REVIEW ARTICLE Open Access

From conventional to advanced approaches in the endodontic-restorative interface: a narrative review

Musliana Mustaffa[1]*, Sobrina Mohamed Khazin[1], Norfaezah Ahmad[2]

[1]Department of Restorative Dentistry, Kulliyyah of Dentistry, International Islamic University Malaysia, Jalan Sultan Ahmad Shah, Bandar Indera Mahkota, 25200 Kuantan, Pahang, Malaysia.
[2]Department of Prosthodontics, Kulliyyah of Dentistry, International Islamic University Malaysia, Jalan Sultan Ahmad Shah, Bandar Indera Mahkota, 25200 Kuantan, Pahang, Malaysia.

Abstract

In the ever-evolving panorama of dental science, the interface between endodontics and restorative dentistry stands as a crucible where traditional doctrine battles cutting edge innovation. This article aims to analyse the strengths and weaknesses of conventional approaches in the endodontic-restorative interface, contemporary bonding materials and restorative plans, including the use of bioactive materials and minimally-invasive approaches. A literature search for English-language publications from January 2000 to July 2025 with a predetermined criteria was conducted via Google Scholar and PubMed using the search terms 'endodontics AND restorative', and Scopus using the search term 'restoration of endodontically treated teeth'. Additional relevant articles were identified through manual review of the reference list from selected publications. Advanced techniques for the restoration of endodontically treated teeth emphasises structural reinforcement, function, and aesthetics, with a focus on preserving as much of the natural tooth as possible. Emerging materials and techniques have demonstrated comparable, or in some respects, superior performance to conventional post-core retained crowns. However, application of these approaches require careful case selection, precise clinical technique, appropriate material choice, and awareness of their limitations in order to secure successful treatment outcomes.

Keywords: *endocrowns, endodontics, endodontic-restorative, root canal treatment*

Received:
2 January 2026
Revised:
18 June 2026
Accepted:
29 June 2026
Published Online:
31 July 2026

How to cite this article:
Mustaffa, M., Mohamed Khazin, S., & Ahmad, N. (2026). From conventional to advanced approaches in the endodontic-restorative interface: a narrative review. *IIUM Journal of Orofacial and Health Sciences*, *7*(2), 186–202. https://doi.org/10.31436/ijohs.v7i2.490

Article DOI:
https://doi.org/10.31436/ijohs.v7i2.490

***Corresponding author**
Address:
Kulliyyah of Dentistry, International Islamic University Malaysia, Jalan Sultan Ahmad Shah, Bandar Indera Mahkota, 25200 Kuantan, Pahang, Malaysia.

Telephone:
+6095705500

Email address:
muslianamustaffa@iium.edu.my
drmusliana@gmail.com

Introduction

The restoration of endodontically treated teeth (ETT) is widely investigated, yet highly controversial topic. Fundamentally, endodontic treatment is a biological intervention aimed at removing the infected pulp, disinfecting the root canal system, creating a hermetic seal, and restoring compromised teeth with durable materials. Over time, this treatment paradigm has its drawbacks, including excessive removal of the coronal tooth structure, potential marginal discrepancies, reduced aesthetic outcomes, and compromised long-term survival of the ETT. To ensure successful endodontic treatment, effective control of intraradicular infection, good coronal seal and provision of an optimal definitive restoration are factors that need to be well executed (Mehta *et al.,* 2025). Various restorative techniques have been described to address the challenges related to coronal seal, each with their own strengths and limitations (Martin *et al.,* 2016).

Following the concepts of minimally invasive endodontic procedures, guided endodontics is emerging as a viable option for a more precise and safer access cavity preparation while preserving the remaining coronal tooth structure. Bio-minimalism as a trend emphasises preserving the remaining coronal tooth structure without compromising the fundamental endodontic objectives (Fernandes & Dessai, 2001). The concept of preserving pericervical dentine and of anatomy-guided access cavity preparation (e.g. truss access, orifice-directed access, minimal invasive/ultraconservative access) is emerging as critical to maintain tooth strength. Truss access cavity have two or more occlusal cavities directed towards root canals while ultraconservative access is a single occlusal cavity that is smaller than the traditional access (Dioguardi *et al.,* 2025). Despite approach in the anatomy-guided access cavity preparation, owing to more dentine to improve fracture resistance, studies have shown conflicting findings where it may (Patil *et al.,* 2022) or may not improve the fracture strength (Karobari *et al.,* 2021) compared to a ultraconservative access design. Meta-analyses data supported the ultraconservative access cavity design, which may improve fracture resistance due to a greater resilience to occlusal loads compared to traditional endodontic access design (Dioguardi *et al.,* 2025). Based on reported data, the minimal invasive approach can preserve as much remaining tooth structure as possible, thereby minimising the risk of further complications.

The use of Computer-Aided Design and Computer-Aided Manufacturing (CAD/CAM) systems and digital dentistry incorporated with artificial intelligence has facilitated digital scanning, milling, and 3-dimensional printing to allow for more precise restorations with regards to improved fitting, thickness of luting cement, and marginal integrity. These systems allow fabrication to follow standardised processes with improved quality materials, thus offering favourable options during the preoperative stage as well as during subsequent definitive restorations (Edelhoff *et al.,* 2019). Monolithic restorations such as milled endocrowns can reduce the number of laboratory steps and can be designed to preserve more tooth structure.

Advances in adhesives and restorative materials have also produced substantial improvements in resin-based composites through improved filler technology, nanomodified matrices, and improved handling, durability, and aesthetics. Adhesives containing ion-releasing or remineralising components that aim to bond different structures and to protect and rebuild it by inhibiting collagen degradation and promoting calcium/phosphate deposition at the resin-dentine interface are actively being studied (Toledano *et al.,* 2022).

This article aims to analyse the strengths and weaknesses of conventional approaches in the endodontic-restorative interface, contemporary bonding materials and restorative plans, including the use of bioactive materials, and minimally invasive approaches.

Materials and Methods

A literature search was conducted via Google Scholar and PubMed using the search terms ‘endodontics AND restorative’, and Scopus using the search term ‘restoration of endodontically treated teeth’. The search included English language publications from January 2000 to July 2025 with a predetermined criteria such as clinical studies, retrospectives, case reports/series, *in vitro* and reviews. Two independent assessors reviewed the scientific content of the identified articles. Additional relevant studies were selected through manual review of the reference lists of selected articles. Disagreements between assessors were resolved through a consensus discussion. This review includes 64 articles related to endodontics and restorative interface, comprising various study designs.

Conventional approaches at the endodontic-restorative interface

Over the decades, conventional approaches have formed the standard of care for the restoration of ETT. These include access cavity designs, post-and-core techniques, ferrule design, full-coverage crowns for cuspal protection, and the use of rigid posts such as metal and/or cast systems. Conventional access cavity preparation or straight-line access requires maximal removal of coronal tissue to facilitate vision into the anatomical landmarks and root canal instrumentation disinfection, thus enabling precise obturation of the root canal system. The access preparation is often triangular in anterior teeth and trapezoidal or rhomboid in molars, involving full removal the roof of the pulp chamber to ensure direct access to all root canals, thus minimising potential procedural mishaps. This approach frequently results in a considerable amount of tooth structure being removed, including the pulp chamber roof, pericervical dentine, and/or marginal ridges, and is exacerbated when pathological conditions such as caries and/or visible crack lines are present. Additionally, further restoration such as crown preparation is necessary to restore structural integrity and improve retention and resistance.

