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CONTEMPORARY CLINICAL PROTOCOLS IN ENDODONTICS: A NARRATIVE LITERATURE REVIEW WITH PRACTICAL IMPLICATIONS

PROTOCOLOS CLÍNICOS CONTEMPORÂNEOS EM ENDODONTIA: UMA REVISÃO NARRATIVA DA LITERATURA COM IMPLICAÇÕES PRÁTICAS

PROTOCOLOS CLÍNICOS CONTEMPORÁNEOS EN ENDODONCIA: UNA REVISIÓN NARRATIVA DE LA LITERATURA CON IMPLICACIONES PRÁCTICAS

Natanael Maschmann[1], Julia Vinholes[2], Juana Lacerda[3]

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ABSTRACT

The outcome of endodontic therapy depends on the clinical execution of protocols grounded in periapical biology and the science of dental materials. This article presents a narrative review of the contemporary literature on the chemomechanical preparation, disinfection, and sealing of the root canal system. References were retrieved from the PubMed/MEDLINE, Scopus, Web of Science and LILACS databases, using the descriptors Endodontics, Root Canal Preparation, Root Canal Obturation, Root Canal Irrigants, and Dental Pulp Cavity, with emphasis on studies published in the last two decades and on seminal works of recognized relevance. From the analysis of this material, the study discusses practical implications for the management of pulpal and periapical infections, focusing on the crown-down technique, apical patency, and irrigation dynamics. The literature identifies clinical measures, such as supplemental infiltration of 4% articaine, smear-layer removal with chelating agents, and the construction of an effective provisional coronal seal, as clinically relevant steps to reduce the risk of recontamination and therapeutic failure.

KEYWORDS: *Endodontics; Root Canal Preparation; Root Canal Obturation.*

RESUMO

O desfecho da terapia endodôntica depende da execução clínica de protocolos fundamentados na biologia periapical e na ciência dos materiais odontológicos. Este artigo apresenta uma revisão narrativa da literatura contemporânea sobre o preparo químico-mecânico, a desinfecção e o selamento do sistema de canais radiculares. As referências foram recuperadas nas bases PubMed/MEDLINE, Scopus, Web of Science e LILACS com os descritores Endodontia, Preparo de Canal Radicular, Obturação do Canal Radicular, Irrigantes do Canal Radicular e Cavidade da Polpa Dentária, priorizando estudos das duas últimas décadas e obras seminais de reconhecida relevância. A partir da análise desse material, o estudo discute implicações práticas para o manejo de infecções pulpares e periapicais, com foco na técnica crown-down, na patência apical e na dinâmica de irrigação. A literatura identifica medidas clínicas, como a infiltração suplementar de articaína a 4%, a remoção da lama dentinária com agentes quelantes e a confecção de um selamento coronário provisório eficaz, como etapas clinicamente relevantes para reduzir o risco de recontaminação e de falha terapêutica.

PALAVRAS-CHAVE*: Endodontia; Preparo de Canal Radicular; Obturação do Canal Radicular.*

[1] Undergraduate Dentistry Student at the Lutheran University of Brazil (ULBRA), Canoas, Rio Grande do Sul, Brazil.
[2] PhD in Dentistry. Professor in the Dentistry Program at the Lutheran University of Brazil, Canoas, Rio Grande do Sul, Brazil.
[3] Master's Degree in Dentistry. Professor in the Dentistry Program at the Lutheran University of Brazil, Canoas, Rio Grande do Sul, Brazil.

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RESUMEN
El resultado de la terapia endodóntica depende de la ejecución clínica de protocolos fundamentados en la biología periapical y en la ciencia de los materiales odontológicos. Este artículo presenta una revisión narrativa de la literatura contemporánea sobre la preparación quimiomecánica, la desinfección y el sellado del sistema de conductos radiculares. Las referencias se obtuvieron de las bases PubMed/MEDLINE, Scopus, Web of Science y LILACS con los descriptores Endodoncia, Preparación del Conducto Radicular, Obturación del Conducto Radicular, Irrigantes del Conducto Radicular y Cavidad de la Pulpa Dental, priorizando estudios de las dos últimas décadas y obras seminales de reconocida relevancia. A partir del análisis de este material, el estudio discute implicaciones prácticas para el manejo de infecciones pulpares y periapicales, centrándose en la técnica crown-down, la permeabilidad apical y la dinámica de irrigación. La literatura identifica medidas clínicas, como la infiltración suplementaria de articaína al 4%, la remoción del barrillo dentinario con agentes quelantes y la confección de un sellado coronal provisional eficaz, como pasos clínicamente relevantes para reducir el riesgo de recontaminación y de fracaso terapéutico.

PALABRAS CLAVE*: Endodoncia; Preparación del Conducto Radicular; Obturación del Conducto Radicular.*

INTRODUCTION

The central objective of endodontic treatment is to prevent apical periodontitis or to promote the healing of an established lesion. To this end, the clinician seeks to reduce the intracanal microbiota and to inactivate the toxins present in the root canal system (Kakehashi *et al.*, 1965; Siqueira Júnior; Rôças, 2022). Periradicular lesions develop from bacteria organized in structured biofilms, which makes understanding their origin a starting point for treatment. The root canal system, however, has a complex architecture, with isthmuses and lateral ramifications that remain inaccessible to instruments during biomechanical preparation. Because instruments and chemical solutions do not reach all of these irregularities, complete sterilization of the canal is generally regarded as unattainable (Peters *et al.*, 2001; Nair *et al.*, 2005). In addition, exposure to salivary fluids can lead to rapid recontamination of the root system (Torabinejad *et al.*, 1990). The practical problem is therefore how the clinician can select and apply protocols that promote substantial microbial reduction and biological predictability while remaining feasible in routine practice.

