Journal of Craniomaxillofacial Research

Vol. 11, Issue. 3 Summer 2024

Cold Ceramic in Endodontics Treatments: A Review

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ARTICLE INFO

Article Type:
Review Article

Received: 18 February 2024
Revised: 17 April 2024
Accepted: 10 May 2024

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ABSTRACT

Introduction: Cold Ceramic (CC) is designed to meet the ideal criteria for root filling materials, offering effective sealing, biocompatibility, non-toxicity, dimensional stability, insolubility in tissue fluids, radiopacity, and ease of handling. It sets in the presence of moisture, making it suitable for various endodontic applications such as root-end filling, root perforation repair, apical barriers in teeth with open apices, and pulp capping. This study aims to evaluate cold ceramic's clinical outcomes and applications as presented in case reports.

Materials and Methods: A comprehensive literature search was conducted to identify published case reports and case series on the clinical application of cold ceramics in endodontics from January 2000 to April 2024. Databases searched included PubMed, MEDLINE, Scopus, Web of Science, Cochrane Library and Google Scholar. The search terms used were "cold ceramic," "bio ceramic," "endodontics," "case report," "clinical outcomes," and "dental materials". Articles in English and Persian were included. Patient demographics, cold ceramic brand, clinical procedures, outcomes, follow-up periods, and any complications were extracted. Quality assessment of the included case reports was performed using the CARE guidelines.

Results: After removing duplicates and screening titles and abstracts, 7 case reports and 2 case series met the inclusion criteria. The reviewed case reports included 16 patients (9 female and 7 male) with a mean age of 29.25±1.2. Clinical outcomes were generally favorable, with high success rates and minimal complications reported.

Conclusion: All cases demonstrated radiographic and clinical healing and an absence of postoperative pain or infection during follow-up periods ranging from 3 months to 4 years. cold ceramics provide promising success rates and negligible complications in various clinical endodontic scenarios.

Keywords: Apexification; Biocompatibility; Case report; Cold ceramic; Endodontics; Root canal; Root perforation; Sealing ability; Treatment.

Please cite this Article as:
Roshani A, Hashemi Baraz SA, Shiezadeh I. Cold Ceramic in Endodontics Treatments: A Review. J Craniomaxillofac Res 2024; 11(3): 146-154- DOI: 10.18502/jcr.v11i3.17655

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Introduction

Cold Ceramic (CC) is a calcium hydroxide-based material introduced in 2000 by Modaresi from Yazd University, Iran. It was developed to overcome the limitations of existing root-end filling materials, such as Mineral Trioxide Aggregate (MTA). CC meets the ideal criteria for root filling materials, including effective sealing, biocompatibility, non-toxicity, dimensional stability, insolubility in tissue fluids, radiopacity, and ease of handling. It sets in the presence of moisture, making it suitable for various endodontic applications, including root-end filling, root perforation repair, apical barriers in teeth with open apices, and pulp capping [1,2].

The clinical significance of Cold Ceramic (CC) lies in its promising properties that address several critical needs in endodontic treatments. Its superior sealing ability helps prevent bacterial leakage, which is essential for the success of root canal therapies [3]. The biocompatibility of CC ensures that it does not induce adverse reactions in the surrounding tissues, promoting healing and regeneration [4]. Additionally, CC's ability to set in a moist environment makes it particularly suitable for endodontic procedures where moisture control can be challenging [5]. Its acceptable radiopacity allows for easy detection on radiographs, facilitating the monitoring of treatment outcomes[6]. While initial studies are encouraging, further clinical research is required to fully establish CC's efficacy and safety. As more data becomes available, CC has the potential to become a standard material in endodontic practice, offering a reliable and effective solution for various dental procedures [7,8].

Despite several previous studies that have demonstrated the promising potential of cold ceramic (CC) [9-13] the existing clinical and patient-centered research, such as that conducted by Rasteh et al [14], is insufficient, hence this paucity of substantial clinical data necessitates conclusions drawn from current case reports. Consequently, this review aims to provide a comprehensive evaluation of cold ceramics by analyzing various case reports, thereby elucidating its efficacy, safety, and potential as a standard material in endodontic treatment.

