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Endodontic implications of hypercementosis: A systematic review of anatomical challenges and therapeutic strategies

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ABSTRACT

Objective: Hypercementosis, characterized by excessive cementum deposition that distorts apical root morphology, poses specific anatomical challenges in endodontics; this systematic review aimed to synthesize its endodontic implications and to propose tailored treatment strategies for affected teeth.
Methods: A systematic search was conducted across PubMed, Scopus, EBSCO-DOSS, and Google Scholar following PRISMA guidelines. The SPIDER tool was used to refine inclusion criteria, focusing on studies involving human teeth affected by hypercementosis and its impact on endodontic treatment.
Results: Ten studies met the inclusion criteria: three experimental/descriptive and seven clinical studies. Hypercementosis was associated with anatomical challenges, complicating working length determination, canal negotiation, and obturation. Reported treatment approaches included orthograde treatment, surgical endodontics [including computer-aided-design-guided microsurgery], and the use of Cone Beam Computed Tomography for enhanced visualization of root morphology. Despite these interventions, treatment outcomes remained limited by persistent anatomical complexities.
Conclusions: Hypercementosis presents a significant challenge in endodontic treatment. A stepwise approach, ranging from clinical monitoring in asymptomatic cases to surgical interventions is recommended. The integration of advanced imaging technologies and individualized treatment planning is essential to improving therapeutic outcomes. Larger cohort studies with standardized diagnostic criteria are needed to better assess the prevalence of hypercementosis and its incidence on endodontic treatment.

1. Introduction

Cementum is a mineralized tissue that covers the entire root surface of the tooth [1]. It is formed by specialized cells called cementoblasts, which secrete an organic matrix primarily composed of collagen and glycoproteins [2]. This matrix subsequently mineralizes to form mature cementum [3].

Histologically, cementum is classified into two main types: acellular and cellular cementum [4]. Acellular cementum consists mainly of Sharpey's fibers, periodontal ligament insertions anchoring the tooth to the alveolar bone [2,5,6]. Cellular cementum contains cementocytes, cementoblasts trapped within the matrix, responsible for post-eruptive cementum apposition [2]. Despite being avascular and non-innervated, cementum grows continuously throughout life and adapts to biological and mechanical stimuli, making it an essential tissue for tooth integrity [7–9].

Hypercementosis is defined as excessive cementum formation beyond physiological limits, without neoplastic characteristics, leading to altered root morphology [10,11]. It involves cellular cementum, where the thickness of the cementum layers can vary depending on the rate of secretion by the cementoblasts. Thus, cement increments can be irregular, forming areas of thicker cement with a variable concentration

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of trapped cementocytes. This phenomenon can induce a modified root morphology, presenting significant structural heterogeneity. This variability in secretion rate can explain the diverse presentations of hypercementosis in terms of shape, location, and severity [10].

Two main types are described: focal and diffuse hypercementosis. Focal forms are characterized by cement deposition concentrated in a specific area of the root, generally presenting as a localized thickening of the cement [e.g., nodular form; [11]. In contrast, diffuse forms involve cement deposition extending over a larger surface area of the root [10, 12] and may include circular cementum hyperplasia, where the cement is deposited in a ring-like pattern around the root [11]. Hypercementosis can occur on different parts of the root, including the apical, middle, and cervical third. The apical third is the most frequently affected area where cement thickening begins. More severe diffuse hypercementosis can extend to the middle and cervical thirds, thus altering the entire shape of the root [11]. Two forms can be distinguished based on their severity: moderate and marked hypercementosis [10]. Moderate hypercementosis is characterized by uniform thickening of the cementum, causing little or no modification of the root morphology. The marked form is characterized by significant cement deposition, leading to alterations in root morphology as club-shaped form [11]. These variations in the presentation of hypercementosis are sometimes detectable on clinical radiographs (Fig. 1).

Hypercementosis significantly complicates endodontic procedures due to morphological alterations in the apical third. Excessive cementum deposition may displace, duplicate, or even obliterate the apical foramen, thereby impairing accurate working length determination. A study reported that such anatomical irregularities can result in multiple foramina or canal deflections into the cemental layer, reducing the reliability of both radiographic and electronic working length determination methods [13]. These structural anomalies increase the risk of under-instrumentation, incomplete debridement, or inadequate obturation, potentially leading to persistent apical pathology. Radiographic interpretation may also be compromised when the altered apex mimics a normal terminal morphology. An other study illustrated such a scenario where undetected hypercementosis necessitated surgical intervention due to treatment failure [14]. Consequently, these anatomical complexities directly affect prognosis, even when standardized protocols are followed. Microbial persistence within cemental extensions or accessory canals may contribute to chronic inflammation or post-treatment apical periodontitis [10]. This reinforces the need for advanced diagnostic tools, such as CBCT, and customized treatment approaches to achieve thorough canal disinfection and three-dimensional obturation in hypercementosed teeth.

Although hypercementosis is a recognized condition in endodontics, few studies provide specific guidelines or therapeutic adaptations for its management. It would therefore be useful to explore in more detail the clinical implications of hypercementosis on endodontic treatment. This systematic review aims to address the following question: what are the specific challenges posed by hypercementosis in endodontic treatment, and what therapeutic strategies can be considered to overcome them? We hypothesize that hypercementosis complicates endodontic therapy and that a better understanding of its clinical implications could help develop more effective and tailored therapeutic approaches.

2. Materials and methods

This systematic review adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines throughout both its design and reporting phases [15]. The review protocol was registered in PROSPERO database (CRD420251142951).

2.1. Eligibility criteria

This review included all studies involving human teeth affected by hypercementosis, in which a connection was established between hypercementosis and its endodontic clinical implications. Clinical case reports were included to help identify and propose treatment strategies. Systematic reviews and meta-analyses were excluded. No age restrictions were applied to studies involving individuals with hypercementosis. Articles published in any language were considered, with translations performed when necessary.

2.2. Search strategy

Given the expected heterogeneity of the available evidence and the predominantly descriptive nature of the data, the eligibility criteria were structured using the SPIDER tool [16] (Sample, Phenomenon of Interest, Design, Evaluation, Research type), which is particularly suited to qualitative and mixed-methods evidence syntheses. In this review, the

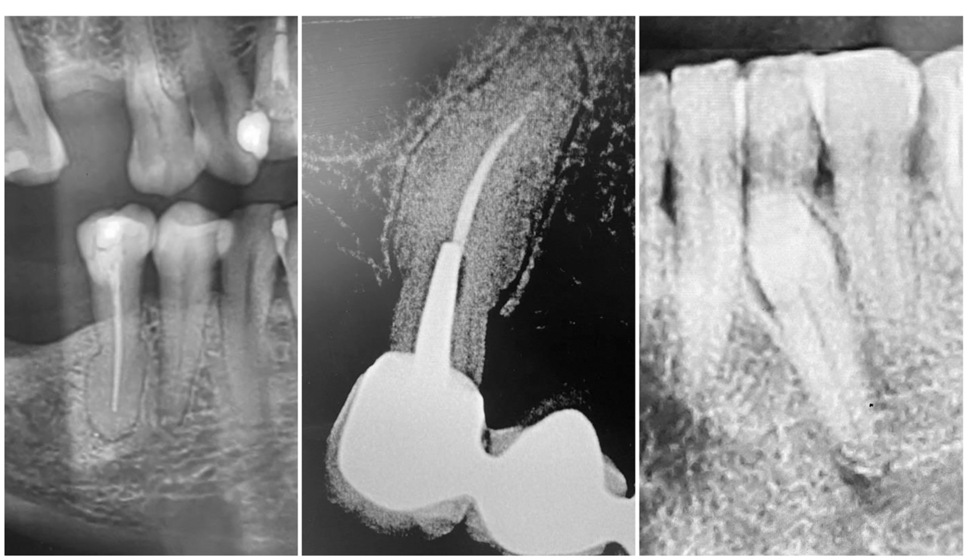

Fig. 1. Radiographic examples illustrating different forms of hypercementosis. From left to right: marked hypercementosis, predominantly localized at the apex of the tooth 45, showing cementum thickening that alters the root morphology; moderate hypercementosis covering the apical and middle third of the tooth, with cement deposition extending over a larger portion of the root; hypercementosis present on an impacted canine, where the excess cement is visible despite incomplete eruption of the tooth.

research question was not centered on a comparative intervention design (e.g., treatment A vs. treatment B), but on a specific condition and phenomenon: teeth affected by hypercementosis, the resulting alterations of apical root morphology, and the associated challenges and strategies in endodontic management. For this reason, a conventional PICO framework, which presupposes clearly defined interventions, comparators and outcomes suitable for quantitative synthesis, was considered less appropriate.

