms were used as follows: 1) endodontically treated teeth, 2) root canal treated teeth, 3) root filled teeth, 4) non-vital teeth, 5) pulpless teeth, 6) cuspal coverage, 7) crown, 8) dental crown, 9) resin composite, 10) non-cuspal coverage, 11) conventional filling, 12) direct restoration, 13) fracture, 14) survival rate, 15) cumulative survival rate, 16) mean survival, and 17) treatment outcome. Final search was obtained with combination strategies of the 17 key terms: (1 OR 2

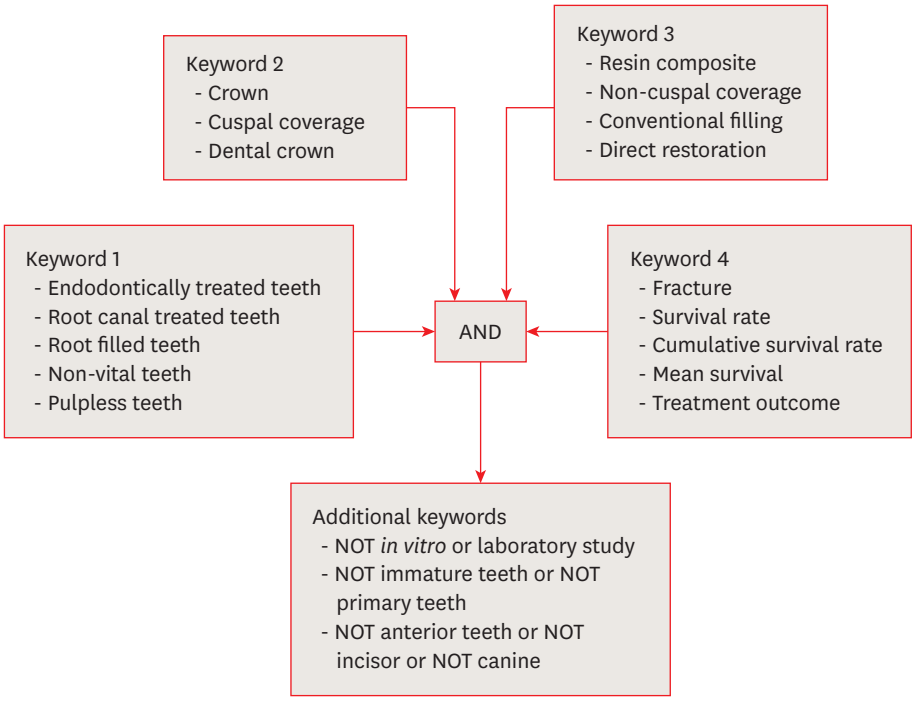

Figure 1. The combination strategies for literature search.

OR 3 OR 4 OR 5) AND (6 OR 7 OR 8) AND (9 OR 10 OR 11 OR 12) AND (13 OR 14 OR 15 OR 16 OR 17). The search result was filtered with additional keywords as follows: NOT *in vitro* or NOT laboratory study, NOT immature teeth or NOT primary teeth, NOT anterior teeth or NOT incisor or NOT canine. All keywords and combination strategies are shown in **Figure 1**.

Study selection and data collection

Titles and abstracts of the searched studies were screened by a reviewer (W.S.) based on the inclusion criteria:

1. Clinical study on posterior ETTs with indirect full-coverage crowns or direct non-cuspal coverage resin composite restorations, presenting comparison of survival rates.
2. The clinical study could be randomized or non-randomized controlled trials, or retrospective or prospective cohort studies.

The studies that did not correspond with inclusion criteria, *i.e.*, case reports, case series, literature reviews, systematic reviews, or meta-analyses were not selected. In addition, manual search was performed on the cited references and citations of the selected studies to find any potentially relevant studies that were not initially found in the electronic search. Full articles of the included studies were screened, and the studies were further excluded if based on exclusion criteria:

1. No evaluation of survival rate against fracture.
2. No detail on the types of post-endodontic restoration.
3. Tooth types were combined between anterior and posterior teeth.

The reasons for study exclusion were recorded. Finally, details of the included studies were collected including publication date, study design, number and type of teeth, type

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Table 1. Levels of evidence and definitions based on the Oxford Centre for Evidence Based Medicine (OCEBM) Levels of Evidence [15]

Level	Definition
1	Systematic review of randomized trials or n-of-1 trials
2	Randomized trial or observational study with dramatic effect
3	Non-randomized controlled cohort/follow-up study
4	Case-series, case-control studies, or historically controlled studies
5	Mechanism-based reasoning

of restorations, type of posts, number of tooth surface loss, evaluation criteria, statistical methods, survival rates from fracture, and follow-up periods.

