Universidad Europea

GRADUATION PROJECT

Degree in Dentistry

EVALUATION OF THE DIFFERENT OPTIONS TO RESTORE ENDODONTICALLY TREATED MOLARS

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Identification number: 186

ABSTRACT

Introduction: Endodontically treated molars undergo structural and biomechanical alterations that make their restoration a major challenge in the dental sector. For long-term performance and durability, choosing the right restorative option is essential. **Objectives:** This study aimed to analyze the different options to restore endodontic molars in terms of clinical outcomes such as durability and success, identify the factors influencing the choice, and the most appropriate materials to use. **Methods:** A systematic literature review was conducted using databases such as PubMed, Medline, Google Scholar, and Dentistry & Oral Science Resources. Studies from the last 10 years were selected based on our PICO strategy. **Results:** Indirect adhesive restorations such as endocrowns and lithium disilicate (LDS) overlays show the highest survival rates (94-100%) and a low rate of catastrophic failures. Fiber-reinforced composites have excellent mechanical strength and superior biomechanical safety, with a repair capacity of up to 95%. Despite increased stiffness of post restorations, they present a higher risk of irreparable failure. However, materials such as lithium retain the best mechanical performance. **Conclusions:** Nowadays, the most efficient and long-lasting method for restoring endodontically treated molars is indirect adhesive restorations. To maximize results, a customized strategy that considers the residual coronary structure, the occlusive forces, the functions of the tooth concerned, and the clinical situation of the patient.

KEYWORDS

Dentistry, endodontically treated molars, dental restorations, materials, clinical outcomes.

RESUMEN

Introducción: Los molares tratados endodónticamente sufren alteraciones estructurales y biomecánicas que hacen de su restauración un gran reto en el sector odontológico. Para garantizar la durabilidad y un rendimiento a largo plazo, es esencial elegir la opción restauradora adecuada. **Objetivos:** Este estudio tuvo como objetivo analizar las diferentes opciones para restaurar molares endodonciados, en términos de resultados clínicos como durabilidad y éxito, identificar los factores que influyen en la elección y los materiales más adecuados a utilizar. **Métodos:** Se realizó una revisión sistemática de la literatura utilizando bases de datos como PubMed, Medline, Google Scholar y Dentistry & Oral Science Resources. Se seleccionaron estudios de los últimos 10 años en base a nuestra estrategia PICO. **Resultados:** Las restauraciones adhesivas indirectas, como las endocoronas y las incrustaciones overlay en disilicato de litio, muestran las mayores tasas de supervivencia (94-100%) y una baja tasa de fracasos catastróficos. Los composites reforzados con fibra presentan una excelente resistencia mecánica y una seguridad biomecánica superior, con una capacidad de reparación de hasta el 95%. A pesar de la mayor rigidez de las restauraciones con poste, presentan un mayor riesgo de fracaso irreparable. Sin embargo, materiales como el disilicato de litio conservan las mejores prestaciones mecánicas. **Conclusiones:** En la actualidad, el método más eficaz y duradero para restaurar los molares tratados endodónticamente son las restauraciones adhesivas indirectas. Para maximizar los resultados, se requiere una estrategia personalizada que tenga en cuenta la estructura coronaria residual, las fuerzas oclusivas, las funciones del diente en cuestión y la situación clínica del paciente.

PALABRAS CLAVE

Odontología, molares tratados endodónticamente, restauraciones dentales, materiales, resultados clínicos.

ÍNDICE

1. INTRODUCTION

1.1. Anatomy of the molars

In the posterior part of the mouth, we find teeth known as molars. Humans have 3 molars on each side of the mouth, both the upper (maxilla) and lower (mandible) arches, that are called first, second and third molars. They are the largest and strongest teeth because of their bulk and their anchorage in the surrounding bone (alveolar bone in the maxillary bone and mandible). They are essential for the mastication as well as for proper occlusion (1).

Like every tooth, they present a crown, roots, and pulp tissue which goes from the pulp chamber to the apex of the tooth. Generally, the occlusal part of the upper or maxillary molars are characterized by a big crown with 4 cusps (mesiovestibular (MV), distovestibular (DV), mesiolingual (ML), distolingual (DL)). Only the first maxillary molar has an additional cusp placed lingually of the ML one, called the Carabelli cusp. The occlusal part of the lower or mandibular molars are generally made of 5 cusps (MV, DV, ML, DL, and distal) for the first molar, 4 for the second (MV, DV, ML, DL), and 5 or more for the third one (1).

The maxillary first molar usually has three roots (in 98% of the cases) with two canals in the mesiobuccal one, and one canal in each the distobuccal and palatal one. The maxillary second molar generally also has three roots (in 86% of the cases) with one or two canals in the mesiobuccal one, and one canal in each the distobuccal and palatal ones (2). The upper third molar is very variable in terms of shape and anatomy, so it depends on each individual (1).

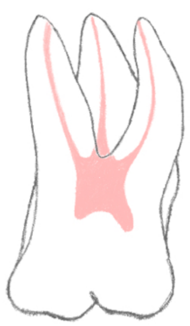


Figure 1. Maxillary first molar

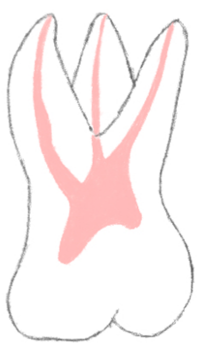


Figure 2. Maxillary second molar

The first mandibular molar is made of two roots, one mesial and one distal (in 85.6% of the cases). Its mesial root contains two canals in 95.6% of the cases, and the distal one usually contains only one canal in 69.3% of cases. The second molar typically has two roots (67.3%) with two canals in the mesial root (in 81.9% of the cases) and 1 canal in the distal root (in 84.6% of the cases) (2). The third one is also very variable (1).