The longevity of the treated tooth depends not only on the initial control of the intracanal infection, but also on the quality of the restoration (Aminoshariae *et al.*, 2020), which requires adequate provisional materials to protect the dentinal substrate until treatment is completed. The outcome also depends on mechanical instrumentation acting together with irrigating solutions (Haapasalo *et al.*, 2010); maneuvers in the crown-to-apex direction favor gradual disinfection and reduce the risk of interappointment inflammatory exacerbations, the so-called flare-ups (Siqueira Júnior, 2003). Given the variety of approaches described in the literature, this review is relevant as an attempt to organize contemporary evidence into a coherent and clinically applicable sequence.

The general objective of this study is to structure a narrative review focused on the clinical applicability of contemporary endodontic techniques. The specific objectives are: to discuss patient

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management through diagnostic imaging and pain control; to examine irrigation dynamics and chemomechanical preparation protocols in the reduction of microbial load; and to analyze the role of provisional and definitive coronal sealing in preventing recontamination of the root canal system.

1. THEORETICAL FRAMEWORK

This review is organized around three interdependent themes of contemporary evidence-based endodontics: diagnostic precision, root canal disinfection, and the maintenance of asepsis throughout the therapeutic workflow.

The first theme concerns diagnosis. Contemporary propaedeutics favors objective evaluation methods. Thermal testing with refrigerant sprays at approximately −50 °C contracts the fluid within the dentinal tubules and elicits neural responses in the A-delta and C fibers, which assists in distinguishing reversible from irreversible pulpitis. Cone Beam Computed Tomography (CBCT) provides three-dimensional mapping of the internal root anatomy and helps overcome the superimposition inherent to conventional two-dimensional radiography. This information is useful for identifying anatomical variations, such as a second mesiobuccal canal in maxillary molars, and for detecting periapical lesions confined to the bone marrow. Diagnosis is complemented by pharmacological pain management, particularly in symptomatic irreversible pulpitis, in which local inflammatory acidosis can reduce anesthetic efficacy. In this context, 4% articaine is reported to offer advantages as a supplemental infiltration, since its thiophene ring increases lipid solubility and may favor diffusion through cortical bone.

The second theme addresses the chemomechanical preparation of the root canal system. It is based on a progressive crown-to-apex approach, known as the crown-down technique. Preparing the cervical and middle thirds before apical exploration removes coronal interferences, creates a reservoir for irrigating solutions, and improves fluid dynamics. This sequence also helps to limit the apical extrusion of contaminated debris, which is associated with interappointment flare-ups. Working length is determined with electronic apex locators based on impedance, which identify the minor apical foramen under different moisture conditions. Because uninstrumented areas such as isthmuses and ramifications cannot be fully cleaned mechanically, the protocol incorporates Passive Ultrasonic Irrigation (PUI), which uses acoustic streaming and cavitation to enhance the action of the irrigants.

The third theme links therapeutic longevity to the restorative phase, given the prognostic relevance of coronal sealing in preventing bacterial recontamination. Long-term success is compromised when the root canal system is exposed to salivary fluids and bacterial microleakage. Accordingly, this theme emphasizes the role of a layered provisional coronal seal between appointments. A three-layer temporary restoration, consisting of a sterile cotton spacer to protect the canal orifices, a polytetrafluoroethylene matrix to limit fluid passage, and a glass ionomer cement barrier

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for chemical adhesion and compressive resistance, is described as a means of preserving asepsis until final rehabilitation.

2. METHODOLOGY

This is a narrative, descriptive review with a qualitative approach, aimed at synthesizing contemporary scientific evidence on biological and mechanical protocols in endodontics.

The literature was retrieved from the PubMed/MEDLINE, Scopus, Web of Science and LILACS databases. The search used the descriptors “Endodontics”, “Root Canal Preparation”, “Root Canal Obturation”, “Root Canal Irrigants”, and “Dental Pulp Cavity”, combined with the Boolean operators AND and OR. The search covered publications between 2000 and 2026, with the inclusion of earlier seminal studies of recognized relevance to the field (such as Kakehashi *et al.*, 1965, and Schilder, 1974).

Inclusion criteria were: original studies, systematic reviews, meta-analyses, and position statements of scientific societies addressing diagnosis, chemomechanical preparation, irrigation, or coronal sealing in endodontics, published in English or Portuguese. Exclusion criteria were: studies without direct clinical or biological relevance to the proposed protocols, and material not available in full text.

As a narrative review, this study did not apply a formal protocol for risk-of-bias assessment. Records were screened by title and abstract and, when relevant, read in full. The selected evidence was organized thematically along the clinical sequence of treatment (diagnostic imaging, pain control, mechanical preparation, final irrigation, and provisional sealing) and analyzed qualitatively, prioritizing convergence among studies and consistency with clinical applicability.