Within the SPIDER framework, the inclusion criteria were defined as follows: S (Sample): human teeth; PI (Phenomenon of Interest): hypercementosis, cementum exostosis, cementum hyperostosis, or excessive cementum apposition; D (Design): case reports, case series, clinical studies, observational studies or *in vitro* or *ex vivo* anatomical/experimental studies; E (Evaluation): presence of hypercementosis associated with endodontic treatment, difficulties during treatment, radiological or surgical findings, or therapeutic decision-making; R (Research type): qualitative clinical studies, descriptive studies, and case-based analyses involving endodontic implications of hypercementosis. The search strategy was developed by the research team and included the following terms: "endodont* AND hypercementosis". The initial search was conducted in September 2025 using four electronic databases: Medline via PubMed, DOSS via EBSCO, Scopus, and Google Scholar. This electronic search was complemented by manual screening of the reference lists of the included studies. In cases where multiple publications were based on the same sample, only the study presenting the most detailed data was included. A reference management software was used to organize the data (Zotero 7.0.12, GMU, Virginia, USA). The full search strategy for each database, including the exact search string, platform, date of the search, and number of records retrieved, is provided in Supplementary Table S1.

2.3. Study selection

After duplicate removal, two authors (CL, LM) independently conducted an initial screening based on titles and abstracts. In cases of disagreement, consensus was sought through discussion, with the involvement of a third author (OK) when necessary. Articles whose titles and abstracts met the inclusion criteria were retrieved in full text. Two authors (CL, LM) then independently assessed the full-text articles according to the predefined inclusion and exclusion criteria. Any discrepancies were resolved by consensus.

2.4. Data extraction

Data extraction was performed using spreadsheets (Excel version 16.62, Microsoft©, 2022) by two authors (CL, LM). In the event of disagreement, resolution was achieved through discussion and consensus among all authors. Each included source was reviewed in full text, and data were extracted independently to minimize bias. Two distinct extraction grids were designed to account for the heterogeneity of the included studies.

For experimental and observational studies, the following data were collected: Bibliographic reference, Study Type, Objective, Methodology, Main findings, Clinical implications, Limitations, and Relevance to hypothesis. These items were extracted to assess the morphological and diagnostic aspects of hypercementosis and their impact on therapeutic decision-making in endodontics.

For clinical case reports and case series, a specific extraction sheet was used to record: Bibliographic reference, Study Type, Clinical Context, Main findings, Endodontic Treatment Strategies, Clinical implications, Limitations, and Relevance to hypothesis. The "Endodontic Treatment Strategies" field included details on the instrumentation protocol, surgical or non-surgical management, and the use of CBCT or operating microscope. Particular attention was paid to the therapeutic adaptations implemented in response to the specific challenges posed by hypercementosis.

For each included study, we extracted information on funding sources and conflicts of interest, as reported by the authors, in order to comply with AMSTAR 2 recommendations [17].

Because of the heterogeneity of study designs and the predominantly qualitative nature of the available data, no meta-analysis was attempted. Instead, a narrative synthesis was conducted in two complementary steps. First, *in vitro* and *ex vivo* descriptive or experimental studies on hypercementosed roots were synthesized to characterize apical and root morphology (Table 1). Second, clinical case reports and the case series were synthesized separately to describe endodontic challenges, treatment strategies and outcomes in hypercementosed teeth (Table 2).

2.5. Risk of bias assessment

Given the heterogeneity of the included studies, risk of bias and reporting quality were assessed using two adapted approaches depending on the study design. For experimental and descriptive in vitro studies, a simplified version of the STROBE checklist was applied [18], focusing on the clarity of the methodology, sample selection, use of control groups when applicable, appropriateness of statistical analysis, and transparency in reporting results.

For clinical case reports and case series, an adapted case-based appraisal approach was used, drawing on the CARE reporting guidelines [19]. The evaluation considered the clarity of the diagnosis, the description of interventions, the measurability of clinical outcomes, the adequacy of follow-up, and whether study limitations were explicitly discussed by the authors.

The aim of this risk of bias assessment was not to generate a composite numerical score, but rather to describe the main potential sources of bias and limitations across studies.

3. Results

3.1. Articles selection

The study selection process followed the PRISMA 2020 guidelines (Fig. 2). A total of 85 records were initially identified through four electronic databases: Medline via PubMed (n = 17), DOSS via EBSCO (n = 11), Scopus (n = 27), and Google Scholar (n = 31). Additional records were retrieved from other sources, including websites (n = 5) and citation searching (n = 4), bringing the total to 94 records. After removal of duplicates, 77 records remained for screening. Following title and abstract screening, 16 articles were selected for full-text evaluation. Among these, 6 articles were excluded for the following reasons: lack of endodontic or pulpal focus (n = 1), absence of primary endodontic data on hypercementosed teeth (n = 4), and narrative review format (n = 1). Details of all full-text articles excluded at the eligibility stage, together with the specific reasons for exclusion, are provided in Supplementary Table S2. A total of 16 articles were assessed in full, of which 10 articles were ultimately included in the present systematic review. These consisted of 3 experimental or descriptive studies, 1 case series, and 6 clinical case reports.

3.2. Characteristics of included articles

Among the 16 full-text articles assessed for eligibility, 10 met the inclusion criteria and were retained for qualitative analysis. These consisted of three experimental or descriptive studies [20–22] and seven clinical articles: six case reports and one case series [14,23–28]. The studies were published between 1987 and 2025, reflecting a long-standing yet still limited scientific exploration of the morphological and clinical implications of hypercementosis in endodontics.

The experimental and descriptive studies focused primarily on the morphology of the apical third, root canal anatomy, and the consequences of excessive cementum deposition. Two studies employed scanning electron microscopy [20,21] to visualize the complexity of

Table 1
Data Extraction from experimental and observational studies.

