Clinical Recommendation for Coronal Restoration of Endodontically Treated Teeth: Direct Resin Composite or Crown/Onlay?

Danuchit Banomyong*[1]

Ornjira Chailert[2]

[1] Private Practice, Bangkok, Thailand

[2] Naval Dental Center, Naval Medical Department, Royal Thai Navy, Bangkok, Thailand

Abstract

A post-endodontic coronal restoration is important to increase the success of endodontic treatment by providing a coronal seal and protection from fracture. The weakening of endodontically treated teeth is caused by significant loss of tooth structure, not from root canal procedures. In other words, the fracture resistance of endodontically treated teeth mainly depends on remaining tooth structure. The teeth with mild to moderate loss of tooth structure may be successfully restored with a bonded restoration (e.g. direct resin composite). In contrast, a more protective restoration such as a crown or onlay/overlay should be placed in the teeth with severely damaged tooth structure. In addition, other risk factors such as tooth type, parafunctional force, or function as abutment for prosthesis should also be considered. In this review, updated clinical guidelines for coronal restoration of endodontically treated anterior and posterior teeth were proposed, based on tooth type and other risk factors.

Keywords: clinical guideline, coronal restoration, dental crown, endodontically treated teeth, resin composite

Correspondence: Associate Prof. Dr. Danuchit Banomyong
Private Practice, Bangkok, Thailand
Email: danuchitb@gmail.com

Received: 13 December 2022 Revised: 11 June 2023 Accepted: 13 June 2023

Introduction

For decades, it has been recommended that endodontically treated teeth should be usually restored and protected by a cuspal- or full-coverage restoration (i.e.- crown or onlay/overlay). However, from recent clinical studies [1-5], the recommendation for restoration of endodontically treated teeth has been considerably changed. Therefore, this review article aimed to briefly describe the principles in the restoration of endodontically treated teeth, and then proposed tentative clinical recommendation.

Literature review

A significance of coronal restoration on endodontic treatment

The outcome of endodontic treatment is mainly affected not only by the quality of root canal treatment but also by the quality of coronal restoration [6, 7]. The highest success in endodontic outcome is obtained when the quality of both root canal and restorative treatment are satisfactory [8].

The reasons for the improvement in endodontic success by placement of proper coronal restoration are a) to provide a coronal seal that prevents re-infection of bacteria into the filled root canals, and b) to protect the remaining tooth structure from fracture [9].

Are endodontically treated teeth weaken than vital teeth?

In the past, it was believed that endodontically treated teeth were weakened and brittle due to microstructural changes after tooth-vitality loss and from the root canal treatment. From a series of studies, the endodontically treated teeth are not significantly different from the vital teeth in the biomechanical properties– moisture content [10] as well as shear strength, toughness, and load to fracture [11]. Additionally, no difference in modulus of elasticity and micro-hardness of radicular dentin is also reported [12].

In contrast, the maximum biting force on endodontically treated teeth (226.6 ± 168.7 N) is significantly higher than that of contralateral vital teeth (207.9 ±158.1 N) [13]. This may be explained by the loss of proprioception from pulp tissues in the root-filled teeth that increases the risk of occlusal overloading resulting in tooth fracture.

It has been widely accepted that the major cause of structural weakening in endodontically treated teeth is the substantial loss of tooth structure from dental caries, traumatic fractures, or pre-existing large restoration [9]. From a classic study in the maxillary premolars, the endodontic procedures– access opening, root canal instrumentation and obturation, slightly decrease tooth stiffness (strength) at 5% compared to that of the intact tooth [14]. In contrast, the loss of one and two marginal ridge(s) significantly decreases the stiffness by about 46% and 69%, respectively.

In accordance with a later study investigating cuspal deflection of molars [15], opening coronal access minimally increased cuspal deflection approximately 1–1.5 microns while cuspal isolation from MO or MOD cavities dramatically raised the deflection by 4-5 times greater [14].

Are endodontically treated teeth risked to fracture?

Even if the cause of the weakening of endodontically treated teeth is the same as that of the vital teeth (i.e.- the amount of tooth structure loss), the root-filled teeth usually possess a higher

incidence of tooth fracture than the vital teeth (32% vs. 11%) [16]. This can be explained that the more tooth structure lost, the higher potential of tooth fracture. In particular, the size and volume of cavities in non-vital teeth are commonly larger than the cavities in vital teeth.

For this reason, a selection of coronal restoration after endodontic treatment must be considered to protect or reinforce the remaining tooth structure [9]. In daily practice, several dental practitioners usually prefer to select cuspal- or full-coverage restorations for the root-filled teeth after endodontic treatment. However, not all endodontically treated teeth require the cuspal-coverage restorations.