When the remaining coronal tooth structure left is insufficient, an intraradicular post is traditionally placed into the ETT to provide retention for the core that supports a definitive extra coronal restoration (Sorrentino *et al.,* 2016). Traditionally, prefabricated intraradicular metal posts or custom casts are used. The core is then built up using a metal cast, amalgam, or other restorative materials, followed by full-coverage crowns. The use of metal or rigid posts with high elastic modulus under occlusal load allows for the transfer of stress to the root dentine. However, their lack of flexibility could lead to concentration of stress forces, and ultimately catastrophic root fractures (Akkayan & Gülmez, 2002). Historically, this approach was widely accepted due to the durability of metal posts. However, over the years, a direct coronal-radicular build-up without the need for an intraradicular post has been recommended for molars with a sufficient pulp chamber (McComb, 2008), particularly in cases characterised by compromised remaining coronal tooth structure (Jardim *et al.,* 2025).

Conventional restorative theory emphasises the geometric principles of tooth preparation, such as ensuring appropriate retention form to prevent restoration dislodgement, the resistance form to prevent cuspal fracture or tooth deformation under occlusal load, as well as the crown height, taper, and finish lines to facilitate crown insertion. The crowns serve to protect the remaining coronal tooth structure, distribute occlusal loads, protect cusps from fracture, thus retaining ETT function and delaying the tooth extraction process. A sufficient ferrule consisting of a minimal band of 1.5-2.0mm of sound tooth structure above the crown margin is considered critical at resisting lateral and lifting forces, ultimately preventing tooth fracture and increasing resistance to crown dislodgment (McComb, 2008; Alshabib *et al.,* 2023). In case of an insufficient ferrule, conventional management often involves a crown-lengthening surgery to expose the cavity margin thus exposing adequate intact tooth structure, or orthodontic extrusion to facilitate the creation of a proper ferrule prior to crown placement.

Contemporary concepts and materials

The intersection between endodontics and restorative dentistry is shifting rapidly due to evolving concepts in biology, biomechanics, and adhesive science. The goal of modern restoration philosophy is to maximise tooth preservation, optimise longevity, reduce potential failures, and improve both function and aesthetic outcomes through minimally invasive preparations that emphasise conservation of the pericervical dentine, marginal ridges, and enough coronal structure to avoid or limit the need for rigid intraradicular posts.

Similarly, access cavity preparation has evolved towards conservative and/or orifice-directed designs to maintain tooth strength while still allowing for efficient instrumentation, disinfection, and obturation (Hussien & Laithy, 2023; Dioguardi *et al.,* 2024). These can be achieved through the use of magnification device and illumination, thereby allowing the clinician to preserve sound tooth structure as much as possible, remove the necrotic pulp tissue, and provide straight line access to the canal orifices to ensure effective endodontic procedures (Elmatary *et al.,* 2025).

Furthermore, monoblock or integrated restorations that integrate the core and crown, and sometimes use the pulp chamber space for retention as in the case with endocrowns are becoming increasingly common, particularly in cases involving severely compromised tooth structure. These approaches aim to reduce the restorative interface, thus introducing fewer weak points, simplifying the restorative workflow, and reducing or eliminating intrusive intraradicular posts.

Besides advances in preparation technique/design, there is a growing shift towards using modern adhesive systems engineered with functional monomers that are capable of creating more durable chemical bonds with the dentine and/or enamel. Additionally, bioactive or ion-releasing materials e.g. zinc facilitate remineralisation, inhibit collagen breakdown, and improve the qualities of the hybrid layer through their action as matrix-metalloproteinases inhibitors and signalling pathway regulators. Together, the materials stimulate dentine mineralisation and remineralisation processes, thereby increasing the longevity of dentine bonding (Toledano *et al.,* 2022).

Successful cementation protocols are critical to ensure effective adhesion, prevent biofilm formation at the tooth-restoration margin, avoid microleakage into the root canal system, thus minimising the risk of mechanical and/or biological complications (He *et al.,* 2021; Heboyan *et al.,* 2023; Patel *et al.,* 2025). The 3-step adhesive system remains the gold standard for cementing indirect restorations. However, universal adhesives, selective etching, and self-etch adhesive cementation protocols are simplifications that have been introduced for higher bond strength and reduced moisture sensitivity. However, these approaches have been limited by reports of technical errors; for example, despite the shortened chair side time with the use of self-etched adhesive systems, these systems behave as permeable membranes that are highly susceptible to degradation at the interface level (Abad-Coronel *et al.,* 2019).

Advanced concepts and materials at the endodontic-restorative interface are increasingly focused on more conservative, biomimetic, and adhesive-based strategies (Alshabib *et al.,* 2023) to ensure the preservation of tooth structure. Improved bonding performance, the use of restorative materials that match or mimic tooth biomechanics, and appropriate design of extra-coronal restorations that can reduce interfaces and potential failure modes are being explored in current research.

Clinical considerations

Preoperative assessment

When establishing treatment planning, various factors need to be considered by the clinician to ensure favourable treatment outcomes. During the preoperative stage, the remaining coronal tooth structure must be assessed, taking into consideration the thickness of the walls, depth and shape of pulp chamber, and presence of ferrule before deciding on endocrowns or post-core retained crowns as the most appropriate restorative option.

When a significant amount of coronal tooth structure is intact and no evidence of an underlying carious lesion is present, existing restoration is retained to allow to facilitate endodontic treatment. However, presence of extra-coronal restoration hinders effective preoperative assessment of the remaining coronal tooth structure. Depending on clinical cases, the extra-coronal restoration might require removal to facilitate thorough preoperative assessment. A tooth lacking sound dentine to establish a sufficient ferrule carries an unfavourable prognosis, further complicating the decision-making process.

In clinical cases with extensive carious lesions, caries removal prior to assessment of the remaining coronal structure is required. When the cavity margin is located at the subgingival level, deep margin elevation or crown lengthening surgery may be performed to facilitate pre-endodontic restoration. In cases where teeth in the aesthetic zone are compromised or tooth discolouration is apparent, comprehensive planning is necessary to improve aesthetics not only during the intracanal stage, but also at the post-operative stage. In cases with a long-span dental bridge, assessment of the remaining coronal tooth structure is not possible without dismantling the bridge. The decision to remove or retain the existing restoration should be assessed carefully in all clinical cases, taking into consideration various factors. Therefore, thorough preoperative planning with informed patient consent is critical to ensure predictable restoration outcomes.

Intra-endodontic stage

For the pre-endodontic interim restoration, the selection of an appropriate adhesive system is critical, and should include modern adhesives with improved reliable chemical bonding to the dentine and/or enamel. Interim restoration can facilitate tooth isolation, provide an effective coronal seal, support tooth function and improve aesthetics, particularly when involving teeth in the aesthetic zone. When conventional temporisation methods are not suitable, a durable temporary restoration and removable partial denture can be used as a provisional solution. Subsequent definitive restoration can be carried out at a later stage after completion of the endodontic treatment.

Post-endodontic stage

The aesthetics, opposing dentition, risk of tooth wear, and tooth shade must be considered during treatment planning. When a significant amount of coronal tooth structure is present, composite resin can be suitable for definitive restoration.

Deciding on the need for an intraradicular post depends on the clinical cases such as size and position of the tooth in the arch, amount of remaining coronal tooth structure, functional requirements of the tooth, and root canal configuration (McComb, 2008). In clinical cases where intraradicular post placement is indicated, favourable stress distribution must be planned. The use of a fabricated metal cast post and core that conforms to the root canal anatomy ensures effective fit and adaptation, and using fibre posts instead of rigid posts can reduce the risk of significant complications to the tooth, such as catastrophic tooth fracture. While fibre posts are biomechanically more compatible with dentine than metal posts, their clinical relevance at enhancing long-term outcomes is highly debated (Carvalho *et al.,* 2018; Mannocci *et al.,* 2022) because ETT with fibre posts have comparable survival rates to those restored with metal posts (Bhuva *et al.,* 2021). It is essential to utilise the intraradicular post system that corresponds to the root canal morphology without disrupting the existing obturation (Patel *et al.,* 2025) and that the use of threaded posts should be avoided owing to the stress accumulation within the root canal (Patel *et al.,* 2025).