Bibliographic reference	Study Type	Objective	Methodology	Main findings	Clinical implications	Limitations	Relevance to hypothesis	Funding (as reported)
Barros et al. 2013	*in vitro* analytical morphological comparative study	Investigate root and canal morphology in teeth with hypercementosis using radiography, clearing, and microscopy	130 teeth [80 with HC]; radiographic, clearing and histological analysis; morphotype classification; statistical comparison of morphological features.	- Club shape (65 %) and focal (35 %) types observed - Apical deltas in 53.3 % of HC teeth vs 20 % in controls - Frequent constrictions (40 %) and path deviations (46.6 %) - Microscopy showed cementum irregularities and canaliculi linked to apical deltas	- Highlights undetectable anatomical variations - Potential for altered apex locator accuracy - Suggests complex anatomy requiring adapted endodontic strategies	Clearing technique not clinically applicable Radiographs lack sensitivity Lack of CBCT/micro-CT use	Strongly supports the hypothesis by evidencing anatomical complexities and challenges in HC teeth affecting endodontic procedures	Authors declare no commercial, proprietary or financial interest in the products or companies described
Pinheiro et al. 2008	*In vitro* Descriptive experimental	Examine apical morphology in hypercementosed teeth via SEM and assess its relevance to endodontics	41 apical segments from 28 teeth examined under SEM for morphology, foramina, and resorption	- Multiple foramina in mild/ moderate forms - Apical obliteration in severe forms - Lateral foramina in focal types - CCH: thick cementum, foraminal depressions	- Complex apical anatomy - Compromised cleaning, shaping, obturation - Working length/ apical seal may be affected	No clinical correlation; in vitro only; limited to morphology	Confirms endodontic complexity; supports need for adapted strategies and further research	Funding not reported
Sarkotić & Šutalo 1987a	Retrospective observational clinical study	Evaluate the prevalence of hypercementosis in teeth with clinically diagnosed chronic pulpitis	212 patients with chronic pulpitis [open or closed]; radiographic detection of hypercementosis; analysis of affected tooth types and root thirds	- Hypercementosis present in 6.6 % of teeth with chronic pulpitis - Most frequent in 16–35 age group - First molars most commonly affected - Lesions mainly up to 2/3 of root length	- Suggests inflammatory origin of hypercementosis linked to chronic pulpitis - Highlights anatomical regions likely to be involved	No control group; no clinical endodontic correlation; radiographic only	Suggests chronic pulpal inflammation as a possible etiological factor for HC; supports part of the hypothesis on complexity but lacks therapeutic perspective	Funding not reported

Table 1: This table presents a summary of experimental and observational studies that investigated various aspects of hypercementosis in teeth. It includes key details and their relevance to the hypothesis regarding the challenges posed by hypercementosis in endodontic treatment. HC: hypercementosis; CBCT: cone beam computed tomography; micro-CT: micro-computed tomography; SEM: scanning electron microscopy; CCH: circular cementum hyperplasia.

apical anatomy and foramina, while another was based on histopathological and macroscopic anatomical observations [22].

The case reports and the case series presented a range of endodontic scenarios involving hypercementosed teeth, such as acute apical periodontitis [28], asymptomatic apical periodontitis [14,23], failed endodontic treatments [25], anatomical anomalies [27], and intraoperative diagnostic challenges [26]. The posterior mandibular region was the most frequently affected site, and CBCT imaging was used in several cases to support diagnostic and therapeutic decision-making [14,23,28]. In terms of treatment, both surgical and non-surgical endodontic approaches were discussed, with outcomes varying depending on the severity and morphology of hypercementosis. Tables 1 and 2 provide a detailed synthesis of each study and clinical report, including methodological or clinical context, findings, endodontic treatment strategies, clinical implications, limitations, and relevance to the research hypothesis.

3.3. Endodontic challenges associated with hypercementosis

Hypercementosis presents multiple anatomical and technical challenges that can significantly hinder the success of endodontic treatment. Across the included studies and case reports, the most frequently reported issue was the high morphological variability of the apical third, especially in club-shaped or bulbous root forms [20,21]. The presence of multiple apical foramina, including lateral and accessory canals, was commonly observed, and is associated with difficulty in achieving complete cleaning, shaping, and sealing of the root canal system.

In several cases, obliteration or narrowing of the main apical foramen was reported [14,21,28], preventing proper canal negotiation or instrumentation. Some studies highlighted the displacement of the apical foramen from the anatomical apex, or its presence on lateral surfaces, complicating the determination of the working length [21]. Additionally, excessive cementum apposition may interfere with electronic apex locators and radiographic interpretations [28].

Instrumentation difficulties were frequently cited, especially in teeth with constricted or irregular apical canals [23–25], increasing the risk of procedural errors such as ledging or perforation. In some reports, instrumentation was deemed impossible, leading to the decision to manage the case surgically or conservatively [14]. These findings emphasize the need for adapted endodontic approaches in teeth affected by hypercementosis.

Table 2
Data extraction from clinical case reports.

Bibliographic reference	Study type	Clinical context	Main findings	Endodontic treatment strategies	Clinical implications	Limitations	Relevance to hypothesis	Funding (as reported)
Reuver et al. 2025	Clinical case report	67-year-old patient with tooth 15 non-vital with a large periapical lesion and radiographic evidence of lateral hypercementosis on the roots of teeth 14 and 15.	- Periapical osteolysis spread and affect the vital tooth 14. - Chronic recurrent periodontitis persisted after the root canal treatment	Complex treatment process on tooth 15: - Root canal treatment and periodontal surgery - apical curettage and root resection - removal of tooth 15 - periodontal access and curettage of lateral lesion on tooth 14 and monitoring.	- Shows diagnostic complexity of hypercementosis. - Highlights use of ultrasonic irrigation with hand instrumentation in apical third. - Shows the importance of therapeutic gradient and monitoring in bone healing.	Single case, no histologic confirmation of calcific tissue nature. Complex presentation: lateral hypercementosis co-occurs with a cemental tear that may have contributed to the persistent extraradicular infection; the specific contribution of hypercementosis to treatment failure and the temporal sequence between these conditions remain unclear.	Supports hypothesis by illustrating endodontic limitations and need for surgical strategies in hypercementosis cases.	Funding not reported
Mobaraki et al. 2023	Clinical case report	35-year-old female with necrotic mandibular premolar and molar; radiographic periapical lesions with apical calcified deposits	Successful periapical healing at 6 and 12 months despite the presence of extensive calcified deposits.	2-session RCT: cleaning, NaOCl/EDTA/CHX irrigation, Ca $(OH)_2$ medication, cold lateral obturation	Orthograde endodontic treatment can be successful in teeth with atypical calcifications around root apices.	Single case, no histologic confirmation of calcific tissue nature	Supports the hypothesis that complex apical morphologies like calcific deposits can complicate RCT but may still allow healing with adapted protocols.	Funding not reported
Heredia et al. 2019	Clinical case report	51-year-old woman with asymptomatic apical lesion, prior RCT. CBCT showed apical hypercementosis. Surgical exploration assessed retreatment feasibility	-Hypercementosis complicated apical access and diagnosis. - Apical surgery not performed due to anatomical limitations. - Lesion curettage was performed, no retreatment attempted.	No endodontic retreatment performed due to anatomical limitations caused by hypercementosis. Conservative management [exploration + curettage] chosen in absence of feasible alternative.	- Shows diagnostic complexity of hypercementosis. - Highlights surgical option when standard retreatment is unfeasible.	No follow-up reported. Single case, no long-term outcome. CBCT parameters not detailed.	Supports hypothesis by illustrating endodontic limitations and need for surgical strategies in hypercementosis cases.	Funded by the Vicerrectoría de Investigación at Pontificia Universidad Javeriana (grant code 9162)
Lai et al. 2019	Clinical case report	38-year-old woman with chronic apical abscess on RCT-treated 46. Hypercementosis in both roots. CBCT showed periradicular lesion. Managed via CAD/CAM-guided surgery	- Hypercementosis complicated surgical access and root-end resection. - CAD/CAM stent enabled precise osteotomy and resection. - Post-operative healing confirmed at 8 months.	CBCT and intraoral scan superimposed in BlueSkyPlan software. CAD/CAM surgical stent designed and 3D printed. Guided osteotomy and root-end resection performed under microscope. Root-end preparation with ultrasonic tips; retrograde obturation with ProRoot MTA.	- Demonstrates value of guided microsurgery in managing complex apical anatomy due to hypercementosis. - CAD/CAM improves precision, reduces operative time and post-op complications.	Case report only, no comparison group. Challenge of image superimposition due to metallic artifacts. Single case, short follow-up.	Illustrates an effective and innovative strategy for managing endodontic complexity in hypercementosis cases through guided microsurgery.	Funding not reported