Different tooth structure losses in endodontically treated teeth

Not all the teeth that require endodontic treatment have substantial loss of coronal structures [17]. For dens evaginatus premolars with pulpal and periapical pathology from the exposed occlusal tubercle, the coronal structure is limitedly lost from coronal access opening in root canal treatment, slightly decreasing tooth strength [14]. Another example is traumatized teeth with a luxation injury, e.g. lateral luxation, intrusion, or extrusion. In such cases, none or minimal tooth structure is damaged from the injury if no combination with the fracture.

Even the teeth with carious exposure, the amount of tooth structure lost differs from tooth to tooth. In addition, the variation in the sizes of pre-existing restorations also influences the remaining tooth structure. Therefore, consideration for coronal restoration after endodontic treatment should mainly depend on the amount of remaining tooth structure, combined with the aspect of occlusal loading forces [9, 18]. Clinically, it is difficult to precisely evaluate remaining tooth structure, which number of wall(s), thickness and height of remaining tooth structure should be carefully estimated [17].

Direct resin composite or crown restoration?

Not all endodontically treated teeth require cuspal- or full-coverage restoration. From a classic study by Reeh and Messer [19] in maxillary premolars with MOD cavity, cuspal-coverage cast gold onlay provided the strongest protection for the endodontically treated teeth, in which the stiffness was approximately two times stronger than that of the intact teeth. Fracture resistance of the teeth restored with crowns or onlays is significantly higher than those restored with direct restorations or inlays [20]. In addition, a higher risk of clinical fracture was found in endodontically treated teeth restored with inlays compared to inlay-restored vital teeth [21]. However, the 'over-protection' by the cuspal-coverage restoration may not be always necessary [22].

Once the coronal structure is not severely damaged, a direct bonded restoration (i.e.- resin composite) tends to be sufficient for providing the protection and the coronal seal. From another Reeh and Messer's study [19], the maxillary premolars with MOD cavities restored with resin composite showed a relative stiffness (90% in approximate) close to that of intact teeth. Moreover, the fracture strength of the teeth restored with resin composite was approximately 80% of the intact teeth [23, 24]. This level of fracture resistance is possibly enough to withstand normal occlusal force for the teeth with adequate remaining coronal structure. However, long-term bond degradation of resin composite restorations is a concern [25]. Further details in selection of resin composite or crown will be

explained in the part of clinical recommendation for restoration of endodontically treated teeth.

Post or without a post?

This review will briefly explain when a post is necessary for endodontically treated teeth. The main function of the post is to provide retention for coronal restoration in severely damaged teeth [26]. In addition, it has been proposed that using a bonded fiber-reinforced post may improve the fracture resistance in anterior teeth [27, 28] and premolars [29], but not for the molars [30]. However, a placement of fiber post in anterior teeth may not improve fracture resistance to static loading [31, 32] or fatigue failure to cyclic loading [33] when a ferrule is presented, but has the benefit when the ferrule is absent [33].

A post may be indicated when less than half of the coronal structure remains [34], but may not be necessary when tooth structure loss is limited [34]. When a full-coverage crown is planned, the anterior teeth more commonly require a post since the amount of remaining tooth structure after tooth preparation tends to be not enough to support the coronal restoration [17]. For the posterior teeth, the remaining tooth structure after tooth preparation of the premolars is generally less than that of the molars. Therefore, a post is more commonly planned for the premolars than the molars [17]. In contrast, the pulp chamber of the molars is usually large enough to provide the retention for the core build-up and coronal restoration, which a post is usually not required [17].

The presence of the remaining circumferential cervical tooth structure (ferrule) is more important than the post placement to prevent tooth fracture [33, 35]. In addition, the benefit of using a post to decrease the chance of tooth fracture or coronal restoration dislodgement is controversial [3]. Extension of core build-up material into the coronal third of the root canal, as a coronal-radicular restoration when the pulp chamber height is less than 4 mm [36, 37], may be enough to provide the retention for the coronal restoration and improve the fracture resistance [30, 38]. Nevertheless, more scientific evidence is required to confirm this proposed concept of the coronal-radicular extension.

Clinical recommendation for restoration of endodontically treated teeth

As previously mentioned, endodontically treated teeth should not always be crowned and can be properly restored with resin composite in appropriate conditions. Tooth type, remaining tooth structure, and functional/parafunctional loading force are the most significant three factors for selecting of cuspal- or non-cuspal-protection restoration (crown vs. resin composite) in endodontically treated teeth. Additionally, onlay (or overlay) is another type of a cuspal-coverage restoration particularly selected for posterior teeth. Most importantly, remaining tooth structure must be evaluated in both vertical and horizontal dimensions- coronal residual walls (from 4 walls to no wall) and cervical tooth structure (intact or defect) [39]. The clinical recommendation for the restoration of endodontically treated teeth, based on clinical studies and reported risk factors, are proposed below.

