Review

Classification of post-and-core assembly failures: An extensive compilation of 33 years of data

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Abstract

Over the past 2 decades, a wide range of post-and-core materials has been developed to restore endodontically treated teeth (ETT) with extensive loss of coronal tooth structure. Although the prognosis and long-term success of ETT are influenced by multiple factors, most research has focused on post-and-core materials, the ferrule effect and luting agents. However, a classification of failures associated with post-and-core assemblies is currently lacking. This study aimed to identify and classify post-and-core assembly failures.

A literature search was conducted using the terms "post and core" and "dental post and core" in the title and abstract. Articles published in English between 1991 and 2024 were retrieved from the PubMed®, Scopus and Cochrane Library databases. Of the 491 articles identified, 23 met the inclusion criteria and were used to develop the proposed classification.

Based on the available evidence, post-and-core assembly failures can be classified into 2 categories: catastrophic and non-catastrophic failures. To the authors' knowledge, this is the first comprehensive classification of post-and-core assembly failures derived from evidence spanning 33 years of published literature. The proposed classification provides a standardized framework for identifying and reporting failures and may facilitate clinical decision-making, laboratory communication and future research.

Keywords: luting agents, ferrule, endodontically treated teeth, post-and-core failures, dental posts

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Highlights

- This article introduces the first comprehensive classification system for post-and-core assembly failures based on 33 years of published literature.
- The classification categorizes post-and-core assembly failures as catastrophic or non-catastrophic, providing a standardized framework for diagnosis, reporting and clinical decision-making.
- The classification supports consistent communication among clinicians, researchers and educators involved in post-and-core treatment.

Introduction

The restorative success of endodontically treated teeth (ETT) has been a subject of considerable debate over the past 2 decades. Because non-vital teeth are generally more susceptible to fracture than vital teeth,[1] a multifactorial approach is essential to ensure long-term survival of ETT. The prognosis of ETT depends on several factors,[2] and careful evaluation of each of these factors enables the clinician to assess the prognosis, determine the complexity of treatment[3] and develop an appropriate treatment plan.

Traditionally, it has been assumed that an endodontically treated tooth with extensive loss of coronal tooth structure requires the use of an anchorage from the root canal to improve strength and function of the restoration. However, Trope et al. demonstrated that preparation of the root canal for post placement weakens the tooth and reduces its resistance to functional forces.[4] It is also commonly believed that pulpless teeth become brittle and more prone to fractures due to reduced moisture content. However, only minor differences were noticed in the hardness and microhardness of dentin between vital and non-vital teeth.[5] Assif and Gorfil stated that the loss of dentin during access cavity preparation and post space preparation is the primary factor compromising the survival of ETT.[6] Hence, performing restorative procedures that preserve the remaining dentin thickness is more crucial than strengthening the tooth.[6]

The wide variety of available post materials and restorative techniques has resulted in conflicting recommendations regarding the optimal restorative approach. A systematic review evaluating the biomechanical considerations for restoring ETT concluded that interfacial defects and severe tooth breakdown associated with post failure occurred more frequently with rigid metal and ceramic posts.[5] However, fiber posts combined with composite resin demonstrated favorable clinical performance because their mechanical properties are more similar to those of dentin. It was also established, based on fatigue studies, that post placement is unnecessary when an adequate ferrule and sufficient coronal tooth structure are present. Nevertheless, when a post is required to improve the stability of the tooth, a resin post must be used along with an adhesive luting agent.[5]

Another systematic review evaluating the clinical performance and failure modes of pulpless teeth restored with posts found no significant differences in the survival rates of metal and fiber posts.[7] The authors concluded that both post systems demonstrate comparable clinical performance during short- to medium-term follow-up.[7]

Although several studies have supported the use of posts,[8–12] whereas others have questioned their placement,[13–17] there is currently no standardized classification of post-and-core failures. Such a classification would facilitate communication among clinicians and provide a standardized framework for research. A simple and reproducible classification describing both the type and severity of post-and-core failures could be useful for surveys, clinical trials, treatment planning, and outcome assessment.

Following a review of the published literature on post-and-core failures and after evaluation of the available evidence, the authors propose a new classification system for post-and-core failures together with recommendations for their management. To the best of our knowledge, no standardized classification of post-and-core failures has been described in the literature. The proposed classification categorizes failures into 2 broad groups, catastrophic and non-catastrophic, based primarily on whether the affected tooth can be salvaged. This classification is intended to assist clinicians in determining whether the tooth requires further treatment or needs to be extracted. Catastrophic failures comprise those resulting in irreparable damage to the tooth, whereas non-catastrophic failures include conditions in which the tooth can be salvaged even after the failure.