Materials and Methods

PICO question

In patients undergoing endodontic treatment for dental issues such as apexification, periapical lesions, canal obstructions, root perforations, and retreatments (P), how effective is Cold Ceramic (I) compared to traditional materials like MTA (C) in achieving successful clinical outcomes, including healing and absence of postoperative complications (O). A comprehensive search was conducted across multiple databases, including PubMed, Scopus, Web of Science, Google Scholar, and the Cochrane Library, to identify relevant literature on the use of Cold Ceramic (CC) in endodontic treatment. The search focused on its application in root canal procedures. The keywords used for the search were "cold ceramic," "endodontics," "treatment," and "root canal." The search targeted articles published over 24 years, from 2000 (January) — marking the introduction of Cold Ceramic materials — up to 2024 (May). This extensive timeframe was chosen to capture the development and application of Cold Ceramics in endodontics comprehensively. Only full-text articles were considered for inclusion in the tabular analysis to ensure the availability of complete data for evaluation. The analysis included case reports and case series, which provide detailed clinical insights and practical applications of Cold Ceramic in endodontic treatments. Review articles were excluded from the analysis to maintain a focus on original research and clinical findings. Language constraints were applied, and only articles published in English and Persian were reviewed. This decision was based on the researchers' proficiency in these languages, ensuring accurate interpretation and analysis of the data.

The initial search yielded a total of 208 articles. Upon review, duplicates and irrelevant articles were removed, reducing the number to 194. Further screening and analysis focused on the availability of full-text versions and the relevance of the content to the study's objectives. As a result, 92 full-text articles were identified as suitable for detailed analysis. Among these, 9 were case reports, providing valuable clinical examples of the application of Cold Ceramic in endodontics. The following flowchart (Figure 1) illustrates the systematic review process: The extracted data from the case reports were tabulated and analyzed based on various parameters, including the authors, year of publication, patient demographics (gender, age), tooth involved, type of treatment, outcome, follow-up duration, chief complaint, first signs of improvement during follow-up, power of evidence, and CARE guideline score. This meticulous selection and review process aimed to gather the most relevant and high-quality evidence to inform the study on the effectiveness and practical use of Cold Ceramic materials in root canal treatments. As

many of our studies were reported by Modarressi et al., this could bias our results.

Results

Analyzed 9 case reports, encompassing 16 patients treated with Cold Ceramic (CC) for various endodontic issues (Table 1). Here are the significant findings:

Patient Demographics:

Age: Ranged from 9 to 53 years old.

Mean age: 29.25±1.2.

Gender: 9 female 7 male.

Treatment Applications & Outcomes:

Apexification (6 cases)[15-19]: CC successfully induced apexification in immature teeth, with follow-ups showing: Reduced lesions and symptom resolution (24-48 months). New periodontal ligament formation and bone regeneration. Retreatment (6 cases) [15,20,21]: periapical lesion healing. Canal Obstruction (1 case): A 32-year-old male remained asymptomatic for 72 months, with radiographic evidence of periapical healing and bone regeneration [22]. Obturated with CC (2 cases): Normally functioning tooth with no symptoms-Nearly complete healing of periapical lesion [21]. Perforation Repair (1 case) [23]: A 39-year-old male with strip perforation experienced complete symptom resolution and excellent peri radicular healing after 19 months.

Follow-Up & Observations:

Short-term (6-12 months): Significant clinical and radiographic improvements, including pain relief and initial healing signs.

Long-term (up to 72 months): Sustained healing, absence of symptoms, and bone regeneration were observed.

Evidence Quality:

All cases were deemed high-quality based on evidence and outcomes.

CARE guideline scores (21-24/26) indicated strong adherence to reporting standards.