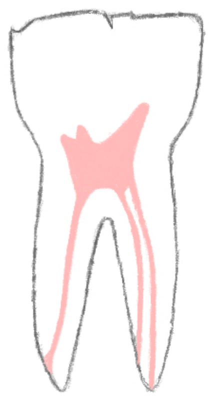


Figure 3. Mandibular first molar

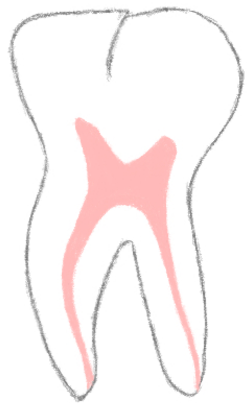


Figure 4. Mandibular second molar

The pulp is a specialized tissue made of nerves, blood vessels, and connective tissue. It provides to the tooth sensory functions and allows regenerative abilities (3).

Since molars are multirooted, they have extremely complex root canal systems with multiple branches and accessory canals, making the endodontic treatment more difficult. A good knowledge of the anatomy is very important (4). As there are several endodontic pathologies, particularly for molars, it is very important to properly diagnose them (5).

1.2. Diagnosis in endodontics

The pulp-dentin complex has the capacity to respond to various stimuli such as microbiological, mechanical, thermal, or chemical. The contamination of the dental pulp occurs in different ways: open communication, carious lesions, exposed dentinal tubules, lateral canals, microleakage, traumatic injury, etc. Among these, microleakage is considered to be the most common source of infection (6).

Patients with teeth that require endodontic treatment can have symptoms like pain, swelling, draining sinus tract, tooth discoloration, fever, malaise, or also lymphadenopathy. That is why it is very important to diagnose teeth that require endodontic treatment in time because this could prevent future extraction or complications. The diagnosis has to be accurate in order to have an adequate treatment plan. It is made of 2 parts: the pulpal and the periapical diagnosis. To do it, we have to consider the medical history of the patient, the clinical evaluation, and the radiological diagnosis. To have a precise diagnosis, all the tests should compare the problematic tooth with a healthy one (7).

There are a number of tests to be carried out in order to make a diagnosis. The clinical examination is very important. It is divided in 3 parts: the general assessment, the intra-oral and extra-oral examination. We have to examined if the patient presents swelling, asymmetries, abnormalities, lumps, or facial palsy (6), (7).

The inflammation of the periodontal ligament can be accurately detected by the percussion test. If the patient has an inflammation of peri-radicular tissues, the result of the percussion test will be positive (6).

When the patient feels pain when biting, it means that he has an inflammation between the periodontal ligament, which can be the consequence of the necrotic pulp (6).

The palpation test allows the evaluation of the inflammation in the surrounding tissues of the tooth (6).

The probing depth is important to diagnose endo-perio lesions or root fractures. It is done with the periodontal probe (7).

The thermal tests indicate the pulp state. There are various methods. Simple ice sticks, ethyl chloride at -4°C, dichlorodifluoromethane (DDM) at -50°C, or carbon dioxide at -72°C are the methods used in cold tests. The hot ones involve using a heated gutta-percha stick or frictional heat (6).

There are other complementary tests that provide a very good help to do the diagnosis, like the electric sensitivity test, the transillumination, the selective anesthesia, or radiography (periapical and CBCT) (7).

The Table 1 and Table 2 show the different pulpal and periapical diagnosis possible. The pulpal ones are reversible pulpitis, irreversible pulpitis, necrotic pulp, and pulp canal obliteration. The periapical ones are acute apical periodontitis, chronic apical periodontitis, chronic suppurative apical periodontitis, acute apical abscess, and condensing osteitis (7).

<table>
<tr><th colspan="4">Pulp diagnosis</th></tr>
<tr><th>Pulp state</th><th>Vitality</th><th>Symptoms</th><th>Etiology</th></tr>
<tr><td rowspan="2">Healthy</td><td>(+)</td><td>No</td><td></td></tr>
<tr><td colspan="3">The pulp responds to cold or electric tests with a brief, non-lingering sensation. There is no pain at percussion or palpation, and on radiographs the tooth has a normal appearance.</td></tr>
<tr><td rowspan="2">Reversible pulpitis</td><td>(++)</td><td>• Discomfort
• Cold and sweet
• Less than 20s</td><td>• Exposed dentin
• Caries
• Deep restorations
• Trauma …</td></tr>
<tr><td colspan="3">Mild inflammation of the pulp due to irritation, which is reversible with proper treatment. Radiographic results are usually unimpressive, and there is no sensitivity to palpation or percussion.</td></tr>
<tr><td rowspan="2">Irreversible pulpitis</td><td>(+++)</td><td>• Sharp, lingering, and referred pain.
• Cold, hot, and continuous when removing the stimulus.
• No pain to percussion.</td><td>• Deep caries
• Deep restorations
• Exposed dentin
• Pulp irritants
• Fractures
• Traumatism
• Orthodontic forces</td></tr>
<tr><td colspan="3">Pain that lasts from a few minutes to several hours can be either spontaneous or triggered by thermal or other stimuli. This condition is irreversible, so if left untreated, pulpal necrosis will develop.</td></tr>
<tr><td rowspan="2">Necrotic pulp</td><td>(-)</td><td>• Asymptomatic</td><td>• Deep caries
• Deep restorations
• Exposed dentin
• Traumatism
• Orthodontic forces</td></tr>
<tr><td colspan="3">Final consequence of irreversible pulpitis. There is no pain, no response to thermal and electric tests, and no sensitivity to palpation or percussion.</td></tr>
<tr><td>Pulpless tooth</td><td>(-)</td><td colspan="2">Previously treated tooth (endodontic procedures, pulpotomy, or pulpectomy).</td></tr>
<tr><td>Pulp canal obliteration</td><td>(-)</td><td>• Asymptomatic
• Tooth discoloration</td><td>• Traumatism</td></tr>
</table>