3. DISCUSSION

Review of the clinical and biomechanical protocols

Diagnostic propaedeutics and imaging planning

Accurate diagnosis depends on the integration of clinical, thermal, and radiographic data. For pulpal assessment, the cold test with tetrafluoroethane, which lowers the temperature to near −50 °C, is a common chairside option. This abrupt drop contracts the fluid in the dentinal tubules and generates hydrodynamic forces that activate the myelinated A-delta fibers, responsible for sharp pain, followed by the unmyelinated C fibers in more advanced inflammatory states. For this reason, the method is widely used to differentiate reversible from irreversible pulpitis (Petersson *et al.*, 1999).

For three-dimensional assessment, conventional periapical radiography is limited by the superimposition of structures (Yapp *et al.*, 2021). Position statements of the European Society of Endodontology recommend Cone Beam Computed Tomography for the planning of complex cases

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(European Society of Endodontology, 2019). CBCT allows spatial visualization and is useful for identifying anatomical variations, such as the second mesiobuccal canal in maxillary molars, and for mapping periapical lesions confined to the bone marrow (Kruse *et al.*, 2019).

Operative magnification

Operative magnification has become part of contemporary endodontic practice, particularly in the location of canal orifices and the detection of additional canals. Magnification combined with coaxial illumination, whether through surgical loupes or the dental operating microscope, improves the visualization of the internal anatomy and may assist in identifying structures such as the second mesiobuccal canal in maxillary molars (Carr; Murgel, 2010). Reviews of clinical use report a growing adoption of magnification in endodontics; the reported effect on treatment outcomes, however, varies and depends on operator training and on the type of procedure (Low; Dom; Baharin, 2018).

Operative field control: anesthetic pharmacokinetics and isolation

Achieving profound anesthesia in teeth with symptomatic irreversible pulpitis is a recognized clinical challenge, mainly because of tissue hyperalgesia and local inflammatory acidosis, which hinder the diffusion of the anesthetic through the nerve sheath. In this setting, 2% lidocaine remains the reference for routine mandibular blocks, while supplemental buccal infiltration with 4% articaine may improve outcomes. The thiophene ring in the articaine molecule increases lipid solubility, which favors diffusion through the mandibular cortical bone and is associated with higher success rates in acute pain (Nagendrababu *et al.*, 2019; Adl *et al.*, 2026).

Once sensitivity is controlled, the operative field should be kept isolated. The rubber dam isolates the field, limits the entry of salivary bacteria into the tooth, protects the patient's airway against accidental ingestion of instruments, and reduces contact of the oral mucosa with the irrigating solutions.

Coronal access, emptying dynamics, and the crown-down technique

Coronal access influences the subsequent clinical stages. Before advancing fine files into the canal, the literature recommends preparing the cervical third and the canal orifice with larger-caliber rotary or manual instruments (Arias; Peters, 2022). This initial enlargement removes coronal interferences, such as the dentin triangle, which can deflect instruments and increase cyclic fatigue. The resulting space functions as a reservoir of sodium hypochlorite and modifies the dynamics of disinfection, allowing the needle to reach the middle third and the irrigant to flow without obstruction. An unobstructed flow reduces internal pressure and the risk of extrusion of irrigant into the periapical tissues (Boutsioukis *et al.*, 2010).

Instrumentation in the crown-to-apex direction is described as a strategy to manage postoperative discomfort. In necrotic teeth, the greatest bacterial load is located in the cervical and

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middle thirds; the early insertion of fine files to the working length can produce a piston effect that displaces contaminated dentin and toxins toward the periapical region. Because debris extrusion is among the main causes of interappointment exacerbations, the crown-down technique favors progressive disinfection and reduces the transport of bacteria to the supporting tissues (Bürklein; Schäfer, 2012).

Patency, working length determination, and final rinse protocol

Root instrumentation generates debris that can obliterate the apical constriction. The patency protocol consists of the gentle passage of fine-caliber instruments, such as the size 10 K-type file, through the major foramen. Using a size 10 file for this purpose ensures the permeability of the canal and prevents the formation of ledges, guaranteeing that irrigating solutions exert their disinfecting effect in the zone of greatest apical complexity (Buchanan, 1989). The precision of the preparation is ensured by the working length determination. In this context, electronic location of the apical foramen by means of the electronic apex locator (EAL) represents a substantial advance over conventional working length determination, whose determination of working length relies exclusively on radiographic references. Conventional working length determination, by relying on the two-dimensional interpretation of the radiographic image, is subject to geometric distortions and does not account for the real position of the physiological foramen, which frequently does not coincide with the radiographic apex (Martins *et al.*, 2014). Third- and fourth-generation electronic apex locators, such as the Root ZX and its successors, operate by the principle of electrical impedance and demonstrate accuracy above 90% in identifying the minor foramen, regardless of the moisture conditions of the canal (Pascon *et al.*, 2009; Tsesis *et al.*, 2015). Thus, the real working length is defined one millimeter short of the radiographic apex, respecting the physiological limit of the transition between cementum and dentin (cementodentinal junction).

Chemomechanical preparation materializes the creation of the apical stop through the master apical file, the last and largest-caliber instrument to reach the real working length without encountering resistance. This file defines the final diameter of the constriction and thereby establishes the adaptation rules for the gutta-percha cone. The precision of this mechanical step at the real diameter of the constriction provides the operator with the tactile lock that prevents extrusion of filling material at the moment of vertical condensation (Schilder, 1974).