Material and methods

Search methodology

A literature search was conducted using the following search terms: ("post and core"(Title/Abstract)) OR ("dental post and core"(Title/Abstract)). Articles published in English between 1991 and 2024 were retrieved from the PubMed®, Scopus and Cochrane Library databases. The identified studies were screened according to the predefined inclusion and exclusion criteria.

Inclusion and exclusion criteria

The inclusion criteria encompassed randomized controlled trials (RCTs), quasi-RCTs, in vivo or in vitro studies, retrospective or prospective studies, cohort studies, case–control studies, systematic reviews, or meta-analyses that evaluated and described the types of post-and-core failures and their management. Literature reviews, scoping reviews, narrative reviews, case reports, and case series were excluded.

Data collection

A total of 511 records were identified across all databases on April 10, 2024. After removal of duplicate records, 491 articles remained for title and abstract screening. Following screening and application of the inclusion and exclusion criteria, 23 studies were included in the final analysis (Fig. 1). These 23 articles were used to formulate the proposed classification system (Table 1).[11,12,18–38]

Results

Classification of post-and-core failures

Post-and-core failures can be broadly classified into 2 major categories: catastrophic and non-catastrophic failures (Fig. 2,3). Each category is further subdivided according to the type and extent of failure. The proposed classification was developed from evidence reported in 23 studies conducted in both clinical and laboratory settings. Hence, it encompasses the various types of failure that may occur under laboratory conditions, in clinical setting, or both. A comprehensive classification of post-and-core failures has the potential to standardize the reporting of outcomes in future RCTs, in vitro studies, cohort and case–control studies, systematic reviews, and meta-analyses. In addition, in may facilitate scientific communication among clinicians, researchers and dental technicians (Table 2,3).

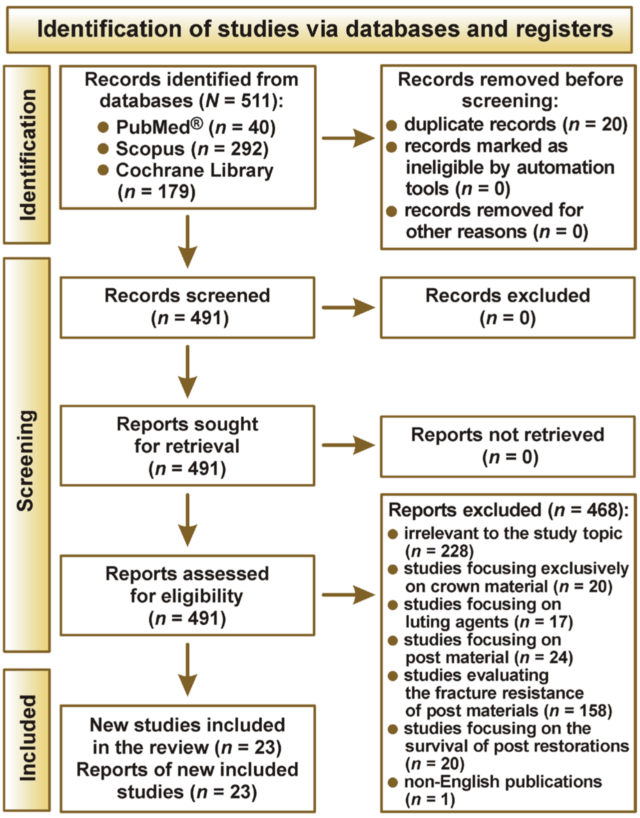

Fig. 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram illustrating the study selection process

Fig. 2. Catastrophic post-and-core assembly failures and their subdivisions

Class IA – vertical root fracture; Class IB – horizontal root fracture; Class IC – oblique root fracture; Class ID – crown/fixed partial denture (FPD)/core fracture; Class IE – root perforation during post placement.

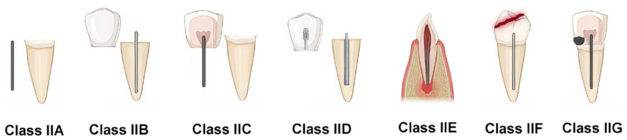

Fig. 3. Non-catastrophic post-and-core assembly failures and their subdivisions

Class IIA – post dislodgement; Class IIB – crown dislodgement with or without core debonding; Class IIC – post-and-core assembly dislodgement; Class IID – crown/FPD/core fracture; Class IIE – endodontic failure; Class IIF – crown chipping; Class IIG – secondary caries.