Table 1. Pulp diagnosis

<table>
<tr><th colspan="5">Periapical diagnosis</th></tr>
<tr><th>Periodontal state</th><th>Tests</th><th>Symptoms</th><th>Radiography</th><th>Etiology</th></tr>
<tr><td>Normal apical tissues</td><td>Percussion (-)
Palpation (-)</td><td>-</td><td>Normal periodontal ligament (PDL)</td><td>-</td></tr>
<tr><td rowspan="2">Symptomatic apical periodontitis</td><td>Percussion (+)</td><td>Discomfort when chewing</td><td>Normal or widened PDL</td><td>Irreversible pulpitis / Traumatism / Periodontal diseases / Restoration</td></tr>
<tr><td colspan="4">This condition occurs when the pulpal disease reaches the periradicular tissue, causing inflammation.</td></tr>
<tr><td rowspan="2">Asymptomatic apical periodontitis</td><td>Percussion (-)</td><td>Slight or no pain</td><td>Normal or widened PDL</td><td>Irreversible pulpitis / Traumatism / Periodontal disease</td></tr>
<tr><td colspan="4">Following pulp necrosis, bacterial invasion and diffusion of their toxins can spread to the periapical region.</td></tr>
<tr><td rowspan="2">Chronic apical abscess</td><td>Vitality (-)
Percussion (-)</td><td>Asymptomatic
Draining sinus tract or suppuration</td><td>Osseous destruction with radiolucency</td><td>Irreversible pulpitis / Traumatism / Periodontal disease</td></tr>
<tr><td colspan="4">There is a periodic discharge of pus through an associated sinus tract that permits drainage.</td></tr>
<tr><td>Acute apical abscess</td><td>Vitality (-)
Percussion (+)
Palpation (+)</td><td>Spontaneous pain with or without swelling</td><td>Normal or widened PDL</td><td>Apical progression of pulpal necrosis / Deep restoration</td></tr>
<tr><td>Condensing osteitis</td><td>Vitality (+/-)</td><td>Pain</td><td>Increased radiopacity</td><td>Irreversible pulpitis / Symptomatic apical periodontitis / Acute apical abscess</td></tr>
</table>

Table 2. Periapical diagnosis

Figure 5. Pulpal diagnosis
(Image generated by IA)

Figure 6. Periapical diagnosis
(Image generated by IA)

1.3. Characteristics of endodontic treatment and consequences

The endodontic treatment is a dental procedure which aims to remove the inflamed or infected pulp in order to preserve healthy teeth. Throughout this procedure, the inner area is meticulously cleaned, disinfected, filled, and sealed to eliminate bacteria and pain, prevent future reinfection, and preserve the natural tooth structure. This treatment helps restore tooth health, function, and aesthetics while avoiding extraction (8). It has a success rate of 97% (9).

Endodontic failures as such are rare, less than 10%. Treatment failure is mainly due to a prosthetic problem (60%) or a periodontal problem (32%).
After endodontic treatment, the tooth undergoes many structural, mechanical and biological changes. They affect the tooth in terms of functionality and prognosis (10).

The tooth becomes fragile as it loses its vitality and its structure because of carious lesions, old restorations, pre-endodontic preparation, endodontic instrumentation, and changes in the composition of dental tissues and fractures (11).

The structure of a healthy tooth allows occlusal forces to be evenly distributed. The dentin is made of collagen fibres, which provide resistance and flexibility to the forces applied on the teeth. With the loss of structure, the collagen fibres are altered and they become rigid. So, by losing its structure and with the changes in the dentin’s composition, the tooth loses its function of distributing forces, making it less resistant. One study (Santana) has shown that endodontic treatment reduces tooth rigidity by 5%, while pre-endodontic preparation reduces it by 60% (12).

The endodontic treatment can result in alterations in the mechanical, physical, and chemical properties of the tooth. The dentin is covered by enamel, the hardest tissue of the human body. It is composed of 12% of water, 70% of inorganic material, and 18% of organic matrix. The water content of the dentin is influenced by the loss of the vitality of the tooth. The endodontically treated teeth present microstructural changes of the dentin. It may lead to greater possibility to fractures (9). For example, 58% of fractures happen in endodontically treated teeth in Chinese patients. But the fractures are favoured by various factors (13).

The irrigants, used in the procedure of the endodontic treatment, like sodium hypochlorite (NaOCl) and ethylenediaminetetraacetic acid (EDTA), are really useful to eliminate microorganism, pulp debris, and smear layer. But if they are use in excessive concentrations, they can alter the mechanical and physical properties of the dentin (9).

From a biological point of view, endodontic treatment eliminates the pulp, which innervates and vascularises the tooth, which will reduce the tooth's ability to repair itself and fight off other possible infections (10).

1.4. Importance of post-endodontic restoration and its requirements.

1.4.1. Assessment of the restorability before the endodontic treatment

Before beginning endodontic treatment, it is essential to assess the possibility of restoring the tooth. This requires the removal of all existing caries and/or restorations in order to examine whether the tooth can be restored sustainably over the long term. It is essential to check whether a suitable ferrule can be used, whether a post is required and how much tooth structure remains (14).

It is essential to carry out a thorough clinical assessment before deciding whether a tooth can be restored. This should include an endodontic assessment, the periodontal support, an occlusal model, the possible parafunctions and the intended function of the tooth (support for a bridge, support for a removable prosthesis, etc.) (6).

The analysis of the restorability is based on a precise examination of the remaining tooth structure, considering the height, thickness and location of the remaining dentinal walls (6).

1.4.2. Coronal sealing and microleakage

We consider the endodontic treatment finished when the tooth is definitely restored (8).