Effective disinfection inside the canal requires the union between fluid hydrodynamics and the exact time of action of the irrigants (Boutsioukis; Arias-Moliz, 2022). The great challenge of this stage arises from the canal instrumentation itself, since the friction of the metal generates the smear layer that blocks the dentinal tubules. Overcoming this physical barrier and dissolving the architecture of the residual biofilm obliges the clinician to follow a rigorous final rinse protocol. The efficiency of this disinfection depends on the mechanical agitation of the liquid, with Passive Ultrasonic Irrigation (PUI) being the modality most widely validated by the literature for enhancing the action of auxiliary chemical

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substances. In this technique, a small-caliber file or smooth tip, without contact with the dentinal walls, is activated by ultrasonic energy, generating acoustic microstreaming and cavitation phenomena that expand the penetration of the irrigant into hard-to-reach isthmuses, ramifications, and dentinal tubules (van der Sluis *et al.*, 2007; Ordinola-Zapata *et al.*, 2014). The final rinse protocol is structured in three stages:

Phase 1 — Primary Organic Dissolution: The protocol begins with the application of 2.5% sodium hypochlorite, subjected to passive ultrasonic activation for three cycles of twenty seconds, totaling one minute. The activation raises the hydrodynamic force at the root walls, promoting the accelerated degradation of macroscopic organic tissue and bacterial membranes (Gu *et al.*, 2009).

Phase 2 — Demineralization and Unblocking: Since hypochlorite is inert to the inorganic portion of the smear layer, the canal is flooded with the chelating agent 17% EDTA, likewise subjected to passive ultrasonic activation for three cycles of twenty seconds. Ultrasonic agitation of EDTA accelerates the chelation of calcium ions, removing the smear layer and opening the entrance of the tubules with efficiency significantly superior to simple passive irrigation (Prado *et al.*, 2019; Zehnder, 2006; Hartmann *et al.*, 2026).

Phase 3 — Deep Disinfection: With the tubular network unblocked and patent, the final rinse is performed with 2.5% sodium hypochlorite, again activated by ultrasound for three cycles of twenty seconds. This last stage allows the actively agitated liquid to penetrate into the depths of the dentinal tubules, maximizing the eradication of persistent microorganisms. This antimicrobial stage directly influences periapical healing rates, with particular relevance in retreatment cases (Zandi *et al.*, 2019). Subsequently, with the dentinal wall purified, the canal offers the ideal substrate for the anchorage and micromechanical retention of the obturating sealer (Violich; Chandler, 2010; Zehnder, 2006).

Minimally invasive instrumentation

In parallel with the search for adequate disinfection, the literature has discussed the preservation of dentinal tissue through minimally invasive access cavities and more conservative instrumentation, on the assumption that preserving structure may favor the fracture resistance of the treated tooth (Silva *et al.*, 2020). This approach is not free of trade-offs: more conservative access and reduced taper can limit visualization, instrumentation, and the penetration of irrigants, and the clinical evidence of a real gain in tooth survival remains limited (Shabbir *et al.*, 2021). The balance between dentin preservation and disinfection efficacy is, therefore, still a matter of debate, and the indication should consider the anatomy and the condition of each case.

Persistent biofilms and microbial resistance

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Even with adequate chemomechanical preparation, microbial persistence remains the main factor associated with the failure of endodontic treatment. Bacteria organized in biofilms, located in isthmuses, ramifications, and dentinal tubules, are more tolerant to disinfecting agents than planktonic forms, which makes their complete elimination difficult (Neelakantan *et al.*, 2017). Persistent species, often associated with refractory infections and with retreatment, sustain the interest in complementary disinfection strategies and reinforce the relevance of the irrigation and activation protocols discussed above (Siqueira Júnior; Rôças, 2022).

Coronal shielding and provisional sealing

The current endodontic literature establishes that the success of apical treatment is directly proportional to the quality of the coronal seal. Recent systematic reviews and longitudinal studies corroborate that the quality of the coronal restoration has a predictive impact on prognosis equivalent to that of the root filling itself (Aminoshariae *et al.*, 2020). In this context, the construction of the provisional seal between sessions requires the use of materials that fulfill complementary protective and mechanical functions.

The clinical protocol indicates the construction of a triple barrier. The procedure begins with the insertion of a small portion of sterile cotton over the floor of the pulp chamber. This material acts as a mechanical protector, preventing the occlusion of the canal orifices by the restorative material and facilitating reopening of the tooth at subsequent appointments (Mathew *et al.*, 2021). To optimize isolation, the protocol calls for the application of a strip of sterile polytetrafluoroethylene, a synthetic and hydrophobic material popularly known as Teflon. Because of its impermeable nature, Teflon complements the action of the cotton, blocking the passage of oral fluids and creating an effective internal barrier (Hashem *et al.*, 2024).

The provisional seal is completed by inserting glass ionomer cement over the base of Teflon and cotton. The indication for this material stems from its chemical affinity with the calcium of dentin, a characteristic needed to ensure a seal free of marginal gaps. Besides adhesiveness, the cement has compressive strength adequate to withstand the transient masticatory forces generated in the period between appointments (Naoum; Chandler, 2002). This set acts as a structural physical block, which prevents bacterial infiltration into the pulp chamber and ensures the maintenance of asepsis until treatment is completed.