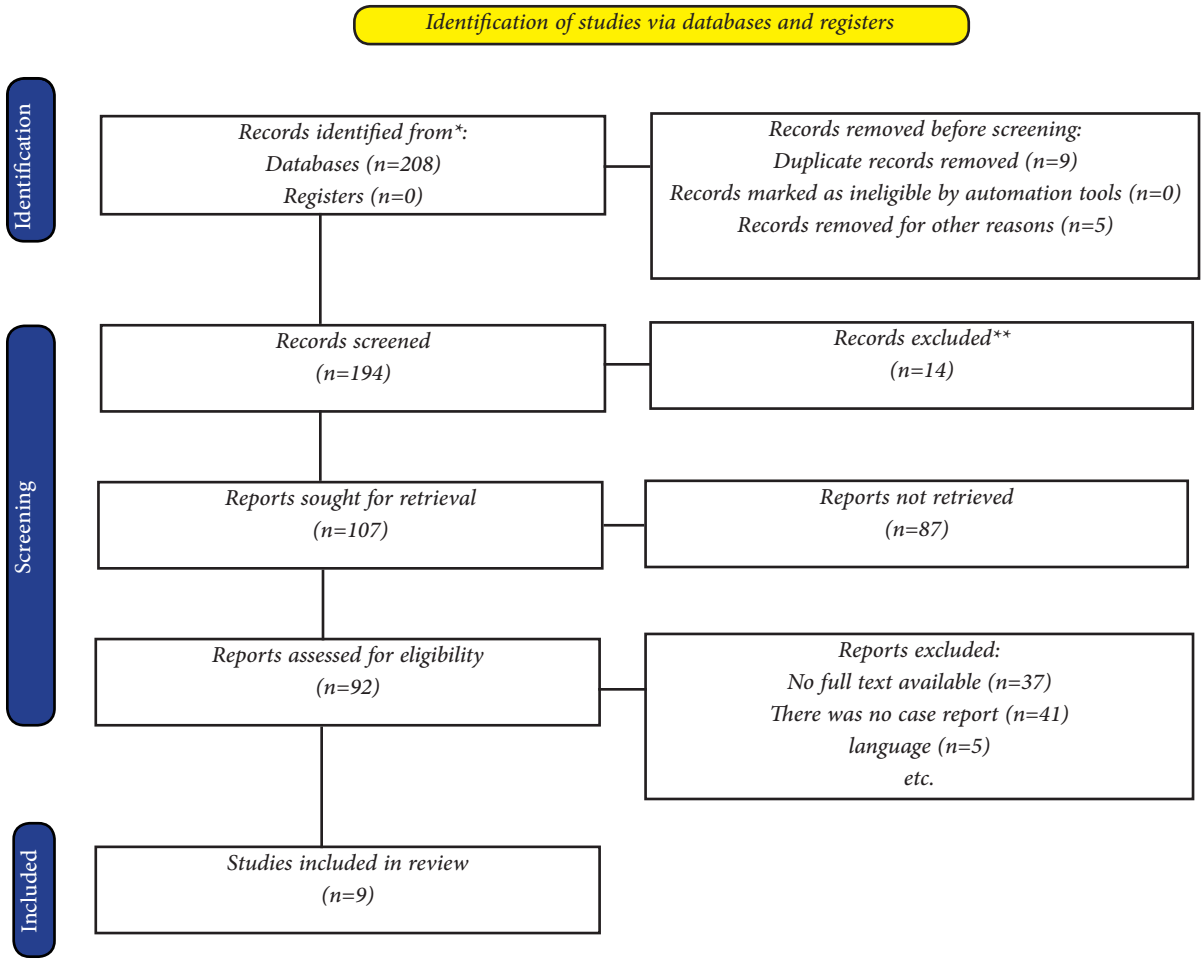

Figure 1. Flowchart of systematic review process.

DOI: 10.18502/jcr.v11i3.17655

Table 1. Results of review.

Authors / Year	Gender	Age	Tooth involved	Type of treatment	Outcome	Follow up	Chief complain	The first signs of improvement in the follow-up	Power of evidence and CARE guideline score
Jalil Modaresi\2020 [16]	Female	10	maxillary right central	apexification	After one and two years of follow-up, the lesion showed improvement, no clinical symptoms were observed on examination, a new periodontal ligament was formed, and the resorbed bone was regenerated	24 and 48 months	Discoloration of front teeth	12 months	High quality/ 24 out of 26
Jalil Modaresi\2021 [20]	Male	42	mandibular first molar	retreatment	Complete healing of the periapical lesion and PDL. Also, the tooth had no mobility or sensitivity to touch and precision	24 months	Severe pain in the lower left first molar tooth	24 months	High quality/ 21 out of 26
Jalil Modaresi\2021 [22]	Male	32	maxillary left central incisor	canal obstruction	After 6 years of which the patient returned, he did not express any pain or discomfort during these 6 years. Furthermore, in radiograph that was taken, periapical lesion relative healing and bone regeneration were amazingly seen.	72 months	symptomatic maxillary left central incisor	72 months	High quality/ 24 out of 26
Shirin Marzoughi [17]	Male	9	mandibular first molar	Apexification of an Immature Permanent First Molar Tooth	Absence of clinical and radiographic symptoms	6 and 12 months	tooth decay	6 months	High quality/ 24 out of 26
Fatemeh Ayatollahi,2023 [18]	Female	14	mandibular left second molar	apexification	In 10-month-old follow up, the tooth was asymptomatic and the periapical lesion healed after 10 months	10 months	Swelling next to the left mandibular second molar tooth	10 months	High quality/ 23 out of 26