(continued on next page)

Table 2 (*continued*)

Bibliographic reference	Study type	Clinical context	Main findings	Endodontic treatment strategies	Clinical implications	Limitations	Relevance to hypothesis	Funding (as reported)
Pauly et al. 2018	Clinical case report	36-year-old male with sharp pain in lower left molar. Toot 37 diagnosed with apical periodontitis and RCT indicated. Incidental finding of hypercementosis on 36. Patient referred for endodontic treatment of 37 and prophylaxis for 36.	- Club-shaped hypercementosis observed in asymptomatic tooth #36. - No symptoms or pathology associated with the hypercementosed tooth.	RCT planned only for symptomatic tooth 37.	- Highlights challenges hypercementosis may pose for future endodontic or extraction procedures. - Stresses importance of diagnosis and vigilance before treatment.	Hypercementosis was incidental and not managed endodontically. Short report, no follow-up, no intervention on the affected tooth.	Contributes to awareness of diagnostic challenges but does not inform therapeutic decision-making. Limited relevance to active treatment strategies.	Funding not reported
Nouman et al. 2015	Clinical case report	25-year-old male with pain in mandibular right first premolar. Clinical and radiographic exam revealed irreversible pulpitis and apical hypercementosis with Vertucci Type V configuration.	- Hypercementosis obstructed apex visibility. - Variable readings from apex locator. - High resistance during apical instrumentation. - Working length determination and apical preparation were challenging.	Working length determined via enhanced digital radiography and apex locator. Apical shaping limited to F1 ProTaper to avoid instrument separation. Obturation done with lateral condensation and AH Plus sealer. Access sealed with composite restoration.	- Highlights practical challenges of endo instrumentation in HC. - Emphasizes importance of cautious WL determination and instrumentation limits in apical region.	Single case; no CBCT used; no long-term follow-up. Prognosis not assessed due to missed recalls.	Supports hypothesis by demonstrating procedural challenges directly linked to hypercementosis during conventional endodontic treatment.	Funding not reported
Sarkotić & Šutalo 1987b	Case series	Several cases with radiographically diagnosed hypercementosis affecting molars and premolars. Contexts included asymptomatic cases, prosthetic restorations, chronic pulpitis, and caries under crowns.	- Hypercementosis varied in location and extent. - Often associated with chronic pulpitis and prosthetic load. - Can obscure root apex, complicating endodontic procedures. - Can hinder eruption or extraction.	No active endodontic treatment reported. Authors note potential for apical canal obliteration. Recommend periapical surgery when pathology and HC coexist and block orthograde access.	- Stresses diagnostic awareness and therapeutic implications. - Highlights situations where HC is problematic vs. protective.	No treatment performed on reported cases. No outcomes or follow-up. Descriptive radiographic analysis only.	Supports hypothesis by describing clinical consequences and challenges of HC, but lacks therapeutic protocol or outcomes.	Funding not reported

Table 2: This table presents a summary of the findings from clinical case reports on teeth affected by hypercementosis, providing insight into the practical challenges encountered during endodontic treatment and the strategies employed to address them. RCT: root canal treatment; NaOCl: Sodium Hypochlorite; EDTA: Ethylenediaminetetraacetic Acid; CHX: Chlorhexidine; Ca[OH]2: Calcium Hydroxide; CBCT: cone beam computed tomography; CAD/CAM: Computer aided-design/ Computer aided-manufacturing; MTA: Mineral Trioxide Aggregate; WL: Working

3.4. *Therapeutic strategies and clinical management*

The reviewed case reports proposed various clinical strategies to manage the endodontic difficulties caused by hypercementosis. Several cases reported the use of cone-beam computed tomography (CBCT) to better visualize the root morphology, confirm the presence of hypercementosis, and guide decision-making [14,23,28]. In cases where conventional retreatment was not feasible due to anatomical constraints, endodontic surgery was performed. A study described a successful case of computer-aided design (CAD)-guided microsurgery, using a 3D-printed template to access the root apex [23]. The use of an operating microscope and ultrasonics tips also supported precise apical resection, root canal shaping and retrograde filling in this context. In other cases, practitioners attempted conventional orthograde treatment [24,25,28] or retreatment [27], often accompanied by thermoplastic obturation techniques and apical gauging to adapt to the altered anatomy. When the hypercementosis rendered treatment impossible, due to obstructed or obliterated canals, conservative management (exploratory curettage without obturation) or tooth extraction was selected as the final treatment option [14,26].

3.5. *Assessment of risk of bias*

Overall, the risk of bias and reporting quality varied across studies. Experimental and descriptive in vitro studies generally presented clear methodological descriptions but often lacked detailed information on sample representativeness and control conditions. Clinical case reports and the case series typically provided well-documented clinical contexts and interventions, whereas long-term outcomes and standardized follow-up measures were inconsistently reported. The detailed risk of bias appraisal is summarized in Figs. 3 and 4 for STROBE-based and CARE-based evaluations, respectively.