One of the main aims of endodontic treatment is to ensure that the coronal seal is perfectly watertight. In fact, micro-infiltration (also known as microleakage), which is defined as the undetectable passage of bacteria, fluids, ions or toxins between the tooth and the restorative material, is now considered to be one of the main factors leading to the reappearance of periapical pathologies and the failure of endodontic treatment. This micro-infiltration can occur at both apical and coronal levels and, in the long term, lead to colonization of the root canal system by remaining or external bacteria (15).

It is therefore imperative to perform a rapid and hermetic definitive restoration to prevent recontamination of the endodontic system. An effective temporary restoration must provide an optimal bacterial seal: its defect or absence is considered to be one of the main reasons for post-surgical pain and an unfavourable prognosis. Consequently, the objective of restoration after endodontics is not limited to the mechanical or aesthetic aspect but also includes maintaining a state of disinfection of the tooth by preventing any possible subsequent bacterial penetration (15).

So, it means that if the definitive restoration is not directly made, we need to restore the tooth with temporary materials such as composite resin or glass ionomer cement, until the final restoration is fitted (9), (13).

1.4.3. Importance of cervical structure and ferrule effect

Maintaining the cervical structure is also essential for long-term success. This area is the preferred site for occlusal forces, particularly in posterior teeth that are subject to lateral stresses. If the cervical structure is weakened too much, the strength of the tooth is threatened (14).

The ferrule effect is a key element to consider when preparing for a crown or post. This involves maintaining a continuous margin of healthy dentin one to two millimetres above the finishing edge, to reinforce resistance to fracture. If the coronal structure is insufficient, surgery to lengthen the crown may be necessary (6).

A 360° dentin collar significantly reinforces the restored tooth, as noted by Sorensen and Engelman in 1990 (16).

1.4.4. Indications and considerations for post placement

Once the pulp chamber has been opened and the canals examined, it may be decided to use a post. Generally, if more than half of the coronal structure is preserved, the use of a post is not essential, as retention can be maintained by conservative methods (6).

However, the danger of tooth loss is greatly increased when a cast post and core is used, or when the tooth is restored using just temporary material. This is particularly true when there is no proximal contact or when the tooth is the terminal abutment (16).

In the past, posts were assumed to be primarily employed to support the tooth structure. Actually, a number of studies have demonstrated that endodontically treated teeth restored with or without posts do not differ significantly in terms of their ability to withstand fractures. When there is not enough tooth structure left to keep the core material, a post is typically used. On the contrary, it is not necessary when the pulp chamber is deep (> 4mm) and there are still at least 2 sound dentinal walls that are 2 mm thick since retention can be guaranteed using adhesive procedures. Post placement is required to provide the restoration enough support, though, if there are less than 2 walls left. A full coverage crown which further reduces the quantity of tooth tissue left, is frequently recommended in these situations (17).

It is crucial to remember that a residual wall thickness of just 1 mm is deemed insufficient because it typically consists of unsupported enamel, which is extremely brittle even while the composite is being polymerized. Fibre posts, metal posts, and zirconia oxide posts are among the post systems that are available; each has unique mechanical and cosmetic qualities that should be considered when making therapeutic decisions (17).

1.4.5. Long term success and restorative strategy

The long-term success of an endodontically treated tooth is influenced by the final restorative treatment. To achieve this, the dentists need to restore the tooth from a mechanical, aesthetic and functional point of view, so that it can withstand the forces of mastication and become as close as possible to the original tooth (10).

It has been demonstrated that a suitable restoration increases the endodontic success rate by over 10% if the root canal filling is of good quality. However, with an inadequate root canal filling, it is impossible to improve the prognosis of the restored tooth with an adequate coronal restoration (16).

So, the rehabilitation of endodontically-treated teeth is not just for aesthetic purposes: it is essential for preserving the coronal-radicular seal and maintaining dental function. According to Mallat Callís, the decision regarding the type of dental restoration should be based on the extent of coronal substance loss, the position of the tooth in the dental arch and its role in mastication. He also highlights the importance of using minimally invasive methods of adhesion, aimed at preserving as much of the remaining dental tissue as possible (17).

The absence of dental pulp makes the non-vital tooth more susceptible to mechanical stress, thereby increasing the risk of cusp fracture. The durability of endodontically-treated teeth therefore depends on optimum conservation of the coronal structure, as well as safeguarding the cusps with an appropriate coronal restoration, such as a crown covering the cusps (6).

Particularly for premolars and molars, complete coronal covering is advised to greatly increase their long-term survival. Natural cuspal deflection under masticatory forces puts molars without cuspal coverage at greater risk. For teeth that have had endodontic treatment, a composite may occasionally be considered as a temporary alternative for a complete crown. Although there has been little strengthening from selective cusp coverage, fracture resistance is much increased by complete reduction (2mm) and composite build-up of all cusps. Until a permanent crown can be placed, this kind of repair might be a suitable temporary solution (16).

There are a number of options for restoring endodontically treated posterior teeth (fillings, inlay/onlay, crowns, etc.) but the choice must be made on a case-by-case basis, as there is still much debate about which option is the most effective and long-lasting (10).

1.5. Justification of the study

Endodontic treatment is a frequent clinical procedure on the molars. These become more fragile following their initial preparation. In order to preserve them as much as possible in the long-term, it is important to consider all post-endodontic restoration options in order to be able to choose the most suitable for each case, which makes these teeth a major challenge in dentistry (10), (11).

That is why we chose to do this study. We want to answer our problematic: What are the best restoration options in terms of durability and success and with which materials?

However, this subject has limits due to the lack of articles with high scientific evidence, the very large number of materials comparisons, etc.

2. OBJECTIVES

Main objective:

- To analyse the different options to restore endodontic molars in terms of clinical outcomes such as durability and the success.