Authors / Year	Gender	Age	Tooth involved	Type of treatment	Outcome	Follow up	Chief complain	The first signs of improvement in the follow-up	Power of evidence and CARE guideline score
Jalil Modaresi,2023 [15]	Male	14	left maxillary central incisor	Filling the root canal of a tooth with external root resorption in the apical area	patient had no pain or discomfort on palpation and periapical healing along with bone regeneration and complete apical closure. the normal appearance of the apical periodontal ligament increased the thickness of the root canal walls, and the formation of a cementum-like tissue near the apical end of the root was observed radiographically	9 months	soft tissue swelling	9 months	High quality/ 23 out of 26
	Female	32	right maxillary lateral incisor	Retreatment	Recall radiographs after 7 months revealed that almost two-thirds of the periapical radiolucency had been resolved and filled with trabecular bone	7 months	facial swelling and a symptomatic right maxillary lateral incisor that had been endodontically treated previously-symptomatic right maxillary lateral incisor that had been endodontically treated previously	7 months	High quality/ 23 out of 26
	Female	41	left maxillary lateral incisor	Filling the root canal of a tooth with external root resorption in the apical area	Radiograph at 4-year follow-up demonstrated adequate healing of the periapical lesion and bone regeneration along with the induction of apical closure	48 months	complaining of pain in her left maxillary lateral incisor region and mild swelling of the lips	48 months	High quality/ 23 out of 26
Sholeh Ghabraei [19]	Male	28	right mandibular second premolar	management of an advanced external cervical resorption	Radiographically, the apical region appeared to be healthy, with no changes in the surrounding bone.	3, 6, 20 months	External cervical resorption detected during routine radiograph	3 month	High quality/24 out of 26

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Authors / Year	gender	Age	Tooth involved	Type of treatment	Outcome	Follow up	chief complain	The first signs of improvement in the follow-up	power of evidence and CARE guideline score
Jalil Modaresi 2023 [23]	Male	39	lower left first molar	Treatment of strip perforation	there were no clinical signs or symptoms, and the radiograph displayed excellent peri radicular healing and bone regeneration	19 months	tenderness to percussion	19 months	High quality/ 24 out of 26
Jalil Modaresi 2024 [21]	Female	50	maxillary left lateral	Retreatment	Significant healing of periapical lesion, functional and firm tooth with sufficient apical seal.	12 months	pain originating from the maxillary left lateral tooth	12 months	High quality/24 out of 26
	Male	24	left mandibular first molar	retreatment	Clear healing of the lesion and furcation bone loss after five years.	60 months	Extensive furcation bone loss and symptomatic left mandibular first molar.	60 months	High quality/24 out of 26
	Female	16	right mandibular first molar	retreatment	Relative healing of periapical lesion, remarkable bone healing despite CC extrusion.	21 months	Spontaneous pain and necrotic right mandibular first molar.	21 months	High quality/23 out of 26
	Female	24	left maxillary second premolar	obturated with CC	Nearly complete healing of periapical lesion, marked remineralization after two years.	24 months	Problematic left maxillary second premolar.	24 months	High quality/24 out of 26
	Female	53	maxillary left second premolar	retreatment	Healing of periapical lesion, favorable bone healing after four years.	48 months	Symptomatic maxillary left second premolar with acute periapical abscess.	48 months	High quality/24 out of 26
	Female	40	right mandibular first molar	obturate the canals with CC	Normally functioning tooth with no symptoms after 30 months.	30 months	Necrotic right mandibular first molar with acute periapical abscess.	30 months	High quality/23 out of 26

Discussion

The predominance of mandibular molars and maxillary incisors among our investigated cases can be attributed to several factors. Firstly, trauma is a common occurrence affecting maxillary incisors, necessitating endodontic intervention [15]. Additionally, these teeth are often subject to extensive caries due to their anatomical position and functional role, further increasing the likelihood of requiring endodontic treatment [24]. Moreover, the prevalence of retreatment cases involving these teeth underscores their susceptibility to complications such as perforations, particularly in mandibular molars where complex root canal anatomy poses challenges for initial treatment success [25,26]. Therefore, our findings reflect both the clinical realities of dental pathology and the necessity for comprehensive endodontic management strategies tailored to address these prevalent challenges [27].