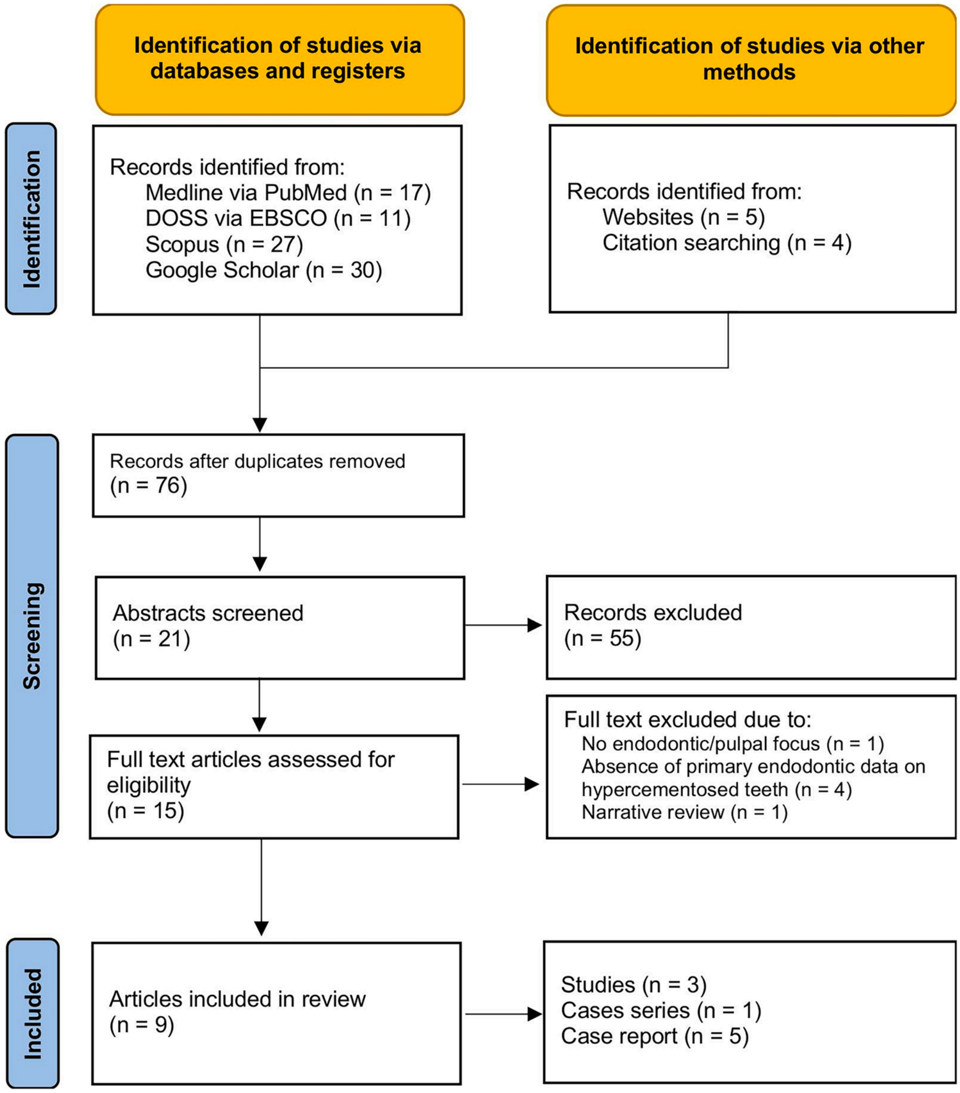

Fig. 2. PRISMA flowchart of study selection from database and additional source searches. HC indicates hypercementosis.

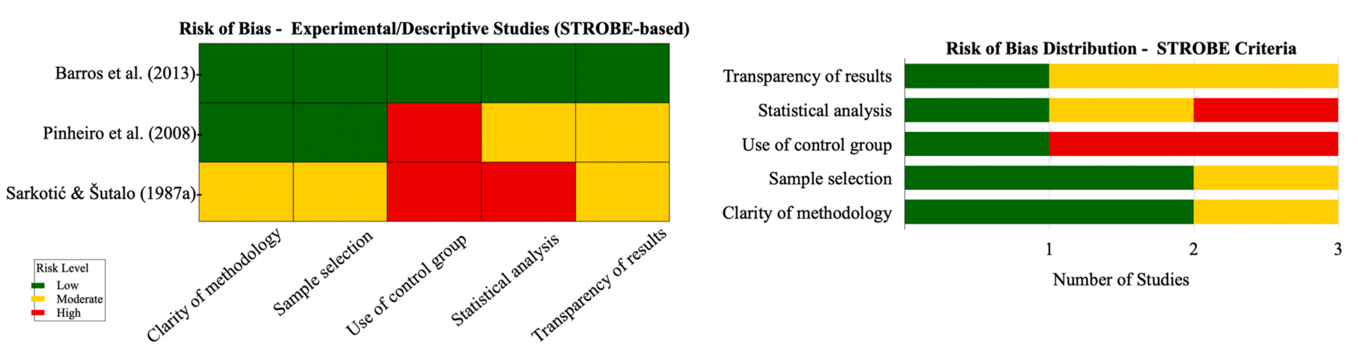

Fig. 3. Risk of bias assessment of experimental and descriptive studies based on STROBE criteria. Heatmap (left) and horizontal bar chart (right) summarizing the risk of bias for each STROBE-based criterion across the included experimental/descriptive studies. Green indicates low risk, yellow moderate risk, and red high risk of bias.

4. Discussion

4.1. Hypercementosed apical third: anatomical complexity and therapeutic challenge

The results of this systematic review reveal a fragmented and heterogeneous body of literature regarding the endodontic implications of hypercementosis. Nevertheless, the included studies highlight a clinical reality: hypercementosis can significantly alter apical anatomy and compromise the performance of conventional endodontic treatments.

The descriptive studies included [20–22] confirm the extreme

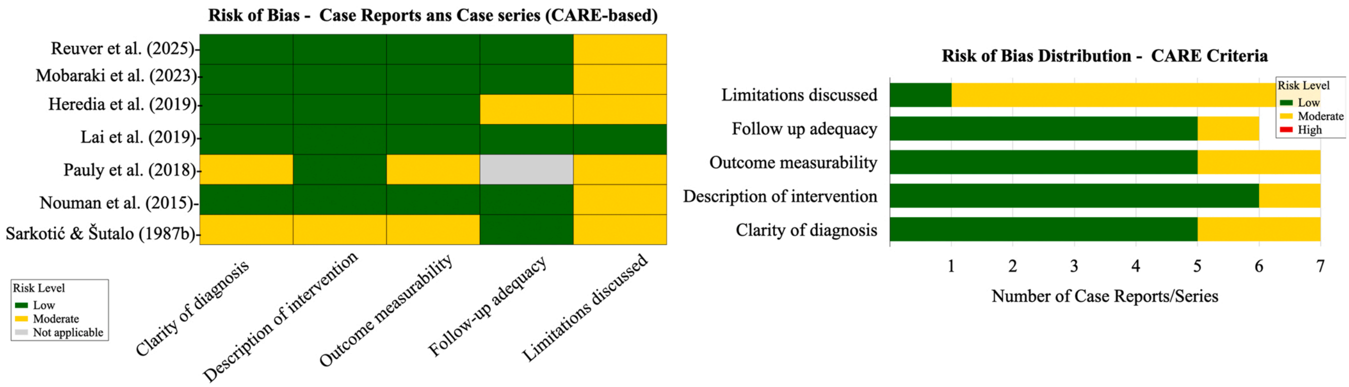

Fig. 4. Risk of bias assessment of case reports and case series based on CARE criteria. Heatmap (left) and horizontal bar chart (right) illustrating the risk of bias distribution for each CARE-based criterion across the included case reports and case series. Green indicates low risk, yellow moderate risk, and gray not applicable.

morphological variability of the apical third in hypercementosed teeth and are consistent with broader findings in the literature regarding this still poorly defined and insufficiently understood condition [10]. This variability affects both the shape of the root, often described as bulbous or "club-shaped", and the configuration of the apical foramen (Fig. 5).

The apical morphology may include complex terminal ramifications, forming a network of pulpal microcanals [29,30]. The location of the main foramen can thus be altered, sometimes shifted to lateral root surfaces, or completely obliterated due to excessive cementum apposition [11,21]. Consolaro et al. suggest that this variability could result from reactive cementogenesis in response to chronic insults or slow necrosis, leading to unregulated growth of radicular cementum. As the main foramen becomes progressively obstructed, the dental pulp may attempt to preserve its vascularization and innervation by developing a secondary network of communication with the periapical tissues [31]. Apical deltas, branched structures within the root apex, could represent this attempt to maintain a functional link with the periodontal environment, despite increasing isolation caused by cementum deposition [29–32]. This compensatory arborization of the root canal system may be interpreted as a biological adaptation mechanism, comparable to vascular anastomoses observed in other tissues under progressive hypoxia [33].

However, this morphological complexity significantly impacts endodontic treatment: it makes accurate apex identification difficult, distorts working length measurements, and compromises the complete disinfection of the canal system, while increasing the risk of canal deviation, apical transportation, or overfilling [32,34]. Moreover, these accessory pathways are not always visible on radiographs, further complicating treatment planning and execution [11,29].