When using endocrowns, clinicians must consider the occlusal thickness and reduction design to optimise load planes. Adequate pulp chamber depth must be prepared to provide retention for the endocrowns without undermining the remaining walls. Apart from that, minimally invasive approaches also include alternatives such as onlays, overlays, endolays, and vonlays. Onlays cover the occlusal surfaces, overlays are onlays where coverage is extended to the cusps, endolays or endo-overlays are modified endocrowns without an axial circumferential shoulder margin, and vonlays or veneerlays are a combination of onlays and veneers where the restoration coverage is extended to include the buccal surface for improved aesthetics (Figure 1). The principle of minimally invasive procedures refers to preservation of sound tooth structure by avoiding a full-coverage dental crowns, which requires more extensive removal of the tooth structure. When a full coverage crown is needed, the preparation margin should be kept at a supragingival or minimally subgingival level whenever possible to minimise the risk of periodontal complications. To prevent catastrophic tooth fracture, the clinician should select flexible materials and designs, preserve the dentine, and avoid overpreparation. Patient-centred concerns, such as aesthetics, financial implications, chairside time, number of dental visits, and outcome expectations should guide clinicians in the decision-making process.

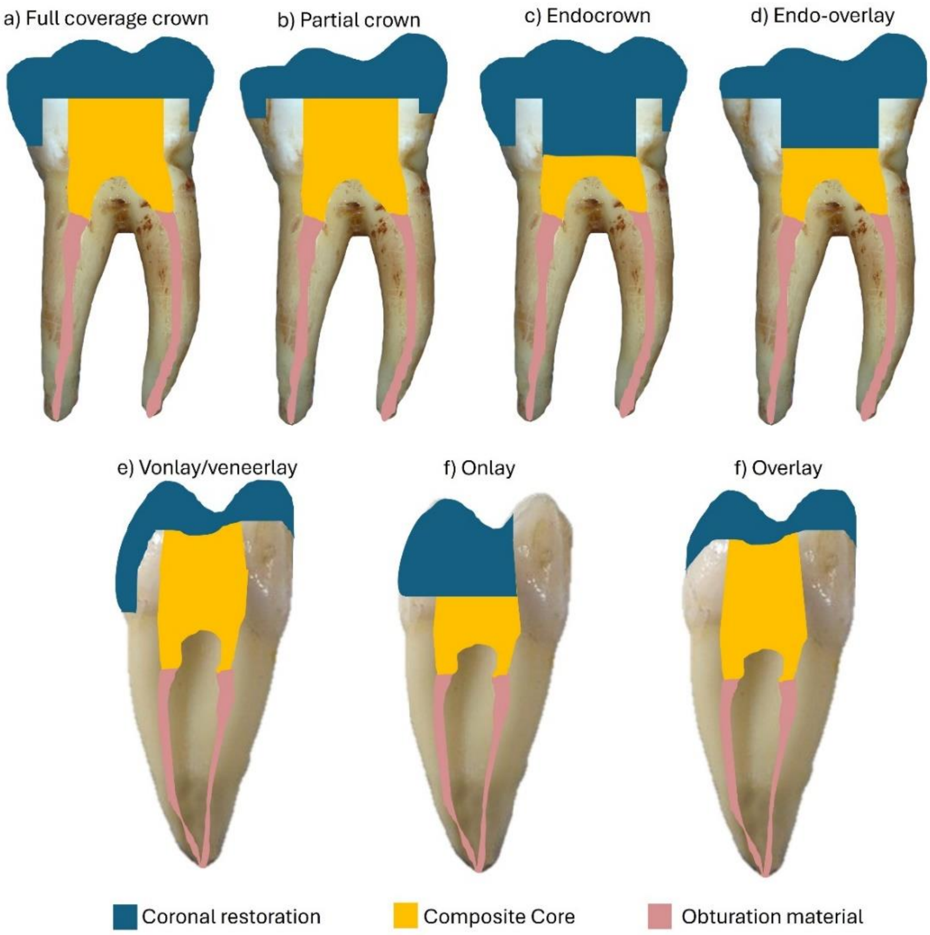

Figure 1. Schematic diagram showing the differences between indirect restoration of ETT, (a-d) mandibular molar cross-sectional buccal view and (e-f) mandibular premolar cross-sectional proximal view.

In a meta-analysis study, single crowns on ETT achieved a 92% success rate, whereas fixed dental prostheses demonstrated a 79% success rate over a six-year observation period, highlighting single crowns as a favourable method for successful treatment outcomes in ETT restoration (Ploumaki *et al.,* 2013). Available data on the restoration of pulpotomised teeth via placement of full-coverage crowns is limited, however, studies indicate higher success rates compared to conventional direct restorations (Philip &

Suneja, 2022). Endocrowns have also showed favourable clinical outcomes, with reported survival rates of approximately 82% to 98%, supporting their use as a conservative and predictable alternative to intraradicular post-and-core retained crowns in molars with significant loss of coronal tooth structure (Kontakou Zoniou *et al.,* 2025).

Advanced techniques and digital integration

Digital integration and workflow

The integration of intraoral scanners and CAD/CAM technology has simplified restoration of ETT through enabling precise digital impression (Figure 2), rapid design, and efficient fabrication of restorations such as endocrowns and custom post-and-core systems, often within a single clinical session. Digital workflows reduce chair side time, improve patient comfort, and enhance the accuracy and fit of restorations, resulting in more predictable and durable clinical outcomes (Davidovich *et al.,* 2020; Al-Qarni, 2022; Neves *et al.,* 2022).

Computer-Aided Design and Computer-Aided Manufacturing systems use intraoral scanners to capture highly accurate digital impressions, improving the fit and marginal adaptation of restorations compared to conventional methods. Direct digitalisation with intraoral scanners offers better adaptation for custom post-and-core fabrication compared to conventional indirect techniques, although scanning deep root canals can remain challenging (Dimitrova *et al.,* 2024). Overall, digital workflows reduce errors associated with conventional impressions and enhance the precision of restorations (Al-Qarni, 2022; Dimitrova *et al.,* 2024; Hiraba *et al.,* 2024).