Premolars

Based on a classic clinical study [40], long-term survival of endodontically treated premolars gained a benefit from the cuspal-coverage restorations, which significantly increased the

survival rate to approximately 90% compared to that of the teeth without the cuspal-coverage restorations (approximately 60%). In contrast, the results of a 3-year randomized controlled clinical trial showed that endodontically treated premolars with only two or three surfaces lost can be successfully restored with resin composite [41]. In that study, the survival rates without fracture at three years of the premolars restored with crowns and those restored with resin composite are very high (100% survival) and not significantly different [41].

From a recent systematic review [42], it has been summarized that the endodontically treated premolars with no more than three-surface loss of coronal structure can be restored with direct resin composite into the coronal access (with or without a use of prefabricated fiber post), in terms of survival without fracture. In a retrospective study [4], the premolars with two-surface cavities and the presence of two adjacent teeth (contacts) had a high survival rate without fracture that was similar to those restored with crowns. Neighboring teeth help distribute occlusal forces, relieving stress loading on the restored teeth.

For the teeth with exposed cervical lesions, the stress from occlusal force concentrates on the cervical region, which makes the teeth are risk to cervical fracture [38]. A placement of a prefabricated fiber post in combination with resin composite core may help in improvement of fracture resistance in these teeth [38]. However, a recent retrospective study reported that endodontically treated teeth with the cervical lesions could be permanently restored with coronal-radicular resin composite restorations by extension the bond restorations into the coronal third of root canal below the exposure site, which showed a fracture survival similar to the teeth restored with crowns [43].

Other alternative for cuspal-coverage restorations of endodontically treated posterior premolars are endo-crown or onlay (overlay) [21, 44, 45]. This kind of cuspal-protection restoration preserves cervical tooth structure (if remains) while still protects endodontically treated teeth from fracture [46]. At 2-4 years, a failure rate at approximately 1% per year is reported for the teeth restored with ceramic onlays [45]. However, the survival of the root-filled teeth restored with onlays in long term is probably inferior to those restored with the crowns [44].

An endo-crown is a special type of crown based on a monoblock concept, which eliminates the bond interfaces compared to when a post/core is used [47]. This 'one-unit' restoration contains the crown segment in the coronal portion and the extension in the pulp chamber (and probably radicular) portion for 2–3 mm, which is currently created by a computer-aided design and manufacturing (or CAD-CAM) technology. The endo-crown is firstly designed for restoring the molars, in which the pulp chamber is usually large enough to retain a coronal restoration. From a recent systematic review, the survival/success rate of endo-crowns in the premolars is not significantly different to that in the molars [48]. Hence, a use of endo-crown is a promising option for restoration of endodontically treated premolars [48-50]. However, this restoration type may be primarily suitable for severely damaged teeth that require additional retention from pulp chamber (or radicular extension).

In summary, endodontically treated premolars with one-surface (e.g. class I- O cavity) or two-surface cavity (e.g. class II- MO or OD cavity), in particular with the presence of two adjacent teeth, can be

safely restored with resin composite. Otherwise, a crown or other cuspal-coverage restoration should be considered. However, occlusal biting force [21], parafunctional habit (if any) [4] and a function as abutments of removable or fixed prosthesis [51] must be also taken into a consideration. In addition, the teeth with absence of ferrule should be carefully considered for adjunctive treatment(s), i.e. crown lengthening, orthodontic extrusion, or tooth extraction [39]. A proposed clinical guideline for the restoration of endodontically treated premolars is presented in **Fig. 1**.

Molars

In the same direction for restoring the premolars previously mentioned, long-term (>10 years) survival of endodontically treated molars mainly depends on the placement of cuspal-coverage restorations [40]. This concept has been confirmed by the results of other studies [52, 53]. Most of the molars should be crowned after complete endodontic treatment. Recently, onlay or endo-crown is an alternative for restoration endodontically treated teeth particularly for the molars [45, 49]; however, it is out of the scope of this review and not further explained in details.

However, in a recent 5-year retrospective study [1], the molars with one surface lost (e.g. class I- O cavity) and restored with resin composite had 100% survival against fracture. Therefore, the molars with only coronal access on the occlusal surface tends to be permanently restored with resin composite. From another retrospective study [2], the molars with two surfaces loss (e.g. class II- MO or OD cavity) and the presence of two adjacent teeth are possibly restored with resin composite. However, high occlusal force, parafunctional force, and abutment for prostheses are crucial factors to shift the treatment plan for cuspal coverage [51]. As previously mentioned for the premolars, onlay/ overlay or endo-crown is also an alternative for restorations of endodontically treated molars with a high success/survival rate at 5 years or longer [48,