Level of evidence (LOE) assessment

LOE (**Table 1**) of the included studies were justified following the criteria of Oxford Centre for Evidence Based Medicine (OCEBM) Levels of Evidence [15].

RESULTS

Literature search results and study selection

An overview of literature searching and study selection for the systematic review is presented in **Figure 2**. From the studies published from 1980 to 2016, 404 articles were initially identified through electronic search in the 6 databases. After screening, 38 duplicated articles were removed, and 366 potentially relevant articles remained. The titles and abstracts of these articles were assessed according to the inclusion criteria, and 360 articles were not included. The reasons for removing these studies are presented in **Figure 2**.

Six articles were included from the electronic search. From the manual search, 3 more relevant articles, according to the inclusion and exclusion criteria, were additionally included. These 9 selected studies [9,11,13,16-21] were qualified for full-text review. Six studies [9,11,18-21] were further excluded following the exclusion criteria because of insufficient data as shown in **Table 2**. Finally, 3 studies [13,16,17] were included in this systematic review.

Information of the included studies

LOE of 3 included studies are shown in **Table 3**. These studies were published between 2002 and 2013, and directly compared the survival rates against fracture of posterior ETT between full-coverage crowns and direct resin composite restorations. These studies were 1 randomized controlled trial (Mannocci *et al.* [13]; LOE level 2), 1 prospective cohort study (Cagidiaco *et al.* [16]; LOE level 3), and 1 retrospective cohort study (Dammaschke *et al.* [17]; LOE level 3).

Posterior ETTs in the studies of Cagidiaco *et al.* [16] and Dammaschke *et al.* [17] were premolars and molars, while the study of Mannocci *et al.* [13] investigated premolars. From the 3 studies, the number of teeth restored with full-coverage crowns ranged from 57 to 364 teeth, and those restored with resin composite restorations ranged from 19 to 60 teeth. The pooled samples composed of 507 teeth restored with full-coverage crowns and 116 teeth restored with resin composite restorations. Types of post used in the studies of Mannocci *et al.* [13] and Cagidiaco *et al.* [16] were prefabricated fiber posts. Prefabricated fiber post, cast metal post or core built-up without post were used in the study of Dammaschke *et al.* [17]. Criteria of survival against fracture were identified as shown in **Table 3**.