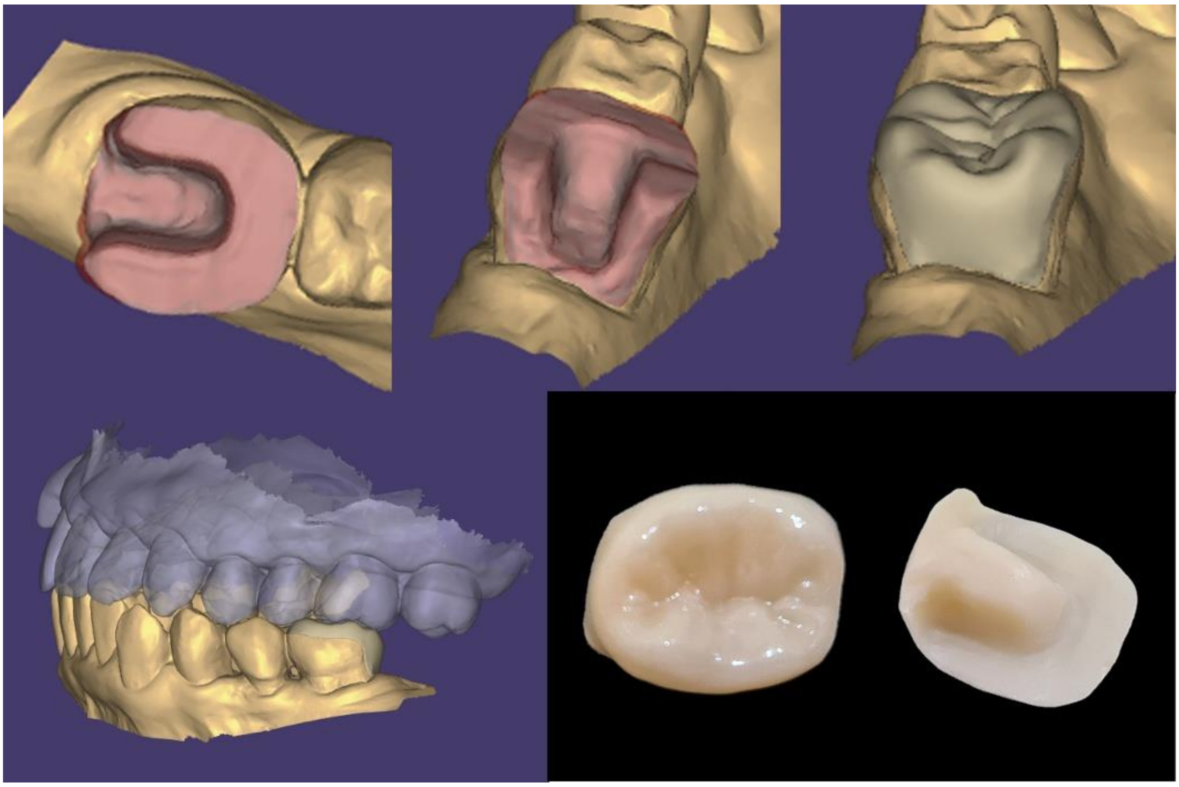

Figure 2. Digital design and construction of zirconia endo-overlay for tooth 36

Additionally, the digital workflow enables chairside or laboratory-based design and milling of restorations in a single session, which significantly reduces treatment time. Endocrowns and custom post-and-core systems can be designed and fabricated immediately and rapidly, allowing for efficient, minimally invasive, and conservative treatment that preserves tooth structure (Al-Qarni, 2022; Hiraba *et al.,* 2024). The high efficiency and accuracy of CAD/CAM systems also facilitate the production of restorations with clinically acceptable fit and marginal gaps (Wakwak *et al.,* 2023; Hiraba *et al.,* 2024). Endocrown restorations leverage the pulp chamber for retention, eliminating the need for conventional posts. Computer-Aided Design and Computer-Aided Manufacturing fabricated endocrowns, especially those constructed from high-strength ceramics or hybrid materials such as lithium disilicate or resin nanoceramics demonstrate high fracture resistance, improved survival rates, and excellent adaptation, and are suitable for restoring posterior teeth with extensive coronal loss (AlHelal, 2023; Hiraba *et al.,* 2024; Jalali *et al.,* 2024; Keskin *et al.,* 2024). Endocrowns offer a conservative, aesthetic, and durable restoration solution, while digital workflows enable efficient and precise fabrication (Davidovich *et al.,* 2020; Janiga, 2021, Neves *et al.,* 2022; Popa *et al.,* 2024; Wejden *et al.,* 2024).

In *in vitro* studies on compromised endodontically treated premolars (Guo *et al.,* 2016) and molars (Rayyan *et al.,* 2019), teeth restored with endocrowns had higher fracture strength than those treated with post-core retained crowns, suggesting their effectiveness at restoring the structural integrity of posterior teeth without the need for intraradicular posts. Additionally, a meta-analysis of clinical studies showed an estimated overall five-year survival rate of 91.4% for endocrowns and 98.3% for conventional crowns, while the estimated overall five-year success rates were 77.7% for endocrowns and 94% for conventional crowns (Al-Dabbagh, 2021). Although no significant differences were observed in the survival and/or success rates between these restorations, endocrowns were the preferred conservative option in selected clinical cases, particularly in endodontically treated posterior teeth (Guo *et al.,* 2016; Rayyan *et al.,* 2019). Furthermore, in finite element analysis stress distribution tests, endocrowns reduced stress concentration at the inner wall of the root canal compared to post-core retained crowns, suggesting that endocrowns better protected root integrity and were less prone to root fracture compared to intraradicular posts (Lin *et al.,* 2020).

Recent modifications to the design of endocrowns have focused especially on the marginal forms. The designs described in literature are: (1) a 90-degree butt joint involving cervical area, (2) 90-degree butt joint limited to 2mm coronal area, (3) axial reduction with shoulder margin at the cervical area, (4) a 20-degree bevelling margin limited to 2mm of the coronal area. The 90-degree butt-joint and 20-degree bevelling margin limited to 2mm coronal area designs are conservative options for endocrowns, and are also known as endolays or endo-overlays.

Custom post-and-core

Digital techniques have enabled the design and milling of custom posts and cores that are tailored to the patient's anatomy, thereby improving fit and reducing the risk of root perforation. Commonly used materials used include zirconia, composite resin, hybrid ceramics and fibre-reinforced posts (Al-Qarni, 2022). Custom CAD/CAM posts show superior adaptation, retention, and bond strength compared to prefabricated systems, with zirconia posts exhibiting the highest fracture resistance (Al-Qarni, 2022; Gutiérrez *et al.,* 2022; Dimitrova *et al.,* 2024; Hamitoglu & Ozkurt-Kayahan, 2025).

Adhesive and biomimetic approaches

Adhesive and biomimetic approaches have transformed the restoration of ETT, emphasizing the preservation of the natural tooth structure, mimicking biomechanical properties and enhancing long-term outcomes. Adhesive dentistry enables minimally invasive restorations by bonding restorative materials directly to tooth tissues, reducing the need for extensive preparation and mechanical retention. This approach preserves the enamel, dentine, and dentino-enamel junction, which are critical for tooth strength and longevity (Carvalho *et al.,* 2018; Barreto *et al.,* 2024; Caussin *et al.,* 2024). Adhesive techniques range from direct composite restorations for teeth with minimal tissue loss to indirect adhesive restorations such as onlays, overlays, and endocrowns (Figure 2) that provide strong, predictable outcomes for teeth with moderate to extensive structure loss (Bhalla *et al.,* 2020; Dioguardi *et al.,* 2022). Meanwhile, fibre-reinforced composites and glass-fibre posts offer improved biomechanical compatibility and reduced catastrophic failure risk compared to conventional metal posts (Carvalho *et al.,* 2018; Barreto *et al.,* 2024).

Biomimetic dentistry aims to restore the tooth's structure, function, and biomechanics by replicating their natural structure and function. Its principles include maximal preservation of sound tooth structure, including avoiding unnecessary removal for posts or full crowns (Carvalho *et al.,* 2018; Kimble *et al.,* 2023; Barreto *et al.,* 2024), material selection that mimics natural tissues, such as ceramics or hybrid materials for enamel replacement and fibre-reinforced composites for dentine replacement that closely match the tooth's mechanical properties (Barreto *et al.,* 2024), partial adhesive restorations that distribute occlusal forces more naturally and reduce the risk of root fracture (Barreto *et al.,* 2024; Popa *et al.,* 2024), and avoiding the use of posts when possible.

The endo-overlay is an advanced adhesive and biomimetic approach that prioritizes structural integrity and functional compatibility for restoring ETT. Similar to conventional endocrowns, it utilizes the pulp chamber for macromechanical retention, but limits the margin to the coronal 2mm, a feature more consistent with overlay and onlay designs (Table 1, Figure 3 b,c,g,h). The design reduces unnecessary removal of sound tooth structure and optimizes adhesion to the remaining dentine and enamel. A recent *in vitro* study found that endocrown preparations with axial reduction concentrates majority of the stress at the cervical margin when compared to endo-overlay designs, where the likelihood of restoration debonding is high (Zheng *et al.,* 2022). In another *in vitro* research, zirconia endo-overlays showed comparable fracture resistance to more extensive axial preparations, supporting their application as a minimally invasive restoration technique for ETT (Jurado *et al.,* 2025).