4.2. *Current therapeutic strategies in endodontics for hypercementosis cases*

4.2.1. *Advanced imaging and decision-making support*

Only three clinical cases in the review utilized CBCT to document cases of hypercementosis [14,23,28], while the majority of the other studies relied on two-dimensional interpretation via periapical radiographs. In the three reported cases, 3D imaging helped confirm apical cemental thickening, better visualize root morphology, refine treatment planning, particularly by identifying irregular apical contours or suspected lateral thickening that were not clearly appreciable on conventional radiographs, and by guiding therapeutic decision-making. In one

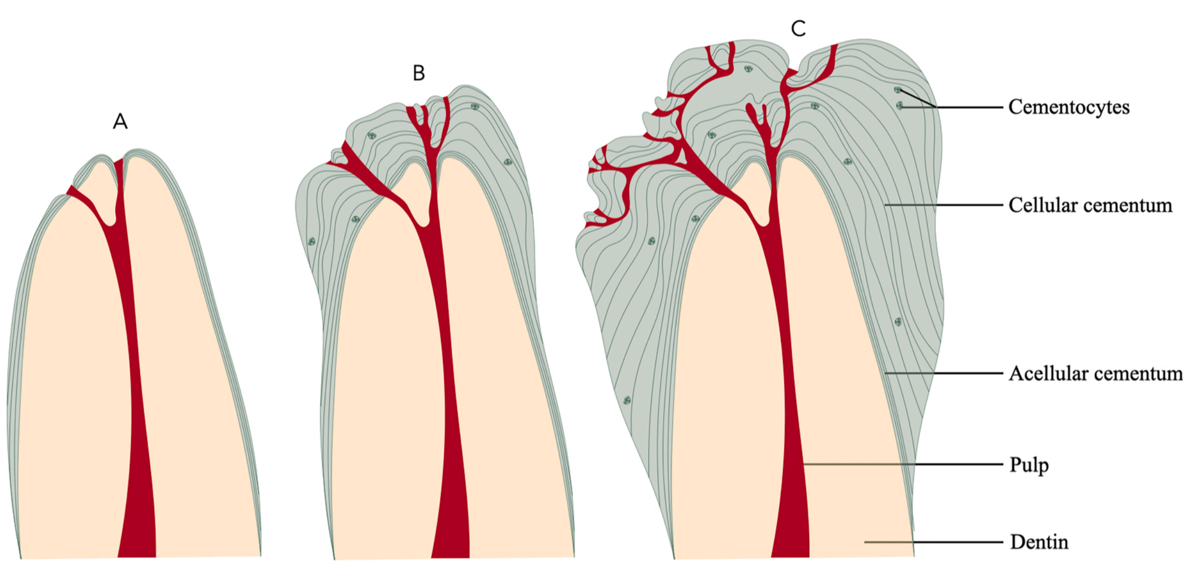

Fig. 5. Illustrations of different degrees of hypercementosis and their effects on root structure. From left to right: A: tooth without hypercementosis, where the cementum covers the entire root surface but does not exceed physiological limits. B: Moderate hypercementosis, where the cementum has thickened beyond physiological levels. In this case, the pulp attempts to maintain its vascular and nerve communication with the surrounding environment by forming pulpal ramifications through the cementum, seeking to preserve the functional link between the pulp and the periapical tissues. C: Marked hypercementosis, where the pulp's vascular and nerve connections are increasingly compromised. Pulpal ramifications may be obliterated, and apical deltas multiply. The root anatomy is significantly altered, making treatment more challenging.

report, CBCT contributed to the decision to perform guided endodontic microsurgery in order to access and resect a complex apical region affected by hypercementosis [23]. These findings suggest that CBCT, when justified, may be particularly valuable in cases where hypercementosis is suspected and conventional radiographs do not fully explain the clinical difficulties encountered during endodontic treatment.

These observations are consistent with a broader body of endodontic literature, outside the specific set of included in this review, recognizing the superiority of CBCT over conventional radiographs in evaluating endodontic outcomes, detecting periapical lesions, incomplete obturations, or complex canal configurations [35–37]. CBCT significantly improves diagnostic sensitivity, with an increased detection rate of endodontic pathologies, even in treatments that appear successful according to conventional radiographic criteria. However, despite its high resolution, CBCT does not always allow visualization of fine structures such as apical deltas, lateral canals, or accessory foramina [37,38]. *In vitro* studies have shown that CBCT, even at high resolution, remains insufficient for detecting complex canal ramifications, and some structures can be completely invisible in clinical imaging [39]. The clinical cases included in this review reveal that the use of CBCT did not allow for precise visualization of the entire pulp system in cases of hypercementosis [23,28]. Moreover, the cemental manifestation may alter the interpretation of apical boundaries in CBCT reconstructions, skewing the measurement of working length or making it difficult to identify the true apical foramen.

4.2.2. Endodontic treatment approaches and therapeutic gradient for hypercementosed teeth

The studies reviewed highlight various treatment strategies including orthograde root canal treatment [24,25,28] or guided microsurgery [23]. A clinical inference can be drawn from these findings: instrumentation of teeth with hypercementosis should always consider the possibility of complex root canal anatomy in the apical third, even if not visible radiographically.

4.2.2.1. Working length (WL) determination. Withing the included clinical reports, WL determination was explicitly described as challenging in hypercementosed teeth. In Nouman et al. (2015), the radiographic apex was indistinct and electronic apex locator readings were variable, making it difficult to define a reliable apical endpoint [25]. By contrast, Mobaraki et al. (2023) reported a pragmatic WL strategy (set 1 mm short using a #10 K-file and an apex locator with radiographic verification) within a two-visit protocol and reported radiographic healing at follow-up [24]. Drawing on general endodontic literature beyond the studies included in this review, several aspects of treatment protocols can be discussed with a view to optimizing management of hypercementosed teeth. WL determination is a critical step: based on apical anatomy studies, the ideal apical termination point has been empirically established to be 0.5–1.0 mm from the radiographic apex [40]. However, the evidence synthesized in this review indicates that, in teeth affected by hypercementosis, the apical foramen may be displaced from the anatomical apex. In such contexts, electronic apex locators are still preferable to relying on radiographs alone for WL determination [41, 42], even though their reliability may be stressed in hypercementosed apices [22]; therefore, multimodal verification is essential.

WL determination typically involves canal exploration with hand files, which may be challenging in narrow or irregular apical canals. Guided endodontics may offer valuable assistance. This emerging technique improves accuracy and safety of root canal treatments [43]. It combines cone-beam computed tomography (CBCT) and intraoral scans to create a virtual treatment plan. A 3D-printed guide then directs the drill precisely to the canal, even in cases of pronounced calcification or complex apical anatomy [44].

4.2.2.2. Canal shaping and irrigation. Following WL determination, canal shaping is performed. The included reports also illustrate how apical hypercementosis may constrain mechanical preparation. Nouman et al. (2015) described marked apical resistance and deliberately limited apical enlargement (ProTaper crown-down up to F1) to reduce the risk of instrument separation, under copious 5 % sodium hypochlorite irrigation [25]. Mobaraki et al. (2023) reported glide-path creation followed by Reciproc R25 shaping, using 2 % NaOCl and 17 % EDTA, with a final protocol including 2 % chlorhexidine and an interappointment calcium hydroxide dressing, followed by radiographic healing at 6 months and 1 year [24].

Despite technological advances, neither hand files nor rotary instruments can fully debride an entire root canal system. Adjunctive use of chemical irrigants, such as 2 % sodium hypochlorite and 17 % ethylenediaminetetraacetic acid (EDTA), is essential for effective disinfection. However, dentinal debris in accessory canals and anatomical irregularities remain a challenge. Activation techniques have been developed to address this limitation [40]. Mechanically activated irrigation significantly improves canal and isthmus cleanliness, debridement, and irrigant delivery up to the working length compared to conventional needle irrigation [45–47]. Focusing on penetration depth of irrigants, ultrasonic, sonic, and laser-induced activation achieve greater irrigant penetration, especially in the apical third [48]. However, standardized protocols for irrigant type, volume, and activation time remain lacking [49].