Bioceramic Materials

Among the developments in dental materials, calcium silicate-based (bioceramic) cements have gained space in endodontics, including in obturation. These materials are valued for their biocompatibility, dimensional stability, and apatite-forming ability, which may favor sealing at the dentin interface (Zamparini *et al.*, 2022). Systematic reviews comparing premixed bioceramic sealers with

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conventional sealers report comparable clinical outcomes, with possible differences in extrusion rate and postoperative pain, although the long-term evidence is still being consolidated (Zamparini *et al.*, 2024).

Definitive Restoration and Tooth Survival

The longevity of the endodontically treated tooth depends not only on the root filling, but also on the quality and the timing of the definitive restoration. Systematic reviews indicate that the quality of the coronal restoration has a prognostic weight comparable to that of the root filling on the success of treatment (Gillen *et al.*, 2011; Aminoshariae *et al.*, 2020). At the level of tooth survival, the available evidence associates the restorative phase with the retention of the treated tooth over time (Ng; Mann; Gulabivala, 2010; Fransson; Dawson, 2023). These data reinforce that the provisional seal discussed earlier is a transitional measure and that the definitive restoration should not be postponed.

Clinical Implications

From the analysis of biomechanical and microbiological aspects, the literature supports the following clinical implications. In diagnostic imaging, Cone Beam Computed Tomography is indicated for the planning of multirooted teeth and retreatments, in order to reduce failures in the identification of

additional canals and isthmuses (American Association of Endodontists; American Academy of Oral and Maxillofacial Radiology, 2015). In pharmacological management, the failure or insufficiency of the conventional anesthetic block supports supplemental submucosal infiltration with 4% articaine, which is associated with effective pain control in different scenarios, including symptomatic irreversible pulpitis (Kung *et al.*, 2015; Shapiro *et al.*, 2018).

In mechanical preparation, the initial exploration of the canal is preceded by cervical enlargement through the crown-down technique, which creates a reservoir of sodium hypochlorite, improves irrigation dynamics, and is associated with a lower incidence of flare-ups (Siqueira Júnior, 2003; Bürklein; Schäfer, 2012). For the dentinal surface, the final irrigation protocol combines sodium hypochlorite, 17% EDTA, and sodium hypochlorite, which favors the removal of the smear layer and the adaptation of the sealer within the tubules (Violich; Chandler, 2010).

For the prevention of coronal infiltration, a layered provisional seal is described, beginning with sterile cotton to protect the canal orifices, followed by a polytetrafluoroethylene matrix with a sealing function, and completed with glass ionomer cement, which provides compressive strength and peripheral chemical sealing during the interappointment period (Zaia *et al.*, 2002).

4. FINAL CONSIDERATIONS

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The clinical outcome and the predictability of contemporary endodontic therapy are related to an integrated understanding of periapical biology and the science of dental materials, rather than to the execution of isolated mechanical steps. The evidence reviewed here suggests that consistent results are associated with the application of protocols grounded in current scientific evidence and adapted to each clinical situation.

This sequence begins in the preoperative phase, in which an accurate diagnosis, supported by the three-dimensional information of Cone Beam Computed Tomography, is combined with anesthetic management that may include supplemental 4% articaine in cases of difficult pain control. In the mechanical phase, prior cervical enlargement through the crown-down technique reduces coronal interferences, favors chemical flow, and limits the apical displacement of contaminated debris. In the final rinse, the alternation of sodium hypochlorite and EDTA under passive ultrasonic agitation favors the removal of the organic and inorganic smear layer and the reduction of the bacterial biofilm in areas not reached by instruments.

Preparation and disinfection, however, represent only part of the treatment and should be followed by an adequate restorative protocol. A layered provisional coronal seal, combining sterile cotton, a polytetrafluoroethylene matrix, and a glass ionomer cement barrier, is described as a means of limiting microleakage and coronal infiltration of fluids and salivary bacteria between appointments.

In summary, contemporary endodontic practice favors clinical decisions based on current evidence and on the integration of the biological and restorative stages of treatment. The sequential application of the protocols discussed here is associated with greater predictability and with the longevity of the treated tooth, although the results depend on the clinical context, on the characteristics of each case, and on the continuous evolution of the available evidence.

Limitations

As a narrative review, this study does not follow a systematic protocol for search, selection, and risk-of-bias assessment, which limits the reproducibility and the exhaustiveness of the synthesis and may introduce selection bias. The implications discussed here have a guiding character and do not replace clinical judgment or the specific evidence applicable to each case.

REFERENCES

ADL, A.; ALIMARDANI, F.; SOBHNAMAYAN, F. Evaluation of articaine infiltration location on the success rate of mandibular lateral incisor anesthesia: a prospective crossover randomized clinical trial study. **Journal of Endodontics**, v. 52, n. 4, p. 658-663, 2026. DOI: 10.1016/j.joen.2025.09.018.

AMERICAN ASSOCIATION OF ENDODONTISTS; AMERICAN ACADEMY OF ORAL AND MAXILLOFACIAL RADIOLOGY. AAE and AAOMR joint position statement: use of cone beam

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computed tomography in endodontics 2015 update. **Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology**, v. 120, n. 4, p. 508-512, 2015. DOI: 10.1016/j.oooo.2015.07.033.