Discussion

The proposed classification identifies the spectrum of failures that may occur in ETT restored with a post-and-core system. It may serve as a practical framework for evaluating outomes in a laboratory setting, predicting prognosis, establishing a diagnosis, formulating treatment plans, and facilitating communication among clinicians. The classification was developed following a critical appraisal of evidence from prospective and retrospective studies, RCTs, in vitro investigations, systematic reviews, and meta-analyses.

There remains no clear consensus regarding the role of post-and-core restorations in improving the clinical outcomes of ETT. Numerous studies have focused on identifying the post-and-core material that provides the greatest fracture resistance and lowest failure rate. However, the prognosis of ETT is influenced by several additional factors, including the periapical status, tooth position, occlusal contacts, collagen degradation, and intermolecular cross-linking of the tooth root dentin.[39]

Table 1. Studies evaluating different types of post-and-core failures

Study	Objectives	Type of failure	Research methodology	Conclusions
Sorensen and Martinoff 1984[18]	To determine the clinical significance of post reinforcement and coronal coverage in ETT.	• post dislodgement • root fractures • root perforation	retrospective study	Intracoronal reinforcement did not significantly increase resistance to fracture or dislodgement. Coronal coverage did not significantly improve the clinical success of anterior teeth but significantly improved the success rate of posterior teeth.
Assif et al. 1993[19]	To evaluate the effect of post design on the fracture resistance of endodontically treated premolars restored with cast crowns.	• oblique root fracture	prospective study	Post design did not influence the fracture resistance of ETT restored with complete cast crowns.
Torbjörner et al. 1995[20]	To investigate the failure rate and failure characteristics of 2 post designs.	• loss of retention • root fracture	retrospective study	ParaPost restorations with cast cores demonstrated a higher success rate than tapered cast post-and-core restorations.
Akkayan and Caniklioglu 1998[21]	To evaluate the effect of 4 different post systems on the fracture resistance of crowned ETT.	• vertical root fracture • horizontal root fracture	prospective study	The choice of prefabricated post systems is important in determining the maximum resistance to fracture in ETT.
Ferrari et al. 2000[22]	To assess the treatment outcomes of cast post-and-core and Composipost systems.	• root fracture • crown dislodgement • endodontic failure	retrospective study	Composipost systems demonstrated superior clinical performance compared with conventional cast post-and-core restorations.
Heydecke et al. 2001[23]	To compare the fracture strength and survival rate of crowned maxillary incisors with approximal Class III cavities using different core build-up techniques.	• oblique root fracture • bent posts • post dislodgement from the root canal • post fracture	prospective study	Enlargement of the root canal after endodontic treatment should be avoided, as it cannot be compensated for by the use of composite resin. Specimens restored without posts exhibited fewer catastrophic failures.
Hu et al. 2003[24]	To evaluate the fracture resistance and failure modes of ETT restored with 4 post-and-core systems.	• catastrophic failures (predominantly root fractures) observed in all groups • higher incidence of catastrophic root fractures in groups restored with ceramic posts and resin composite cores	prospective in vitro study	The fracture resistance of all 4 post systems was considered clinically acceptable. Unfavourable tooth fractures were observed in all groups.
Fokkinga et al. 2006[25]	To investigate the in vitro fracture behavior of severely damaged maxillary premolars restored with different post-and-core systems and covered with full metal crowns.	• post and crown displacement • root fracture • root fractures with or without post and crown displacement	prospective study	Fracture resistance and failure mode of severely damaged premolars restored with adhesively cemented crowns and a limited ferrule were independent of the post-and-core system used.
Salvi et al. 2007[12]	To assess the survival rates and complications of root-filled teeth restored with or without post-and-core systems over a 4-year period.	• root fracture • secondary caries • post-treatment radicular disease • loss of retention	prospective study	Reported survival rates were 92.5% for titanium posts, 94.3% for teeth restored without posts, and 97.1% for cast post-and-core restorations.
Peutzfeldt et al. 2008[26]	To identify the factors associated with failure and characterize the failure modes of post-retained restorations.	• tooth fracture • post loosening • post fracture	prospective study	Tooth fracture was the most common failure, followed by post loosening and post fracture.
Al-Wahadni et al. 2008[27]	To investigate the fracture resistance and failure modes of teeth restored with different prefabricated post systems.	• combined root and core fractures (70%) • root fractures (16%) • core fractures (13%)	prospective study	Teeth restored with titanium posts demonstrated higher fracture resistance than those restored with carbon fiber or glass fiber posts. Most failures were catastrophic, rendering the teeth non-restorable.
Gómez-Polo et al. 2010[28]	To compare the cumulative survival rates of teeth restored with prefabricated posts and Co–Cr cast post-and-core restorations.	• post dislodgement • root fracture • caries	retrospective study	Cast post-and-core restorations appeared to be less retentive than prefabricated posts. Root fractures and caries were common causes of treatment failure in teeth restored with prefabricated posts.
Schmitter et al. 2011[29]	To compare the survival rates of 2 different post systems after 5 years of service.	• post-and-core assembly loosening • loss of retention of fiber posts • chipping or fracture of single crowns • root fracture • loss of retention of the post and crown	prospective study	Teeth with extensive coronal structure loss and those restored with metal screw posts exhibited a higher risk of failure.
Zicari et al. 2011[30]	To compare the 3-year clinical outcomes of glass fiber posts and composite cores with gold alloy-based post-and-core restorations in ETT.	• absolute failures: 2 root fractures and 1 endodontic failure • relative failures: 3 cases of post/core retention loss and 1 post fracture	prospective clinical trial	Both cast gold and composite post-and-core systems demonstrated satisfactory clinical performance. The overall success and survival probabilities at 3 years were 91.7% and 97.2%, respectively.