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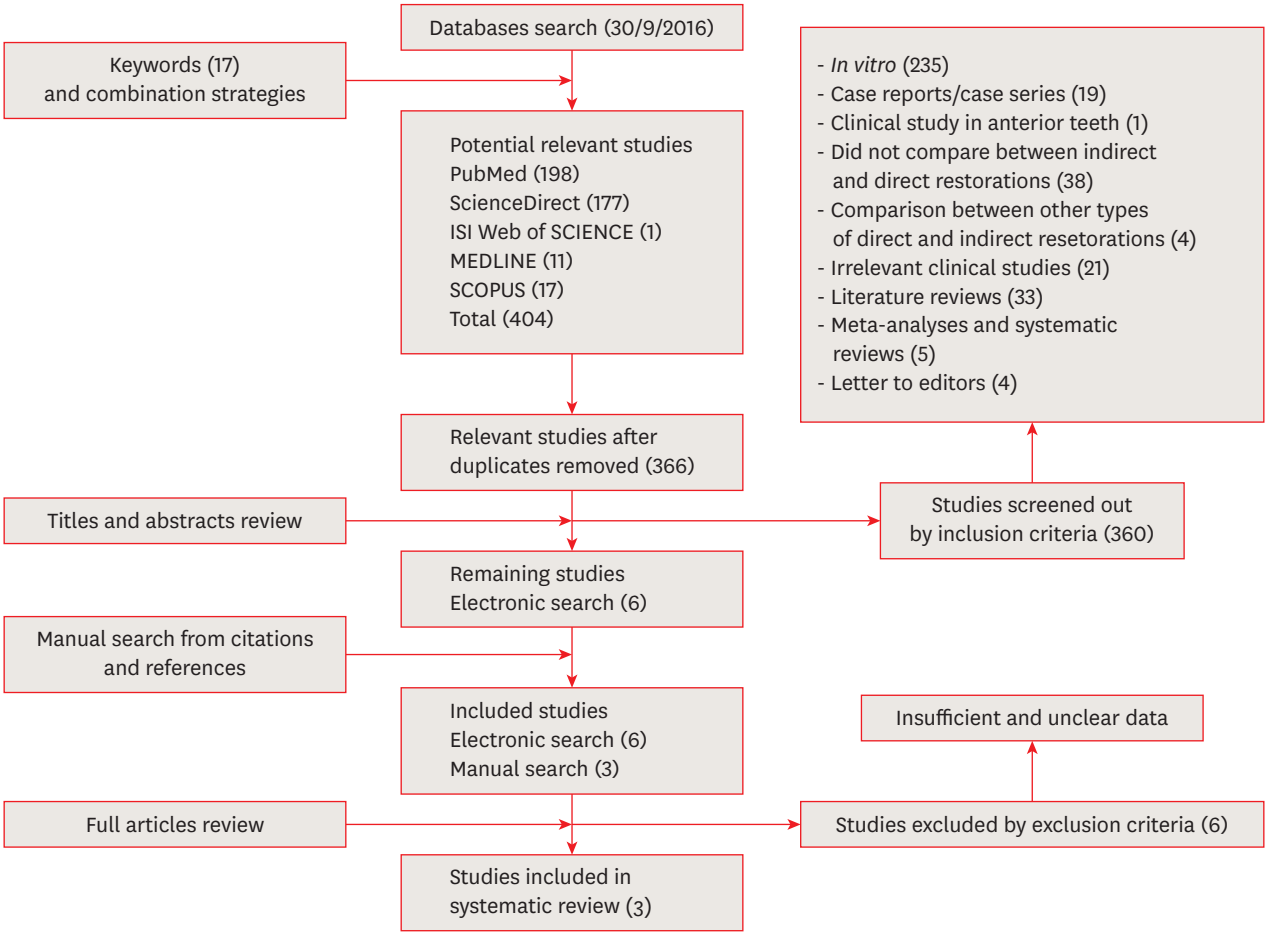

Figure 2. Overview of literature search and study selection for systematic review.

Table 2. Six excluded studies after full paper reviewing and reasons for exclusion

Study	LOE	Study design	Reasons for exclusion
Pratt *et al.* [18]	3	R	· Could not identify definite number and survival rate of resin composite restorations (combined numbers of amalgam and resin composite in direct restorations).
Skupien *et al.* [19]	2	RCT	· Could not identify definite number and survival rate of posterior teeth (combined numbers of anterior and posterior teeth).
Fransson *et al.* [20]	3	R	· Could not identify definite number and survival rate of posterior teeth (combined numbers of anterior and posterior teeth). · Could not identify definite number and survival rate of full-crown or resin composite (including full-crown, inlay and onlay in indirect restorations; combining all types of direct restorations). · Could not identify reasons for tooth extraction.
Skupien *et al.* [21]	3	R	· Could not identify definite number and survival rate of posterior teeth (combined numbers of anterior and posterior teeth).
Aquilino *et al.* [9]	3	R	· Could not identify definite number and survival rate of posterior teeth (combined numbers of anterior and posterior teeth). · Could not identify definite number of resin composite restorations (combined numbers of amalgam and resin composite in direct restorations).
Sorensen *et al.* [11]	3	R	· Could not identify definite number and survival rate of posterior teeth restored with full-coverage crown or resin composite restoration (combining numbers of crown and onlay in cuspal-coverage indirect restoration; combining numbers of amalgam and resin composite in non-cuspal coverage direct restorations).

LOE, level of evidence; R, retrospective cohort study; RCT, randomized control trial study.

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Table 3. Characteristics and survival rates of 3 included studies

Study	LOE	Study design	No. of teeth	Type of teeth	Restoration	Type of post	Criterion of survival from fracture	Statistical method	Survival rate against fracture		F/U period (mon)
									Crown	Composite	
Dammaschke *et al.* [17]	3	R	401	Premolar/ molar	Crown/ bridge (364)	Without post, prefabricated, or cast metal post	Fracture of tooth and/or restorations	LR	94%	91.90%	60–192 (Mean 116.4)
					Resin composite (37)	Without post			Mean survival times (mon)		
									152.4–168.0	160.8	
Cagidiaco *et al.* [16]	3	P	105	Premolar/ molar	Crown (86)	Prefabricated fiber post	Post fracture, vertical, or horizontal root fracture	χ^2	100%	100%	24
					Resin composite (19)	Prefabricated fiber post					
Mannocci *et al.* [13]	2	RCT	117	Premolar	Crown (57)	Prefabricated fiber post	Root fracture, post fracture	1-way ANOVA	100%	100%	12, 24, 36
					Resin composite (60)	Prefabricated fiber post					

LOE, level of evidence; F/U, follow-up; R, retrospective cohort study; LR, log-rank test; P, prospective cohort study; RCT, randomized control trial study; ANOVA, analysis of variance.