In parallel with these findings, a four-year retrospective clinical study similarly reported no significant difference in survival rates or clinical performance between endocrown and overlay restorations for posterior ETT (Ayata *et al.,* 2025). Furthermore, another investigation indicated superior fracture resistance of onlays over zirconia endocrowns, further reinforcing the principle that adhesive integrity and preservation of remaining tooth structure are pivotal to biomechanical outcomes, surpassing the influence of cavity coverage extent. Preservation of pericervical dentine in conjunction with adhesive bonding strategies is thus vital for sustaining the structural integrity of restored teeth, thereby reinforcing fracture resistance, however, these goals are often challenging to achieve in clinical cases with extensive tooth structure loss (Carvalho *et al.,* 2018; Caussin *et al.,* 2024; Mishra *et al.,* 2025). The shift from post-core crowns to endocrowns and more recently, to endo-overlays, exemplifies an ongoing move toward adhesive, conservative, and biologically harmonious restorative approaches.

With advances in restorative design, margin management techniques have also evolved to support minimally invasive and biologically compatible outcomes. The deep marginal elevation (DME) approach, where subgingival margins are relocated coronally using composite resin, has demonstrated promising outcome for subgingival defect restoration in suitable cases. This approach aids procedures such as digital impression and rubber dam isolation when dealing with adhesively bonded ceramic restorations (Hausdörfer *et al.,* 2024). Compared to surgical crown lengthening, DME is more conservative, with similar bleeding on probing at 12 months but less periodontal probing depth and attachment loss (Farouk *et al.,* 2023). Clinical and histological studies show that DME preserves supracrestal tissue integrity and minimizes inflammation and gingival recession when performed within biologically acceptable limits and under proper isolation (Taylor & Burns, 2024). Conversely, conventional full-coverage crowns, which often require greater axial reduction and deeper margin placement, risk violating the biological width and may predispose the surrounding tissues to inflammation or attachment loss. Restorations using DME have shown improved plaque control, reduced probing depth, and enhanced gingival stability relative to conventional crowns, underscoring its utility as a biologically compatible restorative technique (Bertoldi *et al.,* 2020; Ahmed & Moukarab, 2025). When combined with adhesive partial-coverage restorations, such as overlays or endo-overlays, DME can further enhance marginal adaptation, restorative access, and periodontal harmony, further reinforcing the biologically-centred philosophy of adhesive and biomimetic restorative dentistry.

Biomechanical and clinical considerations

Restoring ETT requires a comprehensive understanding of both biomechanical principles and clinical factors to ensure long-term function, strength, and survival of the tooth. The primary challenge during restoration is the loss of coronal tooth structure due to caries, trauma, and endodontic access preparation, which significantly reduces tooth strength and increases the risk of fracture, particularly in the cervical region (Caussin *et al.,* 2024).

A crucial biomechanical factor is the ferrule effect, where preserving a 1.5 to 2 mm band of sound tooth structure above the finish line markedly increases fracture resistance. This structural reinforcement helps distribute occlusal load and prevents catastrophic failures (Soares *et al.,* 2018; Mishra *et al.,* 2025; Mously *et al.,* 2025).

Table 1. Differences between overlay, endodontic-overlay and traditional endocrown.

Type	**Coverage**	**Pulp chamber incorporation**	**Margin design**
Onlay	Covers affected cusps only	May or may not involve pulp chamber	No circumferential margin
Overlay	Covers all cusps; occlusal coverage only	No	No circumferential margin
Endodontic-overlay	Covers all cusps	Yes	No circumferential margin
Endocrown	Full crown replacement	Yes	Circumferential margin

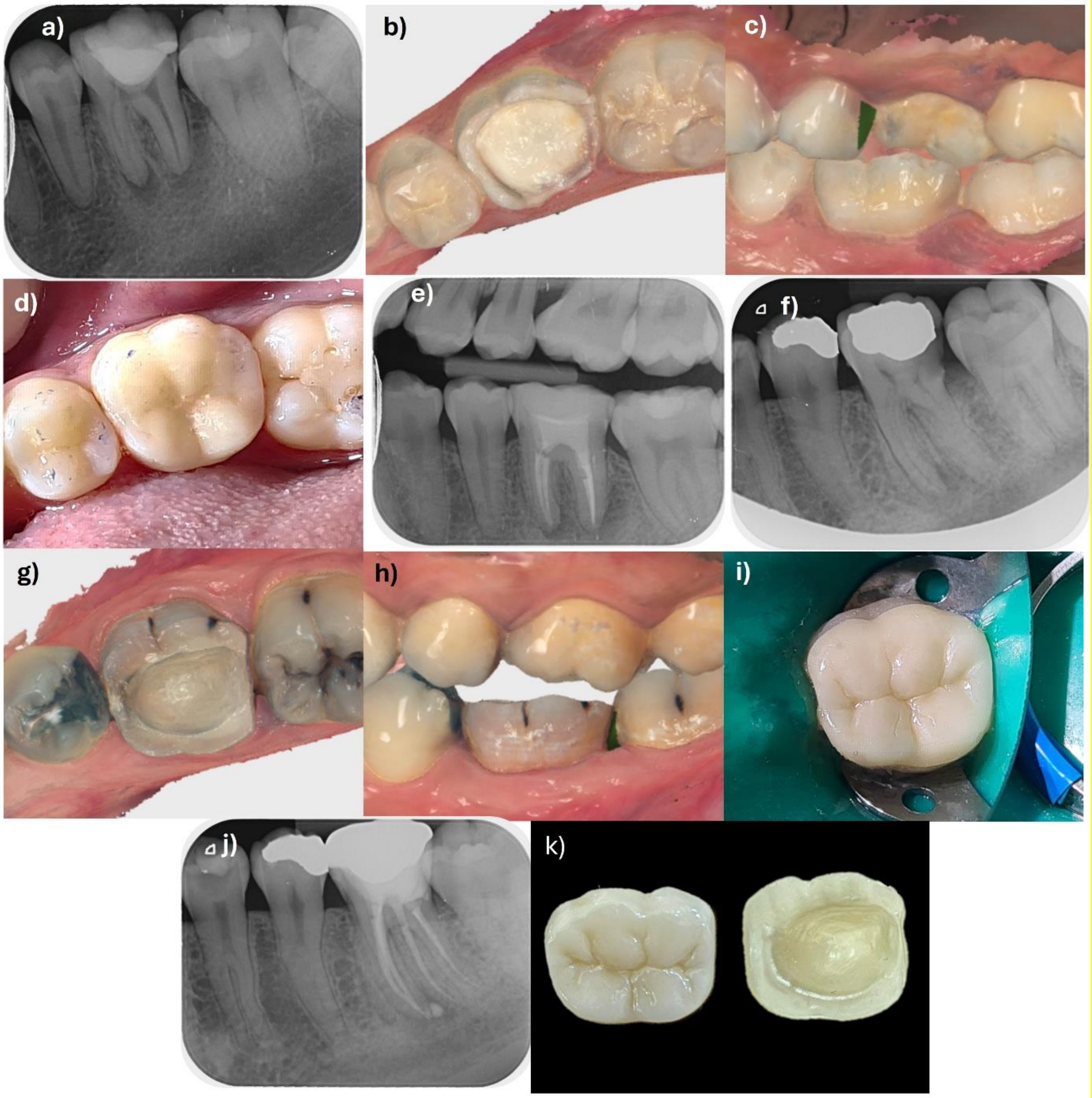

Figure 3. Clinical cases showing distinctions between onlay restoration and endo-overlay with DME on ETT. Case 1: (a) pre-operative radiograph of tooth 36. (b) intra-oral scanned image of tooth 36 after completion of endodontic treatment prepared for onlay (occlusal view); (c) buccal view showing no cuspal reduction, consistent with onlay design; (d) cementation of lithium disilicate onlay; and (e) post-cementation radiograph. Case 2: (f) pre-operative radiograph of tooth 36 showing deep caries margin on distal (g) intra-oral scanned image of tooth 36 after completion of endodontic treatment prepared for endo-overlay (occlusal view) with DME on distal; (h) buccal view of tooth 36 showing occlusal reduction for full cuspal coverage; (i) cementation of zirconia endo-overlay under rubber dam, (j) post-cementation radiograph showed good adaptation of overlay with the DME, and (k) endo-overlay design with 90-degree butt-joint margin limited to coronal 2mm

Table 2. Summary of the biomechanical and clinical factors ETT restoration.