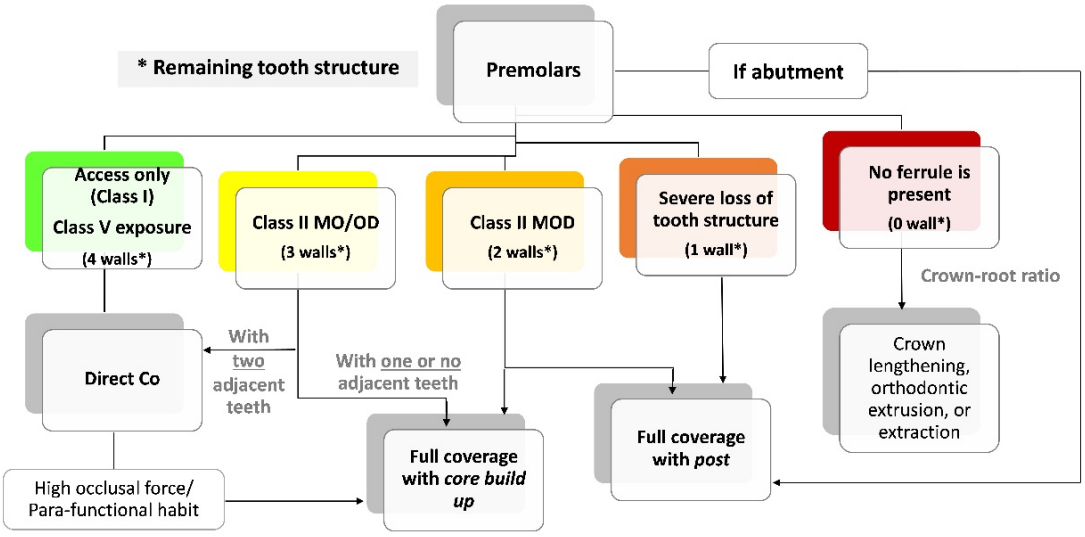

Figure 1: The proposed clinical guideline for restoration of endodontically treated premolars ('full-coverage with core build up': crown or onlay; 'full-coverage with post': post/core and crown, or endo-crown). Co- direct resin composite.

49, 54]. For the severely damaged molars with a lack of ferrule, crown lengthening, orthodontic extrusion, or tooth extraction should be considered [39]. A proposed clinical guideline for the restoration of endodontically treated molars is presented in **Fig. 2**.

Anterior teeth

The results from a classic clinical study [40] showed that long-term survival rates at more than 10 years of endodontically treated anterior teeth were very high (approximately 90%) and not significantly affected by the full-coverage crowns. Additionally, a recent retrospective study also confirmed the high survival (90%, in approximate) of the anterior root-filled teeth only restored with resin composite in a recent 5-year retrospective study [5]. Therefore, the majority of endodontically treated anterior teeth tends to be permanently restored with resin composite.

However, a full-coverage crown may be indicated in the anterior root-filled teeth when- a) the cervical tooth structure remains less than three walls, and/or b) the cervical root dentin thickness is over-flared [5, 55]. Moreover, loss of the palatal cervical tooth structure in the maxillary anterior teeth significantly increases the incidence of tooth fracture after endodontic treatment [5]; crown restoration may be required in such conditions. Additionally, the crown may be selected in a case with high occlusal and parafunctional force, in which the occlusal scheme and loading force should be carefully examined [5, 56]. Moreover, the severely damaged teeth without circumferential ferrule should be considered for crown lengthening, orthodontic extrusion, or even tooth extraction [39]. An endo-crown may be a restorative option for the anterior teeth; however, the scientific study is rare while no clinical study has been found [31]. A proposed clinical guideline for restoration of endodontically treated anterior teeth is presented in **Fig. 3**. Furthermore, tooth discoloration may affect the restorative treatment plan unless the tooth is effectively whitened by a bleaching agent [57].