Table 4. Number of teeth restored with resin composite restorations according to the number of tooth structure loss (surfaces) from the 3 included studies

Clinical study	No.	1–3 surfaces loss		4–5 surfaces loss	
		No.	%	No.	%
Dammaschke *et al.* [17]	37	31	83.8	6	16.2
Cagidiaco *et al.* [16]	19	19	100.0	0	0
Mannocci *et al.* [13]	60	60	100.0	0	0
Total	116	110	94.8	6	5.2

The posterior ETTs in the 2 studies, Mannocci *et al.* [13] and Cagidiaco *et al.* [16], had 1 to 3 surfaces loss, while the posterior ETTs in the study of Dammaschke *et al.* [17] had 1 to 5 surfaces loss. Most of the teeth restored with resin composite restorations had 1 to 3 surfaces loss of tooth structure. The number of teeth restored with resin composite restorations according to tooth structure loss are shown in **Table 4**.

Overall survival rates against fracture of full-coverage crowns ranged from 94% to 100%, while those of resin composite restorations ranged from 91.9% to 100%. For the short-term follow-up, 2 studies (Mannocci *et al.* [13] and Cagidiaco *et al.* [16]) reported 100% survival at 12–36 months of both full-coverage crowns and resin composite restorations. For the long-term follow-up, the study of Dammaschke *et al.* [17] reported survival rate of 94% for full-coverage crowns and 91.9% for resin composite restorations.

Included clinical studies reported high survival rates against fracture in the posterior ETTs restored with full-coverage crowns and resin composite restorations that were not significantly different. In this systematic review, the heterogeneity of the study designs and methodology were observed among the included studies and, therefore, meta-analysis was not performed.

DISCUSSION

For the posterior ETT, a cuspal-coverage restoration is traditionally recommended after endodontic treatment to prevent tooth fracture and improve long-term success [9-12]. This recommendation has been questioned by the result from a randomized controlled clinical

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trial [13]. From the trial, the posterior ETTs (premolars) with minimal to moderate loss of tooth structure (2–3 surfaces loss) could be successfully restored with direct resin composite as a final restoration [13]. At 3 year recall, the premolars restored with resin composite had a high success rate above 90% that was similar to those with full-coverage crowns. This study was included in the previous systematic review by the Cochrane Database of Systematic Review [14]. In our systematic review, the study of Mannocci *et al.* [13] was identified as the highest LOE among the 3 included studies. The indifference in survival against from fracture between direct resin composite and crown restoration was supported by the results of the 2 included cohort studies [16,17].

The 2 cohort studies (Cagidiaco *et al.* [16] and Dammaschke *et al.* [17]) were also included in the present systematic review, while the previous systematic review [14] included only a randomized controlled trial. In general, a higher variation in the studied population is expected due to the nature of cohort study. However, the authors decided to include these cohort studies in the systematic review due to the lack of randomized controlled trial; otherwise, only one study would have been included for the analysis. In our systematic review, the number of studied teeth was increased, and the recall period was longer to confirm the short-term result of the randomized controlled trial [13].

The high survival rate of resin composite restorations was also observed in the 2 cohort studies [16,17]. In the randomized controlled trial of Mannocci *et al.* [13], all premolars with resin composite restorations were restored in combination with fiber-post placement. The question is raised whether the fiber post is necessary to achieve the favorable clinical outcome. In the cohort study of Dammaschke *et al.* [17], high survival rate from fracture was confirmed in the ETTs with resin composite and without post placement [17]. This might indicate that the ETTs with 1- to 2-surface resin composite restorations, with or without fiber post, should have high survival rate comparable to the crown restorations.