4.2.3. Obturation

The final step in endodontics is optimal obturation. The included orthograde reports relied on conventional techniques: Nouman et al. (2015) reported cold lateral compaction with gutta-percha and an epoxy resin sealer (AH Plus), whereas Mobaraki et al. (2023) also reported conventional cold lateral condensation within a two-visit protocol and documented radiographic healing at follow-up [24,25]. These observations highlight that, in the current included evidence base, obturation strategies remain largely pragmatic and conventional, despite the apical irregularities described in hypercementosis.

As the root canal space is inaccessible to the host immune response, three-dimensional obturation is crucial to prevent bacterial ingress. Ideally, the obturation should seal all foramina, be void-free, closely adapt to canal walls, and terminate at the apical constriction [40]. Bioceramic sealers have gained popularity due to their favorable physical, chemical, and biological properties. They are valued for their biocompatibility, bioactivity, and sealing ability. These materials bond chemically to dentin, release bioactive compounds after setting, and show high calcium/phosphorus ratios, suggesting regenerative potential and favorable healing outcomes. When compared to traditional resin-based sealers, bioceramic sealers demonstrate similar or slightly improved clinical outcomes [50–52]. Although none of the studies included in this review evaluated bioceramic sealers specifically in hypercementosed teeth, their sealing capacity and bioactive behavior make them plausible candidates to address irregular apical morphology and multiple accessory pathways, and this should be explored in future research.

4.2.4. Surgical management and guided approaches

In case of failure of orthograde root canal treatment, an alternative treatment is endodontic micro-surgery (EMS). Among the included surgical reports, Lai et al. (2019) described CAD/CAM-guided endodontic microsurgery with ultrasonic retropreparation and ProRoot MTA root-end filling, with healing reported at 8 months, suggesting that guided approaches may support precision in complex apical presentations [23]. Conversely, Heredia et al. (2019) illustrate that hypercementosis itself may limit surgical feasibility: exploratory surgery was performed, but apical surgery was not undertaken because hypercementosis prevented establishing a reliable apical limit [14].

From the broader endodontic literature, conventional EMS is typically performed freehand and includes an osteotomy and a 3-mm apical root resection to locate the root apex and eliminate potential ramifications and lateral canals. Following resection, the canal is retroprepared using ultrasonic inserts and sealed with an appropriate material. Although freehand EMS remains a valid approach in most endodontic surgical cases, it carries a higher risk of excessive bone removal [53]. To overcome this limitation, guided surgical technique can be employed for osteotomy and root resection with benefits like enhancing precision and safety, minimally invasive access and applicability in complex anatomical cases like hypercementosed teeth [53–55].

4.2.5. Therapeutic gradient for the management of hypercementosis teeth

Based on the limited evidence synthesized in this review and supported by broader endodontic principles, we propose a stepwise therapeutic gradient to guide case selection and escalation of care in hypercementosed teeth (Fig. 6):

- Healthy teeth: emphasize prevention strategies to avoid the need for endodontic intervention.
- Teeth with non-symptomatic periapical pathology: adopt a conservative approach with regular clinical and radiographic monitoring.
- Teeth with symptomatic periapical pathology: perform a CBCT imaging to localize the canals and evaluate apical anatomy. Proceed with orthograde root canal treatment utilizing guided endodontic

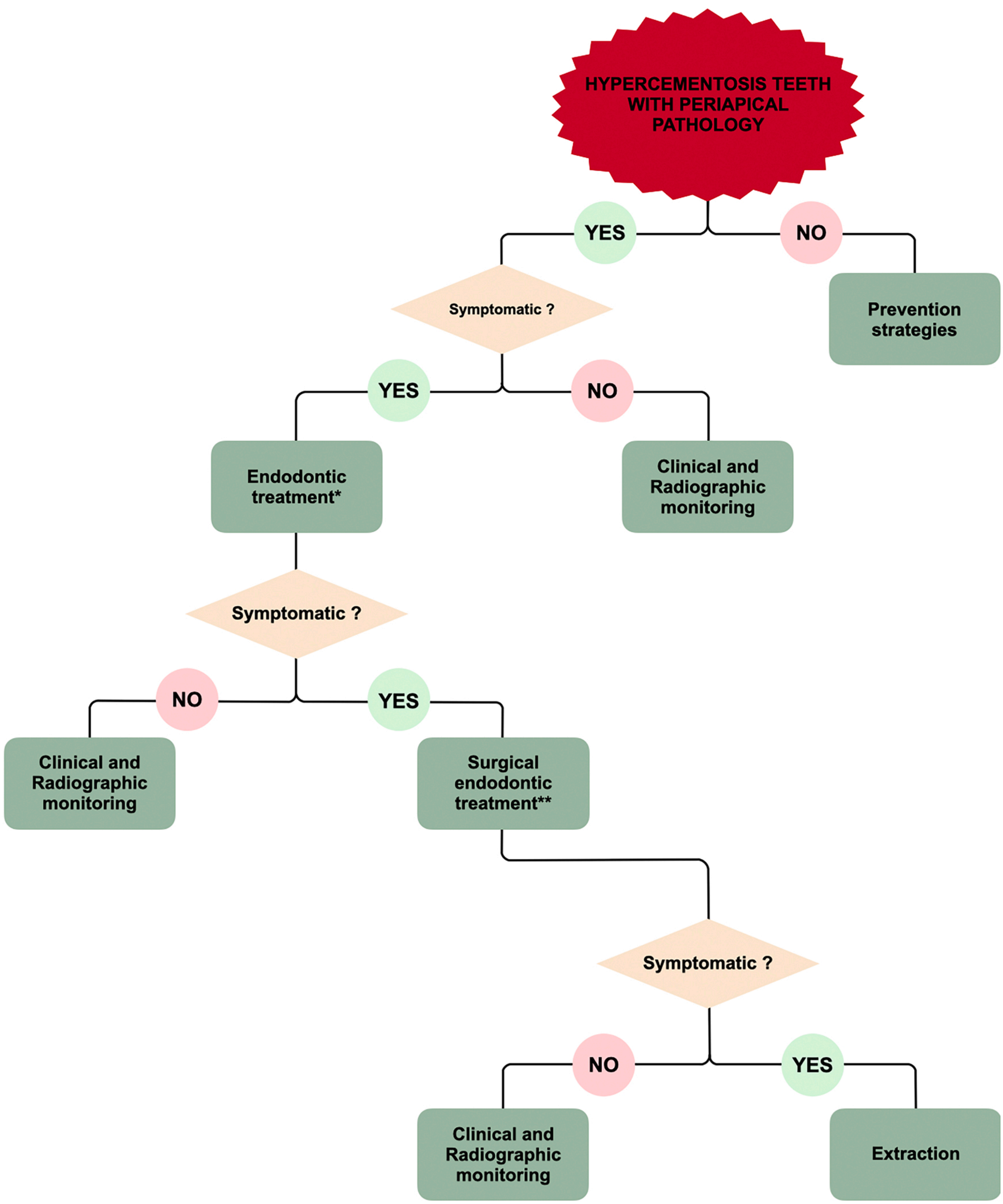

Fig. 6. Therapeutic gradient for the management of hypercementosis teeth. * orthograde root canal treatment utilizing guided endodontic techniques if needed, an electronic apex locator, irrigation activation protocols and bioceramic obturation materials. ** endodontic micro-surgery with a guided approach especially if access is complicated by thick cortical bone.

techniques if needed, an electronic apex locator, irrigation activation protocols and bioceramic obturation materials.
- In cases of incomplete healing: consider endodontic micro-surgery, employing a guided approach especially if access is complicated by thick cortical bone.
- In the absence of healing following surgical treatment: extraction should be considered.