Factors	Mechanism	Clinical Impact	Reference
Ferrule effect	1.5 to 2 mm band of sound tooth structure above the finish line	Increases fracture resistance	Soares *et al.*, 2018; Mishra *et al.*, 2025; Mously *et al.*, 2025
Restorative material selection	Material selection has closer mechanical properties to replaced tooth structure	Effective stress distribution, reduced risk of catastrophic fracture	Soares *et al.*, 2018; Mously *et al.*, 2025
Adhesive technique	Improved bonding between restoration and both coronal and radicular tooth structure	Enhances retention, preserves tooth structure	Caussin *et al.*, 2024
Restoration design	Quantity and quality of remaining tooth structure	Influences invasiveness of the restorative technique and reparability	Lenz *et al.*, 2024; Mously *et al.*, 2025; Naik *et al.*, 2025
Timing of restoration	Early placement of definitive restorations reduces the risk of microleakage and fracture	Early restoration improves survival	Caussin *et al.*, 2024

The choice of restorative material is equally important during treatment planning. Materials with mechanical properties closer to those of dentine, such as fibre-reinforced posts, provide a more favourable stress distribution compared to rigid metal posts, thereby reducing the risk of root fractures (Soares *et al.*, 2018; Mously *et al.*, 2025). Concurrently, advancements in adhesive dentistry have enhanced the survival of ETT by improving bonding at both the coronal and radicular levels. However, reliable adhesion in root canals remains challenging due to canal morphology and dentine microstructure (Caussin *et al.*, 2024).

Optimal restoration depends on the quantity and quality of the remaining tooth structure. Teeth with sufficient coronal dentine may be restored using direct or indirect adhesive techniques, while severely compromised teeth often require post placement for core retention (Mishra *et al.*, 2025). Minimally invasive approaches, such as endocrowns, are particularly advantageous in molars and premolars, as they preserve more tooth structure and demonstrate superior biomechanical performance compared to conventional post-and-core crowns (Lenz *et al.*, 2024; Mously *et al.*, 2025; Naik *et al.*, 2025).

Additionally, the timing of restoration is another determinant of success. Early placement of definitive restorations following endodontic therapy reduces the risk of microleakage and fracture, thereby enhancing long-term survival (Caussin *et al.*, 2024).

Patterns of failure vary with the design of restoration. Adhesive restorations and endocrowns usually fail in a more repairable manner, whereas conventional rigid post-and-core systems are prone to catastrophic root fractures (Lenz *et al.*, 2024; Mously *et al.*, 2025; Naik *et al.*, 2025). Finally, patient-specific factors such as occlusal loading, parafunctional habits, aesthetic concerns, and oral hygiene must always be considered during treatment planning (Mishra *et al.*, 2025).

Current challenges and future directions

Current challenges in restoring ETT

ETT restoration often requires complex clinical decision-making. One of the most significant challenges during restoration is preserving and maintaining the structural integrity of teeth. Due to caries, trauma, and endodontic access preparation, ETT are inherently weaker and more prone to fracture.

Despite having a position statement on the restoration of ETT (Mannocci *et al.,* 2021) and clinical recommendation (Bhuva *et al.,* 2021), treatment planning is often individualised based on remaining coronal tooth structure, aesthetic demands, and functional requirements, further complicating decision-making (Carvalho *et al.,* 2018; Caussin *et al.,* 2024).

The limitations associated with biomechanical and adhesive approaches continue to hinder predictable treatment outcomes. Achieving durable adhesive bonding in root canals remains challenging due to the complex canal anatomy and structure of the dentine. Concurrently, functional stresses predispose ETT to catastrophic failures, such as root fractures (Carvalho *et al.,* 2018; Caussin *et al.,* 2024). Furthermore, occlusal and functional considerations are often overlooked in research, despite their significant impact on long- term restoration survival (Mannocci *et al.,* 2022; Caussin *et al.,* 2024).

Finally, robust long-term clinical evidence on the newer adhesive systems, biomimetic, and minimally invasive restorative approaches for ETT is still lacking. Much of the current knowledge is derived from *in vitro* studies or short-term clinical trials, leaving much uncertainty about the long-term performance and effectiveness of these approaches (Carvalho *et al.,* 2018; Mannocci *et al.,* 2022).

Future direction in ETT restoration

In the future, the restoration of ETT will shift in the direction of biomimetic and conservative strategies that prioritize maximal preservation of natural tooth structure. This includes the use of partial coverage restorations, advanced adhesive techniques and minimally invasive preparation designs (Carvalho *et al.,* 2018; Caussin *et al.,* 2024; Mishra *et al.,* 2025).

There is also positive potential in the development of innovative restorative materials. High-strength ceramics, fibre-reinforced posts, and advanced adhesive systems are being engineered to achieve greater biomechanical compatibility with dentine, thereby enhancing the durability of restoration outcomes and reducing the risk of catastrophic failures (Caussin *et al.,* 2024; Mishra *et al.,* 2025).

The integration of digital workflows is another promising advancement: CAD/CAM technology and intraoral scanning enables more precise, efficient, and customised restorations. This approach supports the fabrication of endocrowns and individualised post-and-core systems, improving both restoration accuracy and clinical outcomes (Mannocci *et al.,* 2022; Mishra *et al.,* 2025).

Furthermore, personalised decision-making tools, such as the Restorative Difficulty Evaluation System (RDES) are being developed to guide clinicians in deciding optimal treatment strategies tailored to individual cases. These systems incorporate the structural, functional, and aesthetic demands of the patient during treatment planning (Mishra *et al.,* 2025). The RDES facilitates the clinicians to evaluate the restorative difficulties by addressing the criteria/parameters and scores ranged from score 1 with favourable tooth condition to 6 with severely compromised tooth (Ferrari *et al.,* 2022). Through this approach, clinicians can determine whether the tooth has a low, moderate or high RDES, thereby can re-evaluate the treated tooth at the end of therapies and/or at each follow-up visit to improve knowledge about the prognosis of ETT after being restored (Ferrari *et al.,* 2022).

In brief, the restoration of ETT continues to face significant biomechanical and clinical challenges, particularly with regards to structural preservation, material selection, adhesive reliability, and the limited availability of long-term evidence. Nevertheless, future directions driven by biomimetic philosophies, innovation in restorative materials, digital workflow integration, and evidence-based frameworks offer promising avenues for more predictable and durable outcomes.

Conclusions

Conventional treatment modalities for endodontic and restorative procedures involves several steps, including endodontic treatment, temporisation, intraradicular post placement, core build-up, crown preparation, impression-taking, laboratory fabrication, and crown cementation. The overall process entails prolonged treatment time, large financial implications, and frequent patient visits to the clinic. Conventional approaches of the endodontic-restorative interface are guided by the removal of infected tissue, straight access, retention via intraradicular posts and cores, and full coverage crowns. However, these methods are associated with weakening of the tooth structure, potential tooth fracture, and unfavourable outcomes when too much tissue is removed or when post-placement is aggressive. Modern strategies increasingly balance conventional principles with the preservation of tooth structure, improved adhesive techniques, and minimally invasive design that emphasises structural reinforcement, function, and aesthetics while preserving as much natural tooth as possible. Recent advances focus on the use of adhesive dentistry, high-strength materials, and minimally invasive approaches, with treatment decision-making tailored to the individual case to optimise long-term outcomes and enhance tooth preservation.

Conflict of Interest

No conflict of interest reported.

Acknowledgements

The authors would like to thank Kulliyyah of Dentistry at the International Islamic University Malaysia for the facilities to support patient management. Written informed consent from patients was obtained for publication purposes.

References

Abad-Coronel, C., Naranjo, B., Valdiviezo, P. (2019). Adhesive systems used in indirect restorations cementation: review of the literature. *Dentistry Journal*, *7*(3), 71.