Whether confronted with perforations (be it strip or apex perforations), apexification challenges, or canal obstructions, cold ceramic presents an invaluable tool for effective resolution [16]. Its biocompatibility and ability to adhere to dentin make it an ideal choice for sealing perforations and reinforcing compromised canal structures, thereby preventing microleakage and promoting optimal healing [17]. This feature was also proven in a study conducted on rats [12]. Moreover, its ability to facilitate apexification procedures by providing a stable barrier against bacterial ingress while promoting continued root development underscores its utility in managing cases where traditional techniques may fall short [15]. Cold Ceramic excels in providing a reliable seal, comparable to MTA. Studies evaluating the sealing ability of CC have shown that it performs exceptionally well, preventing microleakage and ensuring long-term stability [10]. Additionally, CC's dimensional stability is robust, maintaining its integrity over time and under various conditions. This ensures that the root canal remains sealed and protected against potential contaminants [28]. In cytotoxicity studies, CC consistently showed better cell viability than IRM, making it a safer and more biocompatible option for root-end fillings [28]. The biocompatibility of CC is attributed to its composition, which includes calcium oxide and silicon oxide, similar to MTA. This superior biocompatibility is crucial for the regeneration and healing of peri radicular tissues, which are essential for the long-term success of endodontic treatments. However, Cold Ceramic matches MTA's biocompatibility, providing an excellent alternative. In comparative studies, both set and fresh states of CC demonstrated cell viability values comparable to those of MTA. This indicates that Cold Ceramic can be as effective as MTA in promoting the healing and regeneration of periodontal tissues [10]. Cold ceramics offer superior biocompatibility, sealing ability, and handling properties, making them ideal for specific procedures such as root canal treatments, apexification, and root perforation repairs [17]. Cold ceramic has desirable properties for use in one-session apexification. The initial setting of this material occurs in the presence of moisture within 15 minutes, and it completely hardens within 24 hours, making it suitable for one-session apexification treatment. Its sealing ability has been reported to be higher than that of glass ionomer and amalgam [16]. Cold Ceramic has a significantly shorter setting time compared to MTA [29,30], which enhances its practicality in clinical settings [10]. The handling properties of CC are also more favorable, allowing for easier manipulation and application. These characteristics make Cold Ceramic a more convenient and efficient option for clinicians, reducing the procedural complexities associated with MTA [10,28].

Proper case selection is crucial for optimizing the clinical outcomes of cold ceramics in endodontics. Selecting cases that match these strengths ensures the material's efficacy and reduces the risk of complications. Additionally, considering patient-specific factors, such as infection extent and root canal complexity, is essential for predicting successful outcomes. Thoughtful case selection thus maximizes the benefits of cold ceramics and supports their effective use in clinical practice [23]. Generally, the case reports included in this review indicate sustained healing and absence of symptoms over extended periods, suggesting that CC provides durable solutions for endodontic issues. While the current case reports provide valuable insights and despite that an RCT has been conducted in this field [14], but these, are insufficient to draw definitive conclusions about the material's long-term effectiveness and reliability. To better understand the full potential and limitations of cold ceramics, more rigorous RCTs and prospective studies are needed. While our article's case reports demonstrate successful outcomes, they have inherent limitations in providing conclusive evidence.

Conclusion

This review highlights the potential of Cold Ceramic as a reliable material for endodontic treatments. The case reports analyzed provide evidence of its efficacy and safety in clinical applications. Cold Ceramic shows promise as a standard material in endodontic practice,

DOI: 10.18502/jcr.v11i3.17655

offering a comprehensive solution for various dental procedures.

Conflict of Interest

There is no conflict of interest to declare.

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