AMINOSHARIAE, A.; KULILD, J. C.; SYED, A. Impact of coronal restoration quality on the outcome of root canal treatment: a systematic review and meta-analysis. **Journal of Endodontics**, v. 46, n. 4, p. 469-479, 2020. DOI: 10.1016/j.joen.2019.12.010.

ARIAS, A.; PETERS, O. A. Present status and future directions: canal shaping. **International Endodontic Journal**, v. 55, supl. 3, p. 637-655, 2022. DOI: 10.1111/iej.13698.

BOUTSIOUKIS, C.; GOGOS, C.; VERHAAGEN, B.; VERSLUIS, M.; KASTRINAKIS, E.; VAN DER SLUIS, L. W. M. The effect of root canal taper on the irrigant flow: evaluation using an unsteady computational fluid dynamics model. **International Endodontic Journal**, v. 43, n. 10, p. 909-916, 2010. DOI: 10.1111/j.1365-2591.2010.01767.x.

BOUTSIOUKIS, C.; ARIAS-MOLIZ, M. T. Present status and future directions – irrigants and irrigation methods. **International Endodontic Journal**, v. 55, supl. 3, p. 588-612, 2022. DOI: 10.1111/iej.13739.

BUCHANAN, L. S. Management of the curved root canal. **Journal of the California Dental Association**, v. 17, n. 4, p. 18-25, 1989.

BÜRKLEIN, S.; SCHÄFER, E. Apically extruded debris with reciprocating single-file and full-sequence rotary instrumentation systems. **Journal of Endodontics**, v. 38, n. 6, p. 850-852, 2012. DOI: 10.1016/j.joen.2012.02.017.

CARR, G. B.; MURGEL, C. A. The use of the operating microscope in endodontics. **Dental Clinics of North America**, v. 54, n. 2, p. 191-214, abr. 2010. DOI: 10.1016/j.cden.2010.01.002.

EUROPEAN SOCIETY OF ENDODONTOLOGY. European Society of Endodontology position statement: use of cone beam computed tomography in endodontics. **International Endodontic Journal**, v. 52, n. 12, p. 1675-1678, 2019. DOI: 10.1111/iej.13187.

FRANSSON, H.; DAWSON, V. Tooth survival after endodontic treatment. **International Endodontic Journal**, v. 56, supl. 2, p. 140-153, mar. 2023. DOI: 10.1111/iej.13835.

GILLEN, B. M.; LOONEY, S. W.; GU, L. S.; LOUSHINE, B. A.; WELLER, R. N.; LOUSHINE, R. J.; PASHLEY, D. H.; TAY, F. R. Impact of the quality of coronal restoration versus the quality of root canal fillings on success of root canal treatment: a systematic review and meta-analysis. **Journal of Endodontics**, v. 37, n. 7, p. 895-902, 2011. DOI: 10.1016/j.joen.2011.04.002.

GU, L. S.; KIM, J. R.; LING, J.; CHOI, K. K.; PASHLEY, D. H.; TAY, F. R. Review of contemporary irrigant agitation techniques and devices. **Journal of Endodontics**, v. 35, n. 6, p. 791-804, 2009. DOI: 10.1016/j.joen.2009.03.010.

HAAPASALO, M.; SHEN, Y.; QIAN, W.; GAO, Y. Irrigation in endodontics. **Dental Clinics of North America**, v. 54, n. 2, p. 291-312, 2010. DOI: 10.1016/j.cden.2009.12.001.

HARTMANN, C. S.; CZORNOBAY, L. F. M.; SAVARIS, J. M.; ROCHA, A. O.; ANJOS, L. M.; HENRIQUES, B. A. P. C.; CARDOSO, M.; GARCIA, L. F. R.; TEIXEIRA, C. S. Sixty years of ethylenediaminetetraacetic acid use in endodontics: a comprehensive bibliometric study. Journal of Endodontics, v. 52, n. 4, p. 512-524, 2026. DOI: 10.1016/j.joen.2025.11.004.

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SCIENTIFIC JOURNAL - RECIMA21 ISSN 2675-6218

HASHEM, Q.; MUSTAFA, M.; ABUELQOMSAN, M. A. S.; ALTUWALAH, A.; ALMOKHATIEB, A. A.; FAREED, M.; KAROBARI, M. I. Assessing correlation between different temporary restorative materials for microleakage following endodontic treatment: an in-vitro study. **BMC Oral Health**, v. 24, n. 1, art. 1505, dez. 2024. DOI: 10.1186/s12903-024-05302-6.

KAKEHASHI, S.; STANLEY, H. R.; FITZGERALD, R. J. The effects of surgical exposures of dental pulps in germ-free and conventional laboratory rats. **Oral Surgery, Oral Medicine, Oral Pathology**, v. 20, n. 3, p. 340-349, 1965. DOI: 10.1016/0030-4220(65)90166-0.

KRUSE, C.; SPIN-NETO, R.; KRAFT, D. C.; VAETH, M.; KIRKEVANG, L. L. Diagnostic accuracy of cone beam computed tomography used for assessment of apical periodontitis: an ex vivo histopathological study on human cadavers. **International Endodontic Journal**, v. 52, n. 4, p. 439-450, 2019. DOI: 10.1111/iej.13020.