Ahmed, O.S., Moukarab, D. (2025) Impact of marginal elevation in restored endodontically treated teeth with CAD/CAM ceramic endocrowns on the marginal adaptation (*in vitro*). *Journal of Contemporary Dental Practice,* 26(5):473-480.

Akkayan, B., Gülmez, T. (2002). Resistance to fracture of endodontically treated teeth restored with different post systems. *The Journal of Prosthetic Dentistry*, *87*(4), 431-437.

Al-Dabbagh, R.A. (2021). Survival and success of endocrowns: a systematic review and meta-analysis. *The Journal of Prosthetic Dentistry*, *125*(3), 415-e1.

AlHelal, A.A. (2023). Biomechanical behavior of all-ceramic endocrowns fabricated using CAD/CAM: a systematic review. *Journal of Prosthodontic Research*, *68*(1), 50-62.

Al-Qarni, F. (2022). Customized post and cores fabricated with CAD/CAM technology: a literature review. *International Journal of General Medicine*, 15, 4771 - 4779.

Alshabib, A., Abid Althaqafi, K., AlMoharib, H.S., Mirah, M., AlFawaz, Y.F., Algamaiah, H. (2023). Dental fiber-post systems: an in-depth review of their evolution, current practice and future directions. *Bioengineering*, *10*(5), 551.

Ayata, M., Oktay, E. K., Albayrak, H., Çakar, M., Özcan, M. (2025). Evaluation of the clinical performance of endocrown and overlay restorations: a 4-year retrospective study. *Journal of Dentistry*, *160*, 105874.

Barreto, D., Lerma, L., Palencia, P., Fierro, N. (2024). Adhesive approach for endodontically treated teeth, literature review. *International Journal of Applied Dental Sciences.* 10(2), 329-332.

Bertoldi, C., Monari, E., Cortellini, P., Generali, L., Lucchi, A., Spinato, S. *et al.* (2020). Clinical and histological reaction of periodontal tissues to subgingival resin composite restorations. *Clinical Oral Investigations*, *24*(2), 1001-1011.

Bhalla, V., Chockattu, S., Srivastava, S., Prasad, S. (2020). Decision making and restorative planning for adhesively restoring endodontically treated teeth: An update. *Saudi Endodontic Journal*, 10, 181-186.

Bhuva, B., Giovarruscio, M., Rahim, N., Bitter, K., Mannocci, F. (2021). The restoration of root filled teeth: a review of the clinical literature. *International Endodontic Journal*, *54*(4), 509-535.

Carvalho, M.A.D., Lazari, P.C., Gresnigt, M., Del Bel Cury, A.A., Magne, P. (2018). Current options concerning the endodontically-treated teeth restoration with the adhesive approach. *Brazilian Oral Research*, *32*, e74.

Caussin, E., Izart, M., Ceinos, R., Attal, J.P., Beres, F., François, P. (2024). Advanced material strategy for restoring damaged endodontically treated teeth: a comprehensive review. *Materials*, *17*(15), 3736.

Davidovich, E., Dagon, S., Tamari, I., Etinger, M., Mijiritsky, E. (2020). An innovative treatment approach using digital workflow and CAD-CAM part 2: The restoration of molar incisor hypomineralization in children. *International Journal of Environmental Research and Public Health*, *17*(5), 1499.

Dimitrova, M., Vlahova, A., Kazakova, R. (2024). Assessment of CAD/CAM fabrication technologies for post and core restorations - a narrative review. *Medicina*, *60*(5), 748.

Dioguardi, M., Alovisi, M., Comba, A., Baldi, A., Troiano, G., Cadenaro, M. *et al.* (2022). The influence of indirect bonded restorations on clinical prognosis of endodontically treated teeth: a systematic review and meta-analysis. *Dental Materials*, *38*(8), e203-e219.

Dioguardi, M., Esperouz, F., Bizzoca, M.E., Illuzzi, G., Sanesi, L., Sovereto, D. *et al.* (2025). Analysis of the impact of the minimally invasive access preparation on the fracture resistance in endodontics, Systematic Review of Vitro Study. *Current Oral Health Reports*, *12*(1), 29.

Dioguardi, M., La Notte, D., Sovereto, D., Quarta, C., Martella, A., Ballini, A. (2024). Influence of cavity designs on fracture resistance: Analysis of the role of different access techniques to the endodontic cavity in the onset of fractures: narrative review. *The Scientific World Journal*, *2024*(1), 1648011.

Edelhoff, D., Stimmelmayr, M., Schweiger, J., Ahlers, M.O., Güth, J.F. (2019). Advances in materials and concepts in fixed prosthodontics: a selection of possible treatment modalities. *British Dental Journal*, *226*(10), 739-748.

Elmatary, A., Moawad, E., Heidarifar, O., Stone, S. (2025). Endodontic access cavity preparation: challenges and recent advancements. *British Dental Journal*, *238*(7), 469-475.

Farouk, A.T., Hassanein, O.E.S., Fahmy, O.I., Elkady, A.M., ElNahass, H. (2023). Biological evaluation of indirect restorations in endodontically treated posterior teeth with deeply located proximal margins following deep margin elevation versus surgical crown lengthening: a randomized controlled trial. *Clinical Oral Investigations*, *28*(1), 24.

Fernandes, A.S., Dessai, G.S. (2001). Factors affecting the fracture resistance of post-core reconstructed teeth: a review. *International Journal of Prosthodontics*, *14*(4).

Ferrari, M., Pontoriero, D.I., Ferrari Cagidiaco, E., Carboncini, F. (2022). Restorative difficulty evaluation system of endodontically treated teeth. *Journal of Esthetic and Restorative Dentistry*, *34*(1), 65-80.

Guo, J., Wang, Z., Li, X., Sun, C., Gao, E., Li, H. (2016). A comparison of the fracture resistances of endodontically treated mandibular premolars restored with endocrowns and glass fiber post-core retained conventional crowns. *The Journal of Advanced Prosthodontics*, *8*(6), 489.

Gutiérrez, M.A., Guerrero, C.A., Baldion, P.A. (2022). Efficacy of CAD/CAM glass fiber posts for the restoration of endodontically treated teeth. *International Journal of Biomaterials*, *2022*(1), 8621835.

Hamitoglu, B., Ozkurt-Kayahan, Z. (2025). Fracture resistance of endodontically treated teeth restored with CAD-CAM milled and prefabricated post-and-core systems. *Journal of Prosthodontics*. 1-7.

Hausdörfer, T., Lechte, C., Kanzow, P., Rödig, T., Wiegand, A. (2024). Periodontal health in teeth treated with deep-margin-elevation and CAD/CAM partial lithium disilicate restorations-a prospective controlled trial. *Clinical Oral Investigations*, *28*(12), 670.

He, J., Zheng, Z., Wu, M., Zheng, C., Zeng, Y., Yan, W. (2021). Influence of restorative material and cement on the stress distribution of endocrowns: 3D finite element analysis. *BMC Oral Health*, *21*(1), 495.

Heboyan, A., Vardanyan, A., Karobari, M.I., Marya, A., Avagyan, T., Tebyaniyan, H. *et al.* (2023). Dental luting cements: an updated comprehensive review. *Molecules*, *28*(4), 1619.

Hiraba, H., Nishio, K., Takeuchi, Y., Ito, T., Yamamori, T., Kamimoto, A. (2024). Application of one-piece endodontic crowns fabricated with CAD-CAM system to molars. *Japanese Dental Science Review*, 60, 81-94.

Hussien, S.A., Laithy, A.A., 2023. The effect of restoration of endodontically treated teeth with different restorations in both modern and traditional access cavity preparations. *Egyptian Dental Journal*, *69*(4), 3141-3148.