Specific objectives:

- To identify the factors influencing the choice of different restorative options.
- To identify the most appropriate materials to use.

3. MATERIAL AND METHODS

This graduation project was a documentary research work. We have conducted a systematic review based on the literature. It focused on analysing the clinical outcomes of various restorative options treated molars, particularly in terms of durability and success, as well as identifying the factors influencing the choice of different restorative options and the most effective materials.

The databases that we used for this research were Google Scholar, Medline Complete, Dentistry & Oral Science Resources, and PubMed.

We applied the PICO method to organise our research and guide the publication selection process:

P (population)	Endodontically treated molars
I (Intervention)	Final post-endodontic restorations
C (Comparison)	Different types of restorations and materials
O (Outcomes)	Clinical outcomes (survival rate, fracture resistance, failure rate).

The Boolean operators allowed us to combine the keywords and Mesh terms that were based on our PICO question. These terms were:

- Endodontically treated molars
- Dental restorations
- Crown – Onlay – Endocrown – Direct restoration – Indirect restoration
- Materials
- Clinical outcomes (durability, success)

We included in our research the studies about the restoration of endodontically treated molars and articles describing the clinical outcomes of different restorative options (survival rate, fracture resistance, and failure rate), the effectiveness of the different materials that we can used and the factors influencing their selection.
We have chosen articles that were published in the last 10 years, available in free-full text.

We excluded from our project every studies that were about anterior, temporary teeth, and 3rd molars, articles that did not deal with our objectives, and those where the full text is not available.

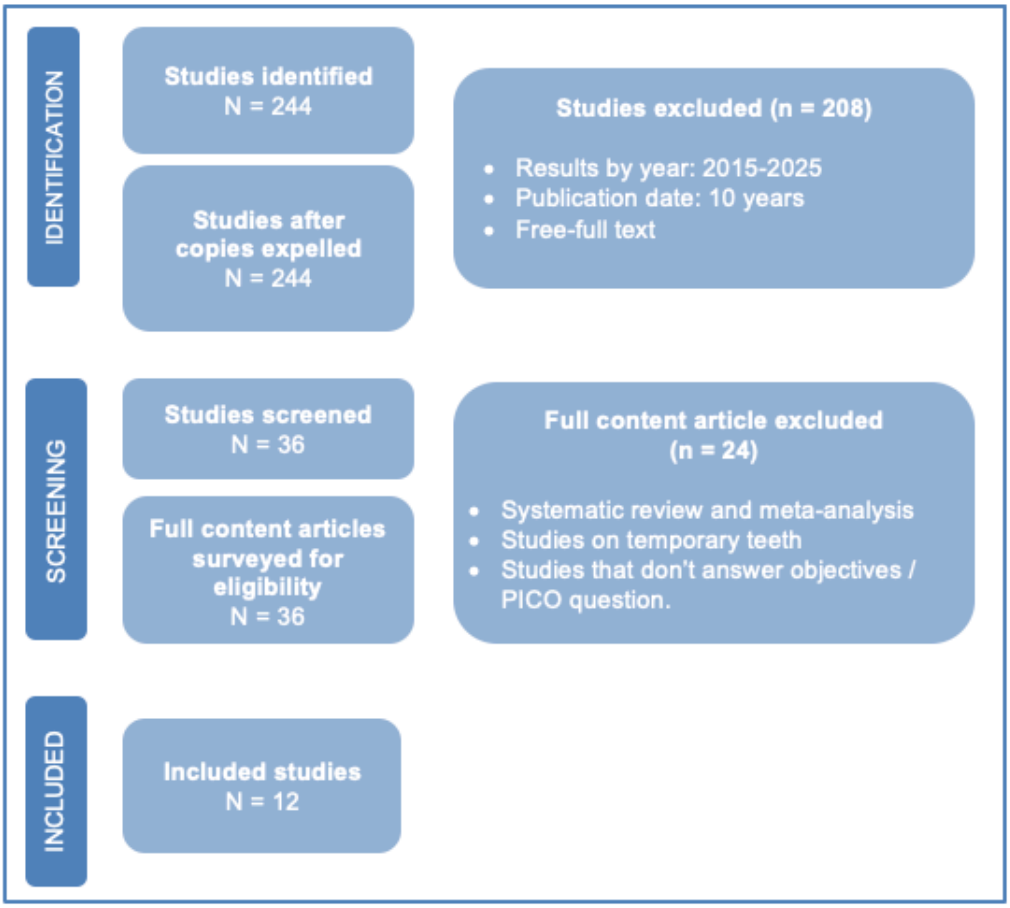
We have also worked with books such as Mallat Callis' "Manual de restauración del diente endodonciado", in addition to scientific databases, to provide theoretical and reliable data to support our research.

4. RESULTS

We have done the search (1st of March 2025) based on keywords ("endodontically treated teeth" OR "teeth, endodontically treated") AND ("molars" OR "posterior teeth") AND ("dental restorations, permanent") on PubMed. We have obtained 244 articles. First, we excluded all studies older than 10 years and all for which the full text is not available. We obtained a total of 36 articles.

Then, we have done a second exclusion of 24 articles based on other criteria: studies that are not done on humans, systematic review and meta-analyses, studies on temporary teeth, and studies that do not answer the objectives or PICO question.

So finally, we included 12 articles for our study. Here is the PRISMA chart, which illustrates the selection process.