KUNG, J.; MCDONAGH, M.; SEDGLEY, C. M. Does articaine provide an advantage over lidocaine in patients with symptomatic irreversible pulpitis? A systematic review and meta-analysis. **Journal of Endodontics**, v. 41, n. 11, p. 1784-1794, nov. 2015. DOI: 10.1016/j.joen.2015.07.001.

LOW, J. F.; DOM, T. N. M.; BAHARIN, S. A. Magnification in endodontics: a review of its application and acceptance among dental practitioners. **European Journal of Dentistry**, v. 12, n. 4, p. 610-616, out./dez. 2018. DOI: 10.4103/ejd.ejd_248_18.

MARTINS, J. N. R.; MARQUES, D.; MATA, A.; CARAMÊS, J. Clinical efficacy of electronic apex locators: systematic review. **Journal of Endodontics**, v. 40, n. 6, p. 759-777, 2014. DOI: 10.1016/j.joen.2014.03.011.

MATHEW, A.; LEE, S.; HA, W.; NAGENDRABABU, V.; ROSSI-FEDELE, G. Microbial contamination comparison between cotton pellet and polytetrafluoroethylene tape endodontic spacers: a systematic review. **European Endodontic Journal**, v. 6, n. 2, p. 143-150, ago. 2021. DOI: 10.14744/eej.2021.52244.

NAGENDRABABU, V.; PULIKKOTIL, S. J.; SURESH, A.; VEETTIL, S. K.; BHATIA, S.; SETZER, F. C. Efficacy of local anaesthetic solutions on the success of inferior alveolar nerve block in patients with irreversible pulpitis: a systematic review and network meta-analysis of randomized clinical trials. **International Endodontic Journal**, v. 52, n. 6, p. 779-789, jun. 2019. DOI: 10.1111/iej.13072.

NAIR, P. N.; HENRY, S.; CANO, V.; VERA, J. Microbial status of apical root canal system of human mandibular first molars with primary apical periodontitis after “one-visit” endodontic treatment. **Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontology**, v. 99, n. 2, p. 231-252, 2005. DOI: 10.1016/j.tripleo.2004.10.005.

NAOUM, H. J.; CHANDLER, N. P. Temporization for endodontics. **International Endodontic Journal**, v. 35, n. 12, p. 964-978, dez. 2002. DOI: 10.1046/j.1365-2591.2002.00600.x.

NEELAKANTAN, P.; ROMERO, M.; VERA, J.; DAOOD, U.; KHAN, A. U.; YAN, A.; CHEUNG, G. S. P. Biofilms in endodontics: current status and future directions. **International Journal of Molecular Sciences**, v. 18, n. 8, art. 1748, 2017. DOI: 10.3390/ijms18081748.

NG, Y. L.; MANN, V.; GULABIVALA, K. Tooth survival following non-surgical root canal treatment: a systematic review of the literature. **International Endodontic Journal**, v. 43, n. 3, p. 171-189, mar. 2010. DOI: 10.1111/j.1365-2591.2009.01671.x.

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SCIENTIFIC JOURNAL - RECIMA21 ISSN 2675-6218

ORDINOLA-ZAPATA, R.; BRAMANTE, C. M.; APRECIO, R. M.; HANDYSIDES, R.; JARAMILLO, D. E. Biofilm removal by 6% sodium hypochlorite activated by different irrigation techniques. **International Endodontic Journal**, v. 47, n. 7, p. 659-666, jul. 2014. DOI: 10.1111/iej.12202.

PASCON, E. A.; MARRELLI, M.; CONGI, O.; CIANCIO, R.; MICELI, F.; VERSIANI, M. A. An in vivo comparison of working length determination of two frequency-based electronic apex locators. **International Endodontic Journal**, v. 42, n. 11, p. 1026-1031, 2009. DOI: 10.1111/j.1365-2591.2009.01615.x.

PETERS, O. A.; SCHÖNENBERGER, K.; LAIB, A. Effects of four Ni-Ti preparation techniques on root canal geometry assessed by micro computed tomography. **International Endodontic Journal**, v. 34, n. 3, p. 221-230, 2001. DOI: 10.1046/j.1365-2591.2001.00373.x.

PETERSSON, K.; SÖDERSTRÖM, C.; KIANI-ANARAKI, M.; LÉVY, G. Evaluation of the ability of thermal and electrical tests to register pulp vitality. **Endodontics & Dental Traumatology**, v. 15, n. 3, p. 127-131, 1999. DOI: 10.1111/j.1600-9657.1999.tb00769.x.

PRADO, M.; SILVA, E. M.; LINHARES, B. A.; GOMES, B. P. F. A. Influence of different irrigation protocols on the bond strength of endodontic sealers. **Journal of Applied Oral Science**, v. 27, p. e20180437, 2019. DOI: 10.1590/1678-7757-2018-0437.

SCHILDER, H. Cleaning and shaping the root canal. **Dental Clinics of North America**, v. 18, n. 2, p. 269-296, 1974. DOI: 10.1016/S0011-8532(22)00677-2.