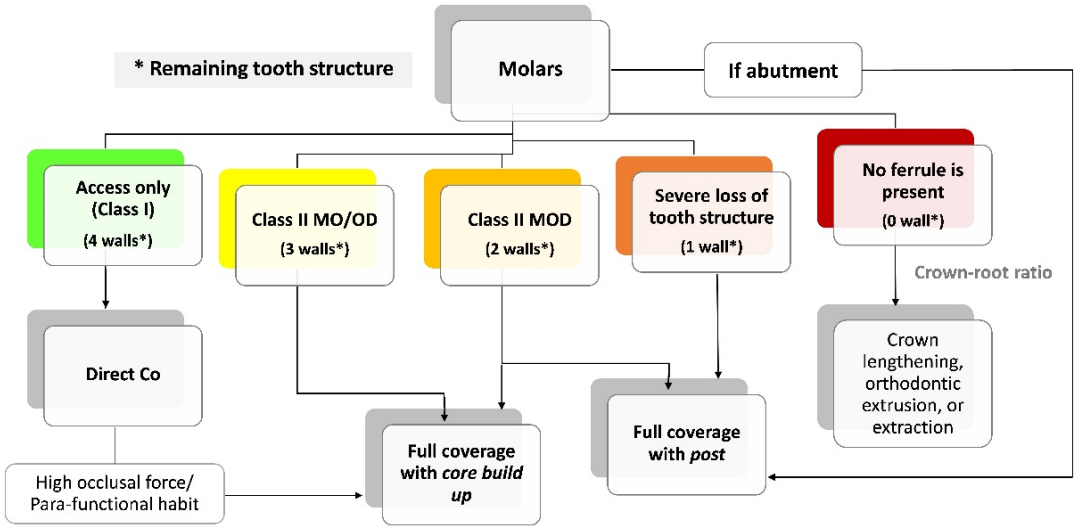

Figure 2: The proposed clinical guideline for restoration of endodontically treated molars ('full-coverage with core build up': crown or onlay; 'full-coverage with post': post/core and crown, or endo-crown). Co- direct resin composite.

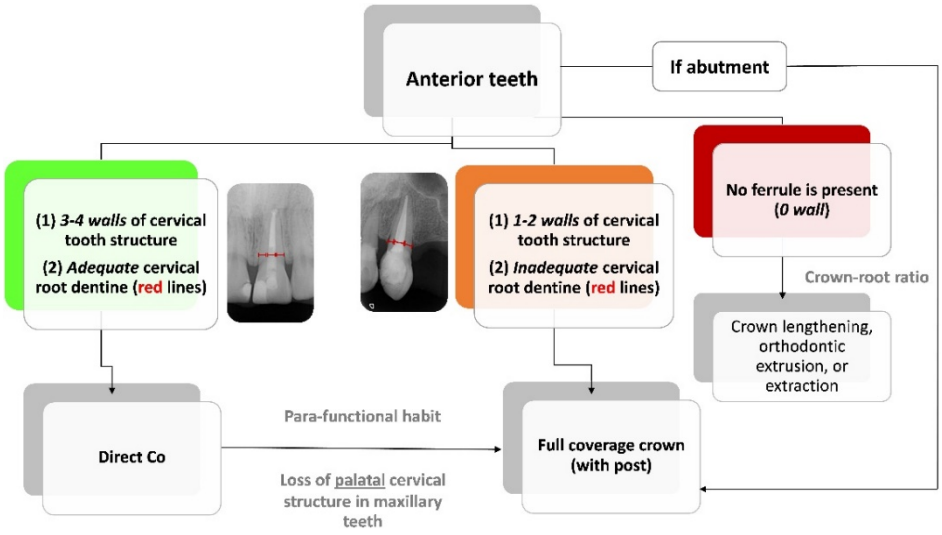

Figure 3: The proposed clinical guideline for restoration of endodontically treated anterior teeth ('with post': intraradicular post, or coronal-radicular core build-up may be used). For the cervical root dentine, adequate root dentine- not over flared; and inadequate root dentine- over flared, in which remaining mesial and/or distal wall thickness is thinner than the size of root canal at that level [5]. Non-vital tooth bleaching before coronal restoration may be considered for the anterior teeth with discoloration. Co- direct resin composite.

Conclusions

In conclusion, it can be summarized that:

1) The best endodontic outcome depends on the high quality of both root canal and restorative treatments.

2) Endodontically treated teeth are weakened from significant tooth structure loss, not from endodontic procedures.

3) A proper choice of coronal restoration to protect tooth fracture is related to the amount of remaining tooth structure as well as the loading force.

4) The premolars with one to two surfaces lost and with two adjacent teeth can be permanently restored with direct resin composite. Otherwise, a full-coverage crown should be considered, which a post is usually required (**Table 1**).

5) A cuspal-coverage restoration is commonly required for the molars, which a post is indicated only in the severely damaged teeth (**Table 1**).

6) Direct resin composite should be considered as the first treatment of choice for the anterior teeth. A crown may be indicated in the teeth with 1-2 walls of remaining cervical tooth structure and/or with compromised cervical root structure. An intra-radicular post is usually indicated before the crown (**Table 2**).

Conflict of interest

none

Funding

N/A

Acknowledgement

N/A

Table 1. The purposed guidelines for restorations of endodontically treated posterior teeth: resin composite or crown (*crown with a post is preferred when a risk factor is present, ** depending on a presence of two adjacent teeth). When a crown is indicated, onlay/overlay or endo-crown may be an alternative.