Graphic 1. Prisma flow diagram

References	Studies	Intervention	Period	Case / Patient	Objectives
Hezavehi et al. (2024) (18)	In vitro	LDS and ceramic endocrowns vs. non-retentive overlays.	-	30	Fracture strength + marginal adaptation
Hafez et al. (2025) (19)	Clinical trial	Short fibre-reinforced resin composites vs. Ceramic overlays	2 years	50	Fracture resistance
Wang et al. (2020) (20)	Clinical trial	Ceramic vs. Resin composite endocrowns	2 years	80	Clinical efficacy
Krug et al. (2024) (21)	Retrospective	Ceramic vs. Cast gold partial crowns	15 years	200	Long-term survival
Nezir et al. (2024) (22)	In vitro	Fibre-reinforced direct restorations	-	40	Fracture resistance
Rodrigues et al. (2020) (23)	Computational simulation (FEA)	Bulk-fill composites	-	3	Stress distribution and bite force
Daher et al. (2020) (24)	In vitro	Fibre-reinforced MOD cavities vs. Direct composite or indirect onlays	-	40	Fracture strength + failure mode
Meng et al. (2021) (25)	In vitro	Feldspathic, LDS, and nanofilled composite resins endocrowns	-	30	Fracture resistance
Bijelic-Donova et al. (2022) (26)	Clinical trial	Direct fibre-reinforced composite vs. Glass-ceramic endocrown	4 years	20	Survival - Clinical performance
Fouda et al. (2024) (27)	Clinical trial	Inlay vs. Onlay	2 years	30	Effect of cavity design

Uzun et al. (2024) (28)	In vitro	CAD/CAM feldspathic porcelain restorations	-	80	Fracture resistance
Metwaly et al. (2024) (29)	Clinical trial	Polyethylene fibre-reinforced composite vs. Bulk-fill composite	2 years	240	Clinical performance

Table 3. General information about the articles.

Reference	Type of restoration	Survival rate	Observations
Wang et al. (2020) (20)	Resin endocrown	99%	Good marginal adaptation, good absorption of occlusal forces
	Ceramic endocrown	94 – 100%	Excellent survival rate but more rigid so we need a good occlusal evaluation
Krug et al. (2024) (21)	Ceramic crowns	93,90%	High long-term survival
	Gold crowns	92,6%	Slightly better durability
Fouda et al. (2024) (27)	Composite overlay	100%	Less stress over the cuspids
	Composite inlay	80%	Higher risk of fracture
Bijelic-Donova et al. (2022) (26)	SFCR	90,90%	Easy to repair but requires maintenance
	GCE	85,7%	More stable but harder to repair
Hafez et al. (2025) (19)	Fibre-reinforced resin composites	85-90%	High resistance
Metwaly et al. (2024) (29)	Polyethylene fibre vs Bulk-fill	88-92%	Occlusal forces absorption

Table 4. Survival rate of the different restorations

Reference	Type de restauration	Reparable failure (%)	Catastrophic failure (%)
Hezavehi et al. (2024) (18)	LDS Overlay	60	40
	Hybrid ceramic endocrown	30	70
Uzun et al. (2024) (28)	Endocrowns (CAD/CAM)	60	40
	Post-core crown	50	50
	Core-full contour crown	40	60
Metwaly et al. (2024) (29)	Fibre-reinforced composite	95	5
Daher et al. (2020) (24)	Fibre-reinforced composites (MOD)	75	25
	Onlays	0	100
Bijelic-Donova et al. (2022) (26)	SFCR vs. endocrowns	85	15
Nezir et al. (2024) (22)	Fiber + bulk-fill composite	80	20
Meng et al. (2021) (25)	LDS endocrown	High survival	Low catastrophic failures
	Nanofilled composite endocrown	More stress to tooth	Higher failure risk

Table 5. Failure rate of the different restorations

Reference	Type of restoration	Fracture resistance	Observations
Hezavehi et al. (2024) (18)	LDS overlay	3776,64 ± 224,54 N	Best performance
	Hybrid ceramic endocrown	2585,14 ± 235,08 N	Worst performance
Hafez et al. (2025) (19)	Fibre-reinforced resin composites	877 N	Comparable to overlays
	Ceramic overlay	913 ± 57 N	No significant difference from fibre-reinforced resin composite
Meng et al. (2021) (25)	LDS (E. Max) endocrown	142 – 161 MPa	Best fracture resistance
	Feldspathic endocrown	133 – 149 MPa	Moderate strength
	Nanofilled composite (lava ultimate)	Higher stress transfer to tooth	Prone to failures
Uzun et al. (2024) (28)	Natural tooth (control)	1830 ± 277 N	Highest resistance
	Endocrown (CAD/CAM)	1679 ± 306 N	Comparable to post-core crowns
	Post-core crown (CAD/CAM)	1679 ± 279 N	Similar to endocrowns
	Core-full contour crown	1532 ± 371 N	Lowest resistance
Nezir et al. (2024) (22)	Fibre-reinforced composite	2007 N	Better force absorption among composites
	Bulk-fill composite	1548,18 N	Weakest restoration
Daher et al. (2020) (24)	Fibre-reinforced MOD vs. onlays / inlays	1548 N	Reinforced MODs have a lower fracture rate

Table 6. Fracture resistance of the different restorations

Reference	Methodological bias	Temporal bias	Selection bias	Material bias	Publication bias
(18)	🔴	🟡	🟢	🟢	🟢
(19)	🟡	🔴	🟡	🟡	🟡
(20)	🔴	🟡	🟡	🟡	🟡
(21)	🟢	🟢	🟢	🟢	🟡
(22)	🟡	🟢	🟢	🟢	🟢
(23)	🟢	🔴	🟡	🟡	🟡
(24)	🟡	🟡	🟢	🟢	🟢
(25)	🟡	🟡	🔴	🔴	🟡
(26)	🟡	🟢	🔴	🔴	🔴
(27)	🟡	🔴	🟡	🟡	🟡
(28)	🔴	🟡	🟡	🟡	🟢
(29)	🔴	🟡	🟡	🟡	🟡

Table 7. Bias tables for selected articles
🔴 – High bias / 🟡 – moderate bias / 🟢 – low bias

The methodological bias refers to the method's rigor (procedure, randomization, and variable control). 🔴 indicates that the study's conception or execution is insufficient.