Study	Objectives	Type of failure	Research methodology	Conclusions
Balkenhol et al. 2011[31]	To evaluate the influence of 2 post materials, preparation design and luting agent on the survival probability of root-filled teeth restored with all-ceramic restorations.	• CeraPost: debonding was the most common failure • DentinPost: post fracture was the most common failure	prospective in vitro study	Teeth restored with a ferrule preparation design exhibited higher survival rates. The luting agent had only a minor importance on survival, whereas post material and ferrule design were the most influential factors. DentinPosts demonstrated superior results.
Ferrari et al. 2012[11]	To evaluate the effect of the amount of remaining coronal dentin and the placement of prefabricated and/or customized fiber posts in endodontically treated premolars after 6 years.	• in the group without posts, the highest incidence of root fractures and crown dislodgement was observed • in the group restored with prefabricated posts, post decementation was mainly observed • teeth with 1, 2 and 3 remaining coronal walls exhibited significantly lower failure rates	prospective study	Preservation of at least 1 coronal wall significantly reduced the risk of failure, regardless of the restorative procedure.
Sterzenbach et al. 2012[32]	To compare the survival rates of abutment teeth with severe coronal tissue loss and 2 or fewer remaining cavity walls restored with either prefabricated glass fiber-reinforced epoxy resin posts or titanium posts luted with a self-adhesive material.	• glass fiber-reinforced epoxy resin posts: 3 root fractures and 1 core fracture • titanium posts: 3 endodontic failures	prospective study	Regardless of post material or rigidity, post-endodontic restorations achieved high long-term survival in severely damaged abutment teeth with two or fewer remaining coronal walls and a 2-mm ferrule.
Hegde et al. 2012[33]	To evaluate the fracture strength and failure modes of ETT with flared root canals restored with glass fiber, quartz fiber and cast base-metal post-and-core systems.	• cast metal posts showed 86.66% non-repairable failures and 13.34% repairable failures • both glass fiber and quartz fiber posts demonstrated 100% repairable fractures	prospective in vitro study	Teeth restored with cast posts demonstrated approximately twice the fracture strength of those restored with fibre posts. Failures associated with fibre posts were repairable, whereas failures associated with cast posts were predominantly non-repairable.
Gbadebo et al. 2014[34]	To compare the clinical performance of metallic and glass fiber posts used for the restoration of ETT.	• in the metallic post group, 1 tooth failed because of decementation of the PFM crown	prospective study	The survival rate was 100% for the fiber-reinforced post group and 97.5% for the ParaPost group; however, the difference was not statistically significant.
Sarkis-Onofre et al. 2014[35]	To compare the survival of glass fiber and cast metal posts used to restore ETT with no remaining coronal walls.	• 2 glass fiber posts debonded • 1 glass fiber post debonded in association with a root fracture • 1 cast metal post was associated with a root fracture	prospective study	The 3-year recall rate was 92.3%, and the survival rates of glass fiber and metal posts were comparable. Post type did not significantly influence restoration survival.
Cloet et al. 2017[36]	To compare the 5-year outcomes of glass fiber composite and cast post-and-core restorations in ETT.	• root fracture • post fracture within the root canal • caries • endodontic failure • periodontal failure • loss of retention of the post	prospective study	After a 5-year follow-up, cast gold and composite post-and-core restorations supporting ceramic crowns with an adequate ferrule demonstrated comparable clinical performance, with success and survival rates of 85.2% and 91.5%, respectively.
Casanova and Özcan 2021[37]	To investigate the load-bearing capacity of intraradicular posts and core materials under static and dynamic loading conditions.	• the titanium post group presented with cohesive failure within the crown material with adhesive detachment from the post and core • remaining post groups showed irreparable failures of the crown and core from the cervical coronal dentin surface	prospective in vitro study	Placement of woven fiber within the core and coronal region did not reinforce the restoration and predominantly resulted in adhesive failure of the crown and core. In the absence of coronal tooth structure, intraradicular posts provided a stable foundation for the core and crown assembly.
Nodehi et al. 2022[38]	To compare the effect of different post-and-core systems (Co–Cr, NPG casting, CAD–CAM) on the fracture toughness and failure modes of root canal-treated premolars.	• catastrophic fractures were observed in 80% of samples restored with Co–Cr and NPG castings • 1 horizontal and 1 vertical root fracture were observed in the CAD–CAM group	prospective in vitro study	CAD–CAM-milled restorations demonstrated the highest fracture strength and the lowest risk of catastrophic failure. CAD–CAM restorations exhibited the highest frequency of restorable failure modes.