Jalali, S., Asgari, N., Pirooz, P., Younespour, S., Atri, F. (2024). Comparison of clinical efficacy of CAD CAM endocrowns made of feldspathic ceramic, zirconia lithium silicate, and lithium disilicate: a two-year mixed cohort study. *Journal of Dentistry*, *149*, 105019.

Janiga, A.M. (2021). The endocrown: a unique method for restoring endodontically treated teeth. *General Dentistry*, *69*(5), 52-55.

Jardim, J.S., Ferreira, V.D.M.F., e Oliveira, H.F.F., Faé, D.S., Lemos, C.A.A. (2025). Is the use of an intraradicular post essential for reducing failures in restoring endodontically treated teeth? a systematic review and meta-analysis. *Journal of Dentistry*, 105739.

Jurado, C.A., Afrashtehfar, K.I., Robles, M., Alaqeely, R.S., Alsayed, H.D., Lindquist, T.J. *et al.* (2025).

Effect of preparation design and endodontic access on fracture resistance of zirconia overlays in mandibular molars: an *in vitro* study. *Journal of Prosthodontics,* 34(4):412-421.

Karobari, M.I., Aziz, A.F.A., Makandar, S.D., Ghani, N.R.N.A., Halim, M.S., Noorani, T.Y. (2021). Fracture resistance of teeth with truss endodontic access: an *in vitro* study and literature review. *European Journal of General Dentistry*, *10*(01), 44-49.

Keskin, S.C., Sakar, A., Bolay, S. (2024). A 3-year clinical evaluation of endocrown restorations with two different materials using the computer-aided design/computer-aided manufacture system. *Journal of Dentistry*, *151*, 105405.

Kimble, P., Stuhr, S., McDonald, N., Venugopalan, A., Campos, M.S., Cavalcanti, B. (2023). Decision making in the restoration of endodontically treated teeth: effect of biomimetic dentistry training. *Dentistry Journal*, *11*(7), 159.

Kontakou Zoniou, A., Tzimas, K., Pappa, E., Rahiotis, C. (2025). Clinical performance of endocrowns in molars: a scoping review. *Medicina*, *61*(9), 1562.

Lenz, U., Bacchi, A., Della Bona, A. (2024). Biomechanical performance of endocrown and core-crown restorations: a systematic review. *Journal of Esthetic and Restorative Dentistry*, *36*(2), 303-323.

Lin, J., Lin, Z., Zheng, Z. (2020). Effect of different restorative crown design and materials on stress distribution in endodontically treated molars: a finite element analysis study. *BMC Oral Health*, *20*(1), 226.

Mannocci, F., Bhuva, B., Roig, M., Zarow, M., Bitter, K. (2021). European Society of Endodontology position statement: the restoration of root filled teeth. *International Endodontic Journal*, *54*(11), 1974-1981.

Mannocci, F., Bitter, K., Sauro, S., Ferrari, P., Austin, R., Bhuva, B. (2022). Present status and future directions: the restoration of root filled teeth. *International Endodontic Journal*, *55*, 1059-1084.

Martin, W., Taylor, C., Jawad, S., Roudsari, R.V., Darcey, J., Qualtrough, A. (2016). Modern endodontic principles part 7: the restorative interface. *Dental Update*, *43*(4), 319-334.

McComb, D. 2008. Restoration of the endodontically treated tooth. *Ensuring Continued Trust.* 1-2

Mehta, D., Coleman, A., Lessani, M. (2025). Success and failure of endodontic treatment: predictability, complications, challenges and maintenance: Success and failure of endodontic treatment: predictability, complications, challenges and maintenance. *British Dental Journal*, *238*(7), 527-535.

Mishra, L., Francis, T., Nooji, D., Aggarwal, H., McColl, E., Eachempati, P. (2025). Current concepts in restoring endodontically treated teeth. *Dental Update*, *52*(1), 26-34.

Mously, H.A., Naguib, G.H., Abougazia, A.O., Almabadi, A.A., Qutub, O.A., Hamed, M.T. (2025). Anterior endocrowns as an alternative to core crown restorations: a systematic review. *International Dental Journal*, *75*(1), 59-74.

Naik, R., Mynam, N.,R,S., Mounika, P., Teja, U., Srinivas, V. (2025). Comparative evaluation of the fracture resistance and marginal adaptation of endodontically treated teeth restored with different prosthodontic techniques: a clinical and *in vitro* study. *International Journal of Environmental Sciences*, 65-69.

Neves, E., Almeida, G., Júnior, J. (2022). Endocrown in digital: literature review. *International Journal of Advanced Engineering Research and Science.* 9(12), 655-660.

Patel, S.R., Youngson, C., Jarad, F. (2025). Principles guiding the restoration of the root-filled tooth: principles guiding the restoration of the root-filled tooth. *British Dental Journal*, *238*(7), 508-516.

Patil, P., Newase, P., Pawar, S., Gosai, H., Shah, D., Parhad, S.M. (2022). Comparison of fracture resistance of endodontically treated teeth with traditional endodontic access cavity, conservative endodontic access cavity, truss endodontic access cavity, and ninja endodontic access cavity designs: An *in vitro* study. *Cureus*, *14*(8).

Philip, N., Suneja, B. (2022). Minimally invasive endodontics: a new era for pulpotomy in mature permanent teeth. *British Dental Journal*, *233*(12), 1035-1041.

Ploumaki, A., Bilkhair, A., Tuna, T., Stampf, S., Strub, J.R. (2013). Success rates of prosthetic restorations on endodontically treated teeth; a systematic review after 6 years. *Journal of Oral Rehabilitation*, *40*(8), 618-630.

Popa, G.D., Gheorghiu, I.M., Nistor, C.C., Scarlatescu, S.A., Marinescu, I.R., Petcu, C. et al. (2024). Endocrown - a change of paradigm for restoring the endodontically treated teeth. *Romanian Journal of Stomatology/Revista Romana de Stomatologie*, *70*(3), 325-329.

Rayyan, M.R., Alauti, R.Y., Abanmy, M.A., AlReshaid, R.M., Ahmad, H.A. (2019). Endocrowns versus post-core retained crowns for restoration of compromised mandibular molars: an *in vitro* study. *International Journal of Computerized Dentistry*, *22*(1).

Soares, C.J., Rodrigues, M.D.P., Faria-e-Silva, A.L., Santos-Filho, P.C.F., Veríssimo, C., Kim, H.C. *et al.* (2018). How biomechanics can affect the endodontic treated teeth and their restorative procedures?. *Brazilian Oral Research*, *32*(suppl 1), e76.

Sorrentino, R., Di Mauro, M.I., Ferrari, M., Leone, R., Zarone, F. (2016). Complications of endodontically treated teeth restored with fiber posts and single crowns or fixed dental prostheses - a systematic review. *Clinical Oral Investigations*, *20*(7), 1449-1457.

Taylor A., Burns L. (2024) Deep margin elevation in restorative dentistry: a scoping review. *Journal of Dentistry,* 146:105066.

Toledano, M., Toledano-Osorio, M., Hannig, M., Carrasco-Carmona, Á., Osorio, M.T., García-Godoy, F. *et al.* (2022). Zn-containing adhesives facilitate collagen protection and remineralization at the resin-dentin interface: a narrative review. *Polymers*, *14*(3), 642.

Wakwak, M., Adly, K., Abdelhady, A., Elmanakhly, A. (2023). Microleakage assessment of CAD/CAM endo crown restorations (an *in vitro* study). *Current Research in Dentistry*, 14, 1-7.

Wejden, B.A., Yosra, G., Elhouda, L.N., Zohra, N., Dalenda, H., Jilani, S. *et al.* (2024). Digital workflow optimization for endocrown restorations on root-treated teeth. *Scholars Journal of Dental Sciences*, *9*, 119-125.

Zheng, Z., Sun, J., Jiang, L., Wu, Y., He, J., Ruan, W. *et al.* (2022). Influence of margin design and restorative material on the stress distribution of endocrowns: a 3D finite element analysis. *BMC Oral Health*, *22*(1), 30.