4.3. Hypercementosis and pulpal/periapical inflammation

This subsection draws on broader histological, experimental, and clinical literature beyond the studies included in this review, in order to contextualize the potential links between hypercementosis and pulpal or periapical inflammation. The relationship between hypercementosis and pulpal or periapical inflammation remains complex and bidirectional. From a biological perspective, cementum is a dynamic tissue capable of responding to chronic stimuli such as inflammation, trauma, or functional overload [10]. Several authors have proposed that excessive cementum deposition may occur in response to longstanding pulpal inflammation or apical periodontitis, potentially as a reparative or protective mechanism [56]. Within this framework, hypercementosis could be interpreted as a secondary process, reflecting chronic irritation and tissue adaptation.

Irregular cementoblast activity and the presence of cementicles have been described in teeth showing both hypercementosis and inflammation [57,58]. Cases of recurrent periapical abscesses and chronic endodontic lesions have been associated with progressive cementum apposition, particularly in apical and interradicular regions [59–61]. A correlation between periapical lesions and excess cementum has also been hypothesized in archeological samples, supporting the notion that chronic inflammation may contribute to pathological cementogenesis [62,63].

Current literature suggests a close interplay between chronic pulpal inflammation and hypercementosis, although the direction of this relationship remains uncertain. On one hand, inflammation may act as a biological signal triggering excessive cementum apposition, through cytokine-mediated activation and differentiation of mesenchymal pulp cells. Several studies have demonstrated increased expression of pro-inflammatory mediators – notably IL-1β, IL-6, and TNF-α –in pathological pulp tissues, which may promote mineralizing responses [64]. On the other hand, the morphological changes induced by hypercementosis could impair apical vascularization, hinder immune clearance, or promote bacterial entrapment, thereby fostering a microenvironment conducive to persistent inflammation. Experimental research has shown that cementum thickening may restrict tissue clearance and contribute to localized inflammatory responses [65]. Such conditions may support the persistence of subclinical or overt apical inflammation even after conventional endodontic therapy. Moreover, the presence of multiple foramina, accessory lateral canals, and the difficulty in determining working length further complicate disinfection and obturation, contributing to treatment failure [20–22].

To clarify these mechanisms, the development of *in vitro* models appears as a promising research direction. Simulating chronic pulpal inflammation on cultured pulp stem cells could help evaluate the mineralizing response and the potential production of cementum or cementum-like structures. Conversely, the controlled induction of hypercementosis in three-dimensional root models may offer insights into its impact on pulpal physiology, particularly regarding ischemia or immune response.

4.4. Limitations of the review

This review presents certain limitations that should be acknowledged. First, the number of included studies remains limited, with a predominance of case reports and case series, which reduces the generalizability of findings and their broader clinical applicability. The diversity of methodological approaches, heterogeneity of objectives, and the absence of standardized treatment protocols hinder any direct comparison or meaningful quantitative synthesis.

Moreover, several publications lack long-term follow-up and do not consistently report outcome measures or clinical results with sufficient detail. This limits the evaluation of the effectiveness of the proposed therapeutic strategies. The absence of comparative or controlled studies also precludes any robust statistical analysis.

Finally, although the literature search was thorough and multifaceted, this review relied on selected databases and complementary sources; therefore, some relevant non-indexed publications may have been overlooked. These limitations highlight the need for larger, better-structured clinical studies using standardized evaluation tools to better understand the endodontic implications of hypercementosis.

4.5. Clinical implications and future research directions

Clinically, this review suggests that hypercementosis should not be regarded as a purely incidental radiographic finding, but as a condition that can substantially increase endodontic complexity, particularly in the apical third. Excessive cementum apposition may alter apical root morphology, obscure or displace the main foramen, and consequently complicate working length determination, canal negotiation, and three-dimensional obturation. Hypercementosis should therefore be considered when clinicians encounter unexplained difficulties in locating the apical constriction, establishing a consistent apical endpoint, or achieving a satisfactory apical seal. Preoperative imaging should be used to anticipate these challenges—CBCT when clinically indicated—while acknowledging that imaging may still fail to depict fine apical ramifications. In this context, the therapeutic gradient proposed in this review, ranging from conventional orthograde treatment to endodontic microsurgery and, ultimately, extraction with prosthetic replacement when necessary, provides a structured framework to guide case selection, treatment planning, risk communication, and patient counseling.

As a future research direction that is not derived from the included studies, Artificial Intelligence (AI) applied to endodontic imaging warrants further investigation for anatomically complex situations such as hypercementosis. In principle, coupling AI with CBCT analysis could help reduce diagnostic uncertainty in challenging apical regions. Convolutional Neural Network (CNN)-based platforms such as Diagnocat [Diagnocat Ltd., San Francisco, CA, USA] have shown high diagnostic accuracy for assessing root canal obturations, including detection of under- or overfills and identification of voids [66]. AI has also been reported to predict treatment difficulty, identify complex canal configurations, and provide real-time decision support [67,68]. In hypercementosis, AI–CBCT integration could therefore be explored to facilitate automated recognition of atypical apical morphologies, assist interpretation of possible secondary canal trajectories or cemental irregularities, and help flag regions at risk for incomplete obturation or ectopic foramina, thereby potentially refining diagnosis and supporting therapeutic choices.

The limited number of studies and the predominance of case reports/series highlight several priorities for future research. Prospective clinical studies and larger case series specifically focused on hypercementosed teeth are needed, using standardized diagnostic criteria and explicit characterization of apical morphology, alongside detailed reporting of imaging parameters, endodontic and/or surgical procedures, and clearly defined clinical and radiographic outcomes with adequate follow-up. Complementary experimental or translational models reproducing apical alterations observed in hypercementosis would further help clarify how irregular cementum deposition and chronic inflammation may interfere with cleaning, shaping, and obturation. Methodologically, future studies should also standardize and report (i) an explicit definition of hypercementosis with a clear morphological description (location, extent, and impact on root morphology), (ii) imaging and treatment protocols—including working length determination strategy, instrumentation and irrigation procedures, and obturation technique—and (iii) outcomes using standardized criteria with adequate follow-up, alongside transparent reporting of limitations/potential sources of bias and clear statements on funding and conflicts of interest. Such standardized and transparent reporting will strengthen the evidence base, facilitate higher-quality synthesis, and ultimately refine therapeutic recommendations for teeth affected by hypercementosis.

5. Conclusion

Hypercementosis is a rare but clinically significant condition that can profoundly alter apical root morphology and jeopardize the success of conventional endodontic therapy. The anatomical complexity introduced by excessive cementum deposition, including apical foramen displacement and the presence of accessory canals, requires clinicians to adapt case assessment, working length determination, canal negotiation, and three-dimensional obturation accordingly. This systematic review underlines the central role of careful pre-operative imaging, including CBCT in selected cases, and supports the use of guided orthograde and surgical techniques when conventional treatment cannot adequately address the altered apical anatomy. Within this context, the stepwise, individualized therapeutic gradient proposed here may assist clinicians in structuring decision-making and optimizing the management of endodontic cases involving hypercementosed teeth.

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CRediT authorship contribution statement

Claire Lafourcade: Conceptualization, Methodology, Writing – original draft**. Cyprien Clark:** Writing – original draft. **Raphaël Devillard:** Writing – review and editing. **Olivia Kérourédan:** Writing – review and editing. **Léa Massé:** Conceptualization, Methodology, Writing – original draft, Supervision.

Declaration of Competing Interest

The authors declare that they have no known conficts interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.jdsr.2026.02.001.

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