Co–Cr – cobalt–chromium; PFM – porcelain-fused metal; NPG – non-precious gold; CAD–CAM – computer-aided design/computer-aided manufacturing.

Table 2. Classification of catastrophic post-and-core assembly failures and their subdivisions

Subdivision	Type of failure	Explanation
Class IA	vertical root fracture	The post fractures together with the root, resulting in a vertical root fracture. This fracture may occur either at the level of the post (below the CEJ) or at the level of the core, crown or FPD, extending into the root. This type of failure may occur in both clinical and laboratory settings.
Class IB	horizontal root fracture	The post fractures together with the root, resulting in a horizontal root fracture. This type of failure may occur in both clinical and laboratory settings.
Class IC	oblique root fracture	The post fractures together with the root, resulting in an oblique root fracture. This fracture may occur either at the level of the post (below the CEJ) or at the level of the core, crown or FPD, extending into the root. This type of failure may occur in both clinical and laboratory settings.
Class ID	crown/FPD/core fracture	This subdivision applies only to bonded posts, for which post retrieval is difficult. The post fractures at or above the level of the CEJ, involving the crown, core or FPD. This type of failure may occur in both clinical and laboratory settings.
Class IE	root perforation during post placement	This is an iatrogenic failure that may occur in both clinical and laboratory settings.

CEJ – cementoenamel junction; FPD – fixed partial denture.

Table 3. Classification of non-catastrophic post-and-core assembly failures and their subdivisions

Subdivision	Type of failure	Explanation	Treatment
Class IIA	post dislodgement	The entire post either debonds or becomes dislodged without fracturing the crown or the root. This type of failure may occur only in a laboratory setting.	none
Class IIB	crown dislodgement with or without core debonding	Only the crown becomes dislodged, either with or without debonding of the core from the post. The post remains intact within the root canal without catastrophic damage to the tooth. This type of failure may occur in both clinical and laboratory settings.	If only the crown is dislodged, recement the crown after evaluating and correcting any occlusal interferences. If both the crown and core are dislodged, identify the underlying cause, remove the existing core material from the internal surface of the crown, rebuild the core, and recement the crown.
Class IIC	post-and-core assembly dislodgement	The entire post-and-core assembly debonds and is displaced as a single unit. This type of failure may occur in both clinical and laboratory settings.	Identify the cause of failure and recement the post-and-core assembly.
Class IID	crown/FPD/ core fracture	In this type of failure, the crown, core or FPD fractures together with part of the post, while the remaining portion of the post is still present in the root canal. This subdivision applies only to non-bonded posts, such as serrated or screw-type posts, for which post retrieval is still possible without causing catastrophic damage to the remaining tooth structure. This type of failure may occur in both clinical and laboratory settings.	Retrieve the remaining post from the root canal while preserving as much radicular dentin as possible, and repeat the post-and-core procedure.
Class IIE	endodontic failure	This type of failure includes apical periodontitis or an endodontic-periodontal lesion affecting a tooth restored with a post-and-core assembly. It occurs only in the clinical setting.	Apical periodontitis: Depending on the type of post used, treatment may consist of either orthograde endodontic retreatment or retrograde apicoectomy. If post removal is likely to cause excessive damage to the remaining tooth structure, retrograde apicoectomy is the preferred treatment. Endodontic-periodontal lesion: Treatment depends primarily on the periodontal status of the tooth. If the lesion is associated with significant mobility, extraction may be the only treatment option.
Class IIF	crown chipping	This type of failure involves fracture of the porcelain without causing catastrophic damage to the tooth or the post-and-core assembly. It may occur in both clinical and laboratory settings.	Repair of the fractured or chipped porcelain may be performed using a porcelain repair kit.
Class IIG	secondary caries	This type of failure involves the development of secondary caries in a tooth restored with a post-and-core assembly. It occurs only in the clinical setting.	Treatment depends on the extent of the carious lesion and may range from replacement of the restoration to extraction of the tooth.