Tooth type	Restoration	Tooth structure loss or remaining tooth structure					*Risk factors
		One surface lost	Two surfaces lost	Three surfaces lost	One wall remaining	No wall remaining	
Premolars	Coronal	Composite	**Composite or Crown	Crown	Crown	Crown	- Parafunction or abutment
	Intraradicular Post	No	No/Yes	No/Yes	Yes	Yes	
Molars	Coronal	Composite	Crown	Crown	Crown	Crown	- Parafunction or abutment
	Intraradicular Post	No	No	No/Yes	Yes	Yes	

Table 2. The purposed guidelines for restorations of endodontically treated anterior teeth: resin composite or crown (*crown with a post is preferred when a risk factor is present).

Teeth	Restoration	Cervical structure loss or remaining cervical structure				*Risk factors
		One side lost	Two sides lost	Three sides lost	No side remaining	
Anterior	Coronal	Composite	Composite	Crown	Crown	- Parafunction or abutment - Thin cervical root dentin
	Intraradicular Post	No	No	Yes	Yes	

References

1. Chotvorrarak K, Suksaphar W, Banomyong D. A retrospective study of survival from unrestorable fracture in endodontically treated molars: the effect of single-unit full-coverage crowns vs. direct resin composite restorations. **Restor Dent Endod**. 2021; 46: e29.
2. Jirathanyanatt T, Suksaphar W, Banomyong D, Ngoenwiwatkul Y. Endodontically treated posterior teeth restored with or without crown restorations: A 5-year retrospective study of survival rates from fracture. **J Investig Clin Dent**. 2019; 10: e12426.
3. Naumann M, Schmitter M, Krastl G. Postendodontic Restoration: Endodontic Post-and-Core or No Post At All? **J Adhes Dent**. 2018; 20: 19-24.
4. Suksaphar W, Banomyong D, Jirathanyanatt T, Ngoenwiwatkul Y. Survival Rates from Fracture of Endodontically Treated Premolars Restored with Full-coverage Crowns or Direct Resin Composite Restorations: A Retrospective Study. **J Endod**. 2018; 44: 233-8.
5. Phengudom P, Banomyong D, Jirathanyanatt T, Ngoenwiwatkul Y, Suksaphar W. Survival Rates of Unrestorable Fracture of Endodontically

Treated Anterior Teeth Restored with Resin Composites or Crowns: A Retrospective Cohort Study. **Iran Endod J**. 2021; 16: 176-83.
6. Ray HA, Trope M. Periapical status of endodontically treated teeth in relation to the technical quality of the root filling and the coronal restoration. **Int Endod J**. 1995; 28: 12-8.
7. Tronstad L, Asbjørnsen K, Døving L, Pedersen I, Eriksen HM. Influence of coronal restorations on the periapical health of endodontically treated teeth. **Endod Dent Traumatol**. 2000; 16: 218-21.
8. Gillen BM, Looney SW, Gu L-S, Loushine BA, Weller RN, Loushine RJ, et al. Impact of the quality of coronal restoration versus the quality of root canal fillings on success of root canal treatment: a systematic review and meta-analysis. **J Endod**. 2011; 37: 895-902.
9. Taha NA, Messer HH. Restoration of the Root-Filled Tooth. **Prim Dent J**. 2016; 5: 29-35.
10. Papa J, Cain C, Messer HH. Moisture content of vital vs endodontically treated teeth. **Endod Dent Traumatol**. 1994; 10: 91-3.
11. Sedgley CM, Messer HH. Are endodontically treated teeth more brittle? **J Endod**. 1992; 18: 332-5.
12. Cheron RA, Marshall SJ, Goodis HE, Peters OA. Nanomechanical properties of endodontically treated teeth. **J Endod**. 2011; 37: 1562-5.
13. Awawdeh L, Hemaidat K, Al-Omari W. Higher Maximal Occlusal Bite Force in Endodontically Treated Teeth Versus Vital Contralateral Counterparts. **J Endod**. 2017; 43: 871-5.
14. Reeh ES, Messer HH, Douglas WH. Reduction in tooth stiffness as a result of endodontic and restorative procedures. **J Endod**. 1989; 15: 512-6.
15. Panitvisai P, Messer HH. Cuspal deflection in molars in relation to endodontic and restorative procedures. **J Endod**. 1995; 21: 57-61.
16. Adolphi G, Zehnder M, Bachmann LM, Göhring TN. Direct resin composite restorations in vital versus root-filled posterior teeth: a controlled comparative long-term follow-up. **Oper Dent**. 2007; 32: 437-42.
17. Atlas A, Grandini S, Martignoni M. Evidence-based treatment planning for the restoration of endodontically treated single teeth: importance of coronal seal, post vs no post, and indirect vs direct restoration. **Quintessence Int**. 2019; 50: 772-81.
18. Ibrahim AM, Richards LC, Berekally TL. Effect of remaining tooth structure on the fracture resistance of endodontically-treated maxillary premolars: An in vitro study. **J Prosthet Dent**. 2016; 115: 290-5.
19. Reeh ES, Douglas WH, Messer HH. Stiffness of endodontically-treated teeth related to restoration technique. **J Dent Res**. 1989; 68: 1540-4.
20. Al Amri MD, Al-Johany S, Sherfudhin H, Al Shammari B, Al Mohefer S, Al Saloum M, et al. Fracture resistance of endodontically treated mandibular first molars with conservative access cavity and different restorative techniques: An in vitro study. **Aust Endod J**. 2016; 42: 124-31.
21. Dioguardi M, Alovisi M, Troiano G, Caponio CVA, Baldi A, Rocca GT, et al. Clinical outcome of bonded partial indirect posterior restorations on vital and non-vital teeth: a systematic review and meta-analysis. **Clin Oral Investig**. 2021; 25: 6597-621.
22. Frankenberger R, Winter J, Dudek MC, Naumann M, Amend S, Braun A, et al. Post-Fatigue Fracture and Marginal Behavior of Endodontically Treated Teeth: Partial Crown vs. Full Crown vs. Endocrown vs. Fiber-Reinforced Resin Composite. **Materials (Basel)**. 2021; 14: 7733.
23. Taha NA, Palamara JE, Messer HH. Fracture strength and fracture patterns of root filled teeth restored with direct resin restorations. **J Dent**. 2011; 39: 527-35.