The temporal bias assesses if the duration of observation or the clinical result is enough. 🔴 indicates a follow-up that is too brief to demonstrate the durability of the restorations.

The selection bias confirms whether the samples are representative and well-chosen. 🔴 suggests an excessively restrained group or an atypical selection.

The use of materials or processes that are not comparable or that are not fully representative of clinical practice is referred to as the material bias.

The publishing bias evaluates both positive and negative aspects. 🔴 indicates a risk that only studies with positive results were chosen.

5. DISCUSSION

In this part of the study, we will analyse the results that we have obtained from the selected articles. As a reminder, the objectives of this research were to analyse the different options to restore endodontic molars, in terms of durability and success, to identify the factors influencing the choice and the most appropriate materials to use.

This analysis of the different options for restoring endodontic molars is essential in clinical practice. It enables dentists to make the most appropriate choices according to their own characteristics (survival rate, fracture resistance, and failure rate, and the situation of each patient.

5.1. Analysis of our results

Firstly, we can see that the survival rate depends on the type of restoration and the materials used. According to our results, resin or ceramic overlays and endocrowns show better survival rates than the others, reaching 94-100% over more than 2 years (20,27). Fibre-reinforced composites also show good results (85-90%) with good clinical stability (19). On the other hand, some restorations, such as composite inlays, have a much lower survival rate than others (80%) due to minimal cusp coverage (27). Metal (gold) or ceramic crowns are a good long-term alternative (≥ 92%), but these types of restoration are much more invasive (21). In conclusion, indirect adhesive restorations (endocrowns, overlays, SFRC) show excellent survival results (Table 4).

The failure table distinguishes between reparable failures (modifiable or replaceable) and catastrophic failures (root fractures requiring extraction). Fibre-reinforced composites show the best results in terms of failure (95% reparable failure and only 5% of catastrophic failure) (29). Disilicate endocrowns have a low catastrophic failure rate (≤ 20%) and satisfactory reparability (25), while hybrid ceramic endocrowns have a higher rate of catastrophic failure (70%) (18). In contrast, onlays, some post-core crowns, and core-full contour crowns show a high rate of irreparable failure (up to 100% in some situations), attributed to excessive rigidity or overly invasive preparation (24,28). To conclude, reinforced composite restorations offer greater biomechanical safety, while rigid non-adhesive restorations (post + crown) present an increased risk of serious failure. (Table 5).

Lithium disilicate restorations offer superior strength (> 3700N for overlays, 140-160 MPa for endocrowns), making them particularly suitable for posterior areas (18,25). Although more conservative, fibre-reinforced composites have a strength comparable to that of ceramic overlays (800-2000 N according to studies) (19,22,22). CAD/CAM restorations (endocrowns or post-core crowns) have a strength comparable to that of the natural tooth (≈ 1679N) (28). Bulk-fill composites have the lowest strength (≈ 1548N) (22). In conclusion, while lithium disilicate (LDS) remains the best-performing material from a mechanical point of view, reinforced composites are a good alternative thanks to their ability to absorb forces effectively (Table 6).

5.2. Analysis of the different options of restorations

Analysis of the different options for restoring endodontically treated molars reveals a distinct hierarchy in terms of clinical efficacy. When there is minimal loss of tissue, especially when the cusp's walls are still intact, direct composite restorations are recommended. Their conservative character, quick application, and inexpensive cost are significant advantages. However, their durability is more limited in situations of major occlusal stress or large cavities (9,26).

Based on our results, fibre-reinforced composites and lithium disilicate overlays (LDS) are considered to be the most appropriate options for the restoration of endodontic molars. They offer an excellent compromise between strength, tissue conservation, and longevity (18,22). Indeed, overlays offer a satisfactory balance between tissue preservation and reinforcement of tooth structure (29,30).

However, because of their high failure rate (e.g. fracture), post-core crowns and inlays are restorative options to be avoided (27,28).

Indirect restorations such as overlays, endocrowns, or crowns demonstrate better mechanical resistance and a better survival rate. Endocrowns target teeth with greater coronal loss, while avoiding the systematic use of posts (17,19).

Finally, crowns on posts with tenons are frequently used as a last resort when the remaining coronal structure is insufficient. However, their intrusive preparation and the restrictions they impose on the root considerably increase the risk of major failure, as highlighted in several studies (27,28).

5.3. Factors influencing the choice of restoration

A customized evaluation that considers several crucial elements should serve as the basis for the choice of post-endodontic restoration type. The level of loss of coronal structure is very important because the greater the loss, the greater the need for the restoration to provide cuspal retention and protection (10,31).

The location of the tooth in the dental arch also has an impact on the decision. Posterior molars, exposed to high occlusal forces, require more resistant restorations, such as overlays or ceramic crowns (8,24).

These findings are entirely consistent with the recommendations of Mallis Callis, who suggests an individualized approach to post-endodontic restoration, based on the extent of coronal damage, the location of the tooth in the arch, and the functional needs (17).

He highlights the importance of minimally invasive adhesive restorations, which help to maintain as much of the remaining anatomy as possible. Overlays seem to be the most beneficial alternative among these several restorative treatments, especially for treating mesio-occluso-distal (MOD) cavities. This is due to their ability to maintain the cusps while guaranteeing effective reorganisation of occlusal forces (17).

He also highlights that if the coronal structure is considerably reduced, root posts should only be used if retention is insufficient. He opts for fibreglass posts whose modulus of elasticity, similar to that of the dentin, helps to considerably reduce the risk of root fracture. This recommendation is in line with our research, which indicates that restorations with posts have a higher proportion of irreversible failures, particularly catastrophic fractures (17).