However, in this systematic review, the indifference between the survival rates of the 2 restorations may have been affected by the tooth selection and the assignment of restorations in the studies. From the 2 cohort studies [16,17], the assignment of the 2 restorations were not controlled, and this might lead to a bias. In those studies, the ETTs restored with resin composite restorations tended to have mild to moderate tooth structure loss (1–3 surfaces), while the ETTs with severe tooth structure loss tended to receive full-coverage crowns. In fact, the more tooth structure remains, the higher chance of survival from fracture is expected [17,22]. Thus, the resin composite group tended to receive a positive effect from these confounding factors. In the randomized control trial [13], the teeth selection was controlled between 2 restorations and included if tooth structure loss was no more than 3 surfaces. However, the results were limited in the premolars that the occlusal force is different from the molars.

Moreover, the numbers of the indirect restorations in the cohort studies were higher than those of the direct restorations, especially at long-term recall periods [16,17]. On the other hand, the number of samples between the direct and indirect restorations were similar in the randomized controlled trial [13] due to the nature of the study. From the 2 cohort studies, direct resin composite restorations were likely to be placed in the ETT with a limited tooth structure loss at short term. Therefore, survival rate of the resin composite group tended to be affected and improved by these positive factors. These might lead to a limitation for generalization, and any clinical implication must be carefully interpreted.

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The remaining tooth structure affects the survival rate against fracture of posterior ETT [1,17,22,23]. The posterior ETTs with 1 to 3 surfaces loss had a significantly higher survival rate than those with more than 3 surfaces loss [17,22,24]. The higher the number of surface loss is, the higher the risk of tooth fracture after post-endodontic restorations is anticipated. For the ETT that has higher amount of residual walls with low or normal occlusal force, higher survival rate against fracture would be expected, regardless of the type of post-endodontic restorations.

Tooth type is also an important factor for the survival rate against the fracture of ETT [7,9]. Several studies reported that the premolar ETT had significantly higher survival rate than the molar ETT [7,9,25]. Occlusal load of posterior tooth is associated with the distance to temporo-mandibular joint. The closer the distance to the fulcrum (temporo-mandibular joint), the higher the mechanical biting force on the tooth is expected [26,27]. It is possible that vertical occlusal forces to the premolars are lower than the molars. However, lateral occlusal forces on premolars are to be higher, and this may have more potential effect on tooth fracture, and should be a concern. Moreover, the smaller size of the occlusal area in premolars withstands less occlusal stress than molars [28]. Therefore, a consideration of survival rate against the fracture in the posterior ETT should be separated between premolars and molars. However, most of the clinical studies presented the survival rate with a combination of premolars and molars [16,17]. Only the study by Mannocci *et al.* [13] specifically reported the survival rate of premolars, but the study did not collect the survival rate of molars.

The placement of a fiber post may affect the survival against the fracture in ETT. In general, posterior ETT does not need a post if the tooth has enough remaining tooth structure to retain a core built-up restoration [12]. From the 2 included studies by Cagidiaco *et al.* [16] and Mannocci *et al.* [13], all the teeth were restored with a placement of fiber post, and 100% survival rate against fracture was observed in both types of restorations. In the study by Dammaschke *et al.* [17], the teeth restored with resin composite restorations without post placement had slightly higher fracture rate than those in the 2 studies. From these results, we may consider the advantage of post placement to provide retention and support of the coronal restoration in posterior ETT. These are supported by the result of a laboratory study that reported the post placement increased fracture resistance and improved stress distribution in the ETT with 2–4 remaining walls [29].

Resin composite restoration is able to reinforce remaining tooth structure of ETT through the concept of adhesion between the restorative materials and tooth substrate [30,31]. In a laboratory study, the fracture resistance of ETT restored with resin composite restoration was similar to that of sound natural tooth [32]. Several retrospective studies reported higher survival against the fracture in the ETT restored with resin composite restorations than those restored with un-bonded amalgam restorations [22,33,34]. However, long-term degradation of bond between the adhesive material and tooth substrate is a concern [35]. This leads to a reduction in bond strength to dentin at long term and, subsequently, fracture strength of the restored tooth [36].

To confirm the result, a randomized controlled trial with long-term follow-up period should be performed. Survival rate in the posterior ETT should be separately investigated between premolars and molars with a consideration of remaining tooth structure or tooth surface loss. In addition, the benefit of post placement in posterior ETT restored with resin composite restoration should be also verified.

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Conclusions

Based on this systematic review, survival rates against fracture of posterior ETT restored with either full-coverage crowns or direct resin composite restorations were not significantly different in the teeth with minimal to moderate loss of tooth structure.

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