SHABBIR, J.; ZEHRA, T.; NAJMI, N.; HASAN, A.; NAZ, M.; PIASECKI, L.; AZIM, A. A. Access cavity preparations: classification and literature review of traditional and minimally invasive endodontic access cavity designs. **Journal of Endodontics**, v. 47, n. 8, p. 1229-1244, 2021. DOI: 10.1016/j.joen.2021.05.007.

SHAPIRO, M. R.; McDONALD, N. J.; GARDNER, R. J.; PETERS, M. C.; BOTERO, T. M. Efficacy of articaine versus lidocaine in supplemental infiltration for mandibular first versus second molars with irreversible pulpitis: a prospective, randomized, double-blind clinical trial. **Journal of Endodontics**, v. 44, n. 4, p. 523-528, 2018. DOI: 10.1016/j.joen.2017.10.003.

SILVA, E. J. N. L.; PINTO, K. P.; FERREIRA, C. M.; BELLADONNA, F. G.; DE-DEUS, G.; DUMMER, P. M. H.; VERSIANI, M. A. Current status on minimal access cavity preparations: a critical analysis and a proposal for a universal nomenclature. **International Endodontic Journal**, v. 53, n. 12, p. 1618-1635, 2020. DOI: 10.1111/iej.13391.

SIQUEIRA JÚNIOR, J. F. Microbial causes of endodontic flare-ups. **International Endodontic Journal**, v. 36, n. 7, p. 453-463, 2003. DOI: 10.1046/j.1365-2591.2003.00671.x.

SIQUEIRA JÚNIOR, J. F.; RÔÇAS, I. N. Present status and future directions: microbiology of endodontic infections. **International Endodontic Journal**, v. 55, supl. 3, p. 512-530, 2022. DOI: 10.1111/iej.13677.

TORABINEJAD, M.; UNG, B.; KETTERING, J. D. In vitro bacterial penetration of coronally unsealed endodontically treated teeth. **Journal of Endodontics**, v. 16, n. 12, p. 566-569, 1990. DOI: 10.1016/S0099-2399(07)80198-1.

TSESIS, I.; BLAZER, T.; BEN-IZHACK, G.; TASCHIERI, S.; DEL FABBRO, M.; CORBELLA, S. *et al.* The precision of electronic apex locators in working length determination: a systematic review and meta-

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SCIENTIFIC JOURNAL - RECIMA21 ISSN 2675-6218

analysis of the literature. **Journal of Endodontics**, v. 41, n. 11, p. 1818-1823, 2015.DOI: 10.1016/j.joen.2015.08.012.

VAN DER SLUIS, L. W. M.; VERSLUIS, M.; WU, M. K.; WESSELINK, P. R. Passive ultrasonic irrigation of the root canal: a review of the literature. **International Endodontic Journal**, v. 40, n. 6, p. 415-426, 2007. DOI: 10.1111/j.1365-2591.2007.01243.x.

VIOLICH, D. R.; CHANDLER, N. P. The smear layer in endodontics: a review. **International Endodontic Journal**, v. 43, n. 1, p. 2-15, 2010. DOI: 10.1111/j.1365-2591.2009.01627.x.

YAPP, K. E.; BRENNAN, P.; EKPO, E. Endodontic disease detection: digital periapical radiography versus cone-beam computed tomography-a systematic review. **Journal of Medical Imaging**, v. 8, n. 4, art. 041205, jul. 2021. DOI: 10.1117/1.JMI.8.4.041205.

ZAIA, A. A.; NAKAGAWA, R.; QUADROS, I.; GOMES, B. P. F. A.; FERRAZ, C. C. R.; TEIXEIRA, F. B.; SOUZA-FILHO, F. J. An in vitro evaluation of four materials as barriers to coronal microleakage in root-filled teeth. **International Endodontic Journal**, v. 35, n. 9, p. 729-734, 2002. DOI: 10.1046/j.1365-2591.2002.00562.x.

ZAMPARINI, F.; PRATI, C.; TADDEI, P.; SPINELLI, A.; DI FOGGIA, M.; GANDOLFI, M. G. Chemical-physical properties and bioactivity of new premixed calcium silicate-bioceramic root canal sealers. **International Journal of Molecular Sciences**, v. 23, n. 22, art. 13914, 2022. DOI: 10.3390/ijms232213914.

ZAMPARINI, F.; LENZI, J.; DUNCAN, H. F.; SPINELLI, A.; GANDOLFI, M. G.; PRATI, C. The efficacy of premixed bioceramic sealers versus standard sealers on root canal treatment outcome, extrusion rate and post-obturation pain: a systematic review and meta-analysis. **International Endodontic Journal**, v. 57, p. 1021-1042, 2024. DOI: 10.1111/iej.14069.

ZANDI, H.; PETRONIJEVIC, N.; MDALA, I.; KRISTOFFERSEN, A. K.; ENERSEN, M.; RÔÇAS, I. N. *et al.* Outcome of endodontic retreatment using 2 root canal irrigants and influence of infection on healing as determined by a molecular method: a randomized clinical trial. **Journal of Endodontics**, v. 45, n. 9, p. 1089-1098, 2019. DOI: 10.1016/j.joen.2019.05.021.

ZEHNDER, M. Root canal irrigants. **Journal of Endodontics**, v. 32, n. 5, p. 389-398, 2006. DOI: 10.1016/j.joen.2005.09.014.

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