Other factors also need to be considered, such as the existence of parafunctions (such as bruxism), the periodontal situation, the occlusal model or the function envisaged for the tooth in question (bridge abutment, partial prosthesis, etc.) (29). The clinical decision is also influenced by the patient's economic restrictions and aesthetic expectations, particularly when selecting materials (13).

5.4. Different types of materials and performance

The greatest challenge in post-endodontic restoration is to ensure maximum tooth strength while minimising the loss of tooth structure. Our results indicate that LDS overlays demonstrate superior strength and occlusal force distribution compared to other restorative alternatives. Lithium disilicate helps to prevent excessive alteration of coronal tooth structure.

Our results also showed that fibre-reinforced composites are good restorative options. Their clinical performance is comparable to that of ceramic restorations in terms of strength, but their advantage lies in the fact that they require less invasive preparation.

Analysis of the materials used in post-endodontic restorations reveals significant variations in performance. Lithium disilicate is characterised by its fracture resistance, marginal fit, and aesthetics, making it a preferred material for overlays and endocrowns (17,19,24).

Although less rigid, fibre-reinforced composites have an excellent capacity to absorb occlusal forces, making them particularly attractive for conservative restorations. Their ability to be clinically repaired is also an important advantage.

Materials such as zirconia or metal alloys (e.g. gold) are very durable; however, their rigidity can cause root tension if the preparation is not carried out correctly (20,30).

Clinical studies reviewed indicate that ceramic materials, when used with strict adhesive procedures, can achieve survival rates in excess of 90% over a period of 2 to 4 years (19,25). Reinforced composites show similar results in carefully selected situations (18,26).

5.5. General clinical recommendations

The increasing use of adhesive restorations, whether direct or indirect, for restoring endodontic molars is due to their excellent alternative to crowns. Overlays preserve dental tissue while protecting the cusps. Crowns, on the other hand, require much more invasive preparation, as they require mechanical fixation (32).

Post-core crowns are used when the remaining tooth structure is insufficient (31). Although they are frequently used, they have a high failure rate. This is mainly due to the need for an invasive procedure for this type of repair, which makes the tooth more vulnerable and increases the risk of fracture (28).

An additional article validates our findings by highlighting the relevance of indirect adhesive restorations. These restorations offer significant benefits in terms of survival rate, increased resistance to fractures and occlusal forces (thanks to a more balanced distribution of stresses), not to mention aesthetics and cost-effectiveness. It also highlights overlays as the best performing solution for mesio-occluso-distal (MOD) cavities. The author argues that a crown should be reserved for situations where the tooth structure is deficient, because the stronger the tooth structure, the more likely it is to hold in the long term (33).

Based on the analysis of clinical results and recommendations from the literature, we can propose several guidelines:

- Minimal tissue loss: direct repair in composite resin (9,10).
- Moderate loss with weakened cuspids: coverage by lithium disilicate or reinforced composite (17,18).
- Significant coronary loss but stable: endocrown (19,24).
- Very restricted residual coronary structure: crown with post (27,33).

The ferrule effect should always be sought to improve fracture resistance (32). If this is not feasible, a coronary extension may be considered (33). Fibre posts are recommended as opposed to metal posts, due to their biomechanical compatibility with dentin (31,33).

5.6. Limitations of the study and perspectives

This study has several limitations, mainly due to the methodological diversity of the publications analysed. Most of the studies included are short-term in vitro or clinical studies, with minimal long-term follow-up, which limits the applicability of the results (25,26,28).

In addition, the heterogeneity of materials, operating protocols and evaluation criteria complicates an entirely homogeneous comparison. The analysis of bias (Table 7) also shows that some studies have methodological weaknesses or publication bias (27,28).

There is a need to conduct randomised controlled trials, with larger groups of participants and long-term follow-up, in order to improve the recommendations. It would also be judicious to incorporate patient-centered evaluation criteria (pain, satisfaction, aesthetics) to enrich the strictly mechanical or biological analysis (30,32).

6. CONCLUSIONS

The analysis of the different options to restore endodontically treated molars allow us to identify which type of restoration is better in terms of clinical outcomes (durability and success), the factors influencing the choice and the most appropriated materials to use.

1. The indirect adhesive restorations, such as endocrowns and lithium disilicate overlays or fibre-reinforced composites, show the highest survival rates (sometimes up to 100%) and represent an excellent balance between tissue preservation, mechanical strength, and aesthetics. These restorative options maintain the dental structure while providing high-performance protection against occlusal forces.

2. The choice of material depends on the clinical factors such as the extent of the loss of coronary structure, the location of the tooth, the occlusive forces, the functions of the tooth concerned, but also the clinical situation of the patient (parafunctions, aesthetics, etc.).

3. The materials such as lithium disilicate (LDS) remains the preferred option for its robustness, while fibre-reinforced composites are an effective solution, especially from a conservation dental perspective.

To conclude, indirect adhesive restorations are currently the optimal solution for molars that have undergone endodontic treatment, with a selection appropriated to the particularities of each clinical case.

7. SUSTAINABILITY

Nowadays, the dentistry is based on ethics and eco-responsible principles, so it is very important to consider also the economic, environmental, and social aspects to guarantee the sustainability of the post-endodontic treatment.

Fibre-reinforced composites or LDS overlays are known as durable restorations. Using these types of restorations allow us to reduce the need for subsequent complex interventions such as retreatments. This makes them the most cost-effective alternatives.

From a social point of view, conservative treatments help to improve the quality of life of the patient including their self-esteem, their aesthetics, and their functions.

From an environmental point of view, minimally invasive approaches allow us to preserve the natural dental tissue of the patient and therefore to minimize waste production and the use of additional resources. Using durable, biocompatible materials, such as fibre-reinforced composites or LDS, lowers the frequency of replacements and, consequently the environmental impact associated with packaging, sterilisation, and transportation.

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