



MECHANIZED AND ROTARY SYSTEMS IN ROOT CANAL PREPARATION

SISTEMAS MECANIZADOS E ROTATÓRIOS NA PREPARAÇÃO DE CANALIS RADICULARES

SISTEMAS MECANIZADOS Y ROTATORIOS EN LA PREPARACIÓN DE CONDUCTOS RADICULARES

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João Marcos Arruda Dassoler¹, Matheus Prates Santos², Bruna Queiroz da Silva Prates³, Fabio Luis Lopes de Oliveira⁴, Maria Julia Marques Cruz Bogéa⁵, Jennifer Alves Tomas⁶, Paula Loures Valle Lima⁷, Maria Luisa Silva de Melo⁸, Eduardo Loures Filho⁹, Lays Palmeira Veloso Loures¹⁰, Anna Julia Rosa Ferraz¹¹, Isabella Pereira da Silva¹²

ABSTRACT

The biomechanical preparation of the root canal system is a fundamental step for the success of endodontic treatment, as it is directly related to the removal of microorganisms, organic tissues, and dentinal debris. With technological advances, mechanized and rotary nickel-titanium (NiTi) systems have assumed a central role in clinical practice, providing greater efficiency, predictability, and safety when compared to traditional manual instrumentation. The present study aims to review recent scientific literature on mechanized and rotary systems used in root canal preparation, discussing their characteristics, advantages, limitations, and association with irrigation protocols. This is a narrative bibliographic review conducted using the PubMed database, with the selection of articles published over the last five years. The analyzed studies demonstrate that mechanized systems promote better centering of canal preparation, reduction of procedural errors, and optimization of clinical time, especially in curved canals and those with complex anatomy. However, evidence indicates that no instrumentation technique is capable of reaching all root canal surfaces, making the association with chemical irrigants and activation methods indispensable. It is concluded that mechanized and rotary systems represent a significant advance in contemporary endodontics, provided they are used judiciously and integrated into effective irrigation protocols.

Keywords: Endodontics. Root Canal Preparation. Mechanized Instrumentation. Nickel-Titanium.

¹ Professor in Dentistry. Anhanguera Uniderp.

² Graduated in Dentistry. UNIME SALVADOR.

³ Graduated in Dentistry. Centro Universitário do Estado do Pará (CESUPA).

⁴ Undergraduated Student in Dentistry. Universidade Federal do Pará (UFPA).

⁵ Graduated in Dentistry. Universidade Federal do Maranhão (UFMA).

⁶ Graduated in Dentistry. Universidade de Brasília (UnB).

⁷ Professor in Dentistry. UNA de Conselheiro Lafaiete. Universidade Federal de Ouro Preto (UFOP).

⁸ Specialist in Endodontics. Faculdade de Odontologia do Recife (FOR).

⁹ Graduated in Dentistry. Universidade Paulista (UNIP).

¹⁰ Undergraduated Student in Dentistry. Centro Universitário Evangélico de Goianésia (UNIEGO).

¹¹ Undergraduated Student in Dentistry. Centro Universitário de Várzea Grande (UNIVAG).

¹² Graduated in Dentistry. Faculdade Morgana Potrich (FAMP).



RESUMO

O preparo biomecânico do sistema de canais radiculares é uma etapa fundamental para o sucesso do tratamento endodôntico, pois está diretamente relacionado à remoção de microrganismos, tecidos orgânicos e detritos dentinários. Com o avanço tecnológico, os sistemas mecanizados e rotatórios de níquel-titânio (NiTi) passaram a ocupar papel central na prática clínica, proporcionando maior eficiência, previsibilidade e segurança quando comparados à instrumentação manual tradicional. O presente estudo tem como objetivo revisar a literatura científica recente acerca dos sistemas mecanizados e rotatórios utilizados na preparação de canais radiculares, discutindo suas características, vantagens, limitações e associação com protocolos de irrigação. Trata-se de uma revisão bibliográfica narrativa, realizada na base de dados PubMed, com seleção de artigos publicados nos últimos cinco anos. Os estudos analisados demonstram que os sistemas mecanizados promovem melhor centralização do preparo, redução de erros operatórios e otimização do tempo clínico, especialmente em canais curvos e de anatomia complexa. Entretanto, evidências indicam que nenhuma técnica de instrumentação é capaz de atingir todas as superfícies do canal radicular, tornando indispensável a associação com irrigantes químicos e métodos de ativação. Conclui-se que os sistemas mecanizados e rotatórios representam um avanço significativo na endodontia contemporânea, desde que utilizados de forma criteriosa e integrados a protocolos eficazes de irrigação.

Palavras-chave: Endodontia. Preparo do Canal Radicular. Instrumentação Mecanizada. Níquel-Titânio.

RESUMEN

La preparación biomecánica del sistema de conductos radiculares es una etapa fundamental para el éxito del tratamiento endodóntico, ya que está directamente relacionada con la eliminación de microorganismos, tejidos orgánicos y detritos dentinarios. Con los avances tecnológicos, los sistemas mecanizados y rotatorios de níquel-titanio (NiTi) han asumido un papel central en la práctica clínica, proporcionando mayor eficiencia, previsibilidad y seguridad en comparación con la instrumentación manual tradicional. El presente estudio tiene como objetivo revisar la literatura científica reciente sobre los sistemas mecanizados y rotatorios utilizados en la preparación de conductos radiculares, discutiendo sus características, ventajas, limitaciones y su asociación con los protocolos de irrigación. Se trata de una revisión bibliográfica narrativa realizada en la base de datos PubMed, con la selección de artículos publicados en los últimos cinco años. Los estudios analizados demuestran que los sistemas mecanizados promueven una mejor centralización del preparado, la reducción de errores operativos y la optimización del tiempo clínico, especialmente en conductos curvos y de anatomía compleja. No obstante, la evidencia indica que ninguna técnica de instrumentación es capaz de alcanzar todas las superficies del conducto radicular, lo que hace indispensable su asociación con irrigantes químicos y métodos de activación. Se concluye que los sistemas mecanizados y rotatorios representan un avance significativo en la endodoncia contemporánea, siempre que se utilicen de manera criteriosa e integrados a protocolos eficaces de irrigación.

Palabras clave: Endodoncia. Preparación del Conducto Radicular. Instrumentación Mecanizada. Níquel-Titanio.



1 INTRODUCTION

The success of endodontic treatment is intrinsically linked to the effective disinfection of the root canal system, achieved through rigorous biomechanical preparation. This process involves modeling the canal space while simultaneously reducing the microbiological burden to allow resolution of periradicular inflammation (Tomson et al., 2025). Historically, this task was performed exclusively with stainless steel hand instruments; however, technological evolution has introduced mechanized systems that have transformed clinical practice.

The introduction of nickel-titanium (NiTi) files represented a