24. Thongbai-On N, Chotvorrarak K, Banomyong D, Burrow MF, Osiri S, Pattaravisitsate N. Fracture resistance, gap and void formation in root-filled mandibular molars restored with bulk-fill resin composites and glass-ionomer cement base. **J Investig Dent**. 2019; 10: e12435.
25. Banomyong D, Palamara JE, Messer HH, Burrow MF. Sealing ability of occlusal resin composite restoration using four restorative procedures. **Eur J Oral Sci**. 2008; 116: 571-8.
26. Schwartz RS, Robbins JW. Post placement and restoration of endodontically treated teeth: a literature review. **J Endod**. 2004; 30: 289-301.
27. Veríssimo C, Simamoto Júnior PC, Soares CJ, Noritomi PY, Santos-Filho PC. Effect of the crown, post, and remaining coronal dentin on the biomechanical behavior of endodontically treated maxillary central incisors. **J Prosthet Dent**. 2014; 111: 234-46.
28. Jurema ALB, Filgueiras AT, Santos KA, Bresciani E, Caneppele TMF. Effect of intraradicular fiber post on the fracture resistance of endodontically treated and restored anterior teeth: A systematic review and meta-analysis. **J Prosthet Dent**. 2022; 128: 13-24.
29. Furuya Y, Huang SH, Takeda Y, Fok A, Hayashi M. Fracture strength and stress distributions of pulpless premolars restored with fiber posts. **Dent Mater J**. 2014; 33: 852-8.
30. Magne P, Goldberg J, Edelhoff D, Güth J-F. Composite Resin Core Buildups With and Without Post for the Restoration of Endodontically Treated Molars Without Ferrule. **Oper Dent**. 2016; 41: 64-75.
31. Ramírez-Sebastià A, Bortolotto T, Cattani-Lorente M, Giner L, Roig M, Krejci I. Adhesive restoration of anterior endodontically treated teeth: influence of post length on fracture strength. **Clin Oral Investig**. 2014; 18: 545-54.
32. Valdivia AD, Raposo LH, Simamoto-Júnior PC, Novais VR, Soares CJ. The effect of fiber post presence and restorative technique on the biomechanical behavior of endodontically treated maxillary incisors: an in vitro study. **J Prosthet Dent**. 2012; 108: 147-57.
33. Magne P, Lazari PC, Carvalho MA, Johnson T, Del Bel Cury AA. Ferrule-Effect Dominates Over Use of a Fiber Post When Restoring Endodontically Treated Incisors: An In Vitro Study. **Oper Dent**. 2017; 42: 396-406.
34. Aurélio IL, Fraga S, Rippe MP, Valandro LF. Are posts necessary for the restoration of root filled teeth with limited tissue loss? A structured review of laboratory and clinical studies. **Int Endod J**. 2016; 49: 827-35.
35. Naumann M, Schmitter M, Frankenberger R, Krastl G. "Ferrule Comes First. Post Is Second!" Fake News and Alternative Facts? A Systematic Review. **J Endod** 2018; 44: 212-9.
36. Ferrier S, Sekhon BS, Brunton PA. A study of the fracture resistance of nyyar cores of three restorative materials. **Oper Dent**. 2008; 33: 305-11.
37. Kane JJ, Burgess JO, Summitt JB. Fracture resistance of amalgam coronal-radicular restorations. **J Prosthet Dent**. 1990; 63: 607-13.
38. Tangsripongkul P, Jearanaiphaisarn T. Resin Composite Core and Fiber Post Improved the Fracture Parameters of Endodontically Treated Maxillary Premolars with Wedge-shaped Cervical Lesions. **J Endod.** 2020; 46: 1733-7.
39. Ferrari M, Pontoriero DIK, Ferrari Cagidiaco E, Carboncini F. Restorative difficulty evaluation system of endodontically treated teeth. **J Esthet Restor Dent**. 2022; 34: 65-80.
40. Sorensen JA, Martinoff JT. Intracoronal reinforcement and coronal coverage: a study of endodontically treated teeth. **J Prosthet Dent**. 1984; 51: 780-4.