The primary purpose of a post is to retain the core in teeth with extensive loss of coronal tooth structure rather than to reinforce the remaining tooth structure.[6] Post placement has been shown to reduce the incidence of catastrophic failures in selected ETT. However, when 3 or 4 coronal walls remain intact, neither post placement nor the type of post-and-core material appears to significantly influence the clinical outcome.[39]

A nationwide survey conducted among German dentists in 2006 reported that 52% of respondents routinely placed a post in every second endodontically treated tooth, while almost 54% believed that posts reinforce ETTs.[2] Current evidence, however, indicates that unnecessary post placement increases the risk of root perforation and may predispose the tooth to root fracture.[1,40–42]

Although in vitro studies provide valuable information regarding the prognosis and prediction of clinical outcomes of ETT, RCTs produce the highest level of clinical evidence. A 17-year follow-up of a RCT by Fokkinga et al. on ETT with and without prefabricated metal posts concluded that placement of a post did not significantly influence tooth survival.[43] Similar findings were reported by Mannocci et al.[44] However, a RCT by Zicari et al. noted a 3-year survival probability of 97.2% and a success rate of 91.7% for restorations supported by glass fiber and gold alloy-based posts, respectively.[15] Similar results were reported in another clinical trial,[45] in which post-endodontic restorations exhibited a failure rate of only 6.42% after 3 years.

Bitter et al. in their in vitro study reported that self-adhesive resin cements produced only a modest increase in the retentive strength of the dowel.[17] Conversely, Mazzoni et al. demonstrated significantly reduced retention and increased interfacial nanoleakage with 2 self-adhesive resin cement.[46] Balkenhol et al. investigated the influence of luting agents under cyclic loading conditions and concluded that the choice of luting agent had a minor influence on the survival of post-and-core restorations.[31]

As far as luting agents are concerned, the survival of the post-and-core assembly depends largely on the accuracy of each clinical step and the operator's handling of the procedure. In addition to technical challenges involved, the limited access within the root canal space further complicates the bonding procedure. To better understand the effect of luting agents on the survival of the post-and-core assembly, long-term clinical investigations in the form of RCTs are required; however, such evidence is currently lacking.

Although several RCTs have investigated the performance of post-and-core restorations, definite conclusions regarding the optimal restorative strategy remain elusive. The success or failure of these restorations depends on numerous factors. Therefore, additional well-designed, comprehensive RCTs that account for these variables are required to reach a consensus. At present, the available literature remains heterogeneous, contributing to continued uncertainty regarding the indications for post placement, the selection of rigid versus flexible posts, the importance of the ferrule effect, and the optimal luting agent.

Conclusions

Until comprehensive RCTs evaluating all relevant factors affecting the success and failure of post-and-core restorations become available, consensus regarding the indications for post placement is unlikely to be achieved. Future in vitro studies and well-designed clinical trials are needed to validate the proposed classification and assess its reliability and clinical applicability. Based on the currently available evidence, the authors propose a novel classification of post-and-core failures that may provide a standardized approach for classifying the type of post-and-core failures, predicting prognosis, and guiding treatment planning.

Ethics approval and consent to participate

Not applicable.

Data availability

Not applicable.

Consent for publication

Not applicable.

Use of AI and AI-assisted technologies

The AI tool (BioRender; Science Suite Inc., Toronto, Canada) was used to generate the images and graphical abstract.

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