41. Mannocci F, Bertelli E, Sherriff M, Watson TF, Ford TR. Three-year clinical comparison of survival of endodontically treated teeth restored with either full cast coverage or with direct composite restoration. **J Prosthet Dent**. 2002; 88: 297-301.
42. Suksaphar W, Banomyong D, Jirathanyanatt T, Ngoenwiwatkul Y. Survival rates against fracture of endodontically treated posterior teeth restored with full-coverage crowns or resin composite restorations: a systematic review. **Restor Dent Endod**. 2017; 42: 157-67.
43. Kaewchomphoo K, Banomyong D, Ngoenwiwatkul Y, Pumpaluk P. Comparison of the Survival Rate Against Fracture of Endodontically Treated Premolars with Exposed Cervical Lesions Restored with Crowns and Resin Composites: A Retrospective Study. **Eur Endod J**. 2022; 7: 27-32.
44. Fathi A, Ebadian B, Dezaki SN, Mardasi N, Mosharraf R, Isler S, et al. An Umbrella Review of Systematic Reviews and Meta-Analyses Evaluating the Success Rate of Prosthetic Restorations on Endodontically Treated Teeth. **Int J Dent**. 2022; 2022: 4748291.
45. Mario D, Mario A, Allegra C, Andrea B, Giuseppe T, Milena C, et al. The influence of indirect bonded restorations on clinical prognosis of endodontically treated teeth: A systematic review and meta-analysis. **Dent Mater**. 2022; 38: e203-e19.
46. Kassis C, Khoury P, Mehanna CZ, Baba NZ, Bou Chebel F, Daou M, et al. Effect of Inlays, Onlays and Endocrown Cavity Design Preparation on Fracture Resistance and Fracture Mode of Endodontically Treated Teeth: An In Vitro Study. **J Prosthodont**. 2021; 30: 625-31.
47. Govare N, Contrepois M. Endocrowns: A systematic review. **J Prosthet Dent**. 2020; 123: 411-8.
48. Thomas RM, Kelly A, Tagiyeva N, Kanagasingam S. Comparing endocrown restorations on permanent molars and premolars: a systematic review and meta-analysis. **Br Dent J**. 2020; https://doi.org/10.1038/s41415-020-2279-y.
49. Al-Dabbagh RA. Survival and success of endocrowns: A systematic review and meta-analysis. **J Prosthet Dent**. 2021; 125: 415 e1-e9.
50. Mannocci F, Bitter K, Sauro S, Ferrari P, Austin R, Bhuva B. Present status and future directions: The restoration of root filled teeth. **Int Endod J**. 2022; 55: 1059-84.
51. Sorensen JA, Martinoff JT. Endodontically treated teeth as abutments. **J Prosthet Dent**. 1985; 53: 631-6.
52. Aquilino SA, Caplan DJ. Relationship between crown placement and the survival of endodontically treated teeth. **J Prosthet Dent**. 2002; 87: 256-63.
53. Nagasiri R, Chitmongkolsuk S. Long-term survival of endodontically treated molars without crown coverage: a retrospective cohort study. **J Prosthet Dent**.. 2005; 93: 164-70.
54. El-Ma'aita A, M AA-Ra, Abu-Awwad M, Hattar S, Devlin H. Endocrowns Clinical Performance and Patient Satisfaction: A Randomized Clinical Trial of Three Monolithic Ceramic Restorations. **J Prosthodont**. 2022; 31: 30-7.
55. da Silva PB, Duarte SF, Alcalde MP, Duarte MAH, Vivan RR, da Rosa RA, et al. Influence of cervical preflaring and root canal preparation on the fracture resistance of endodontically treated teeth. **BMC Oral Health**. 2020; 20: 111.
56. Atlas AM, Behrooz E, Barzilay I. Can bite-force measurement play a role in dental treatment planning, clinical trials, and survival outcomes? A literature review and clinical recommendations. **Quintessence Int**. 2022; 53: 632-42.
57. Banomyong D. Clinical considerations for non-vital tooth walking bleaching. **Thai Endod J**. 2022; 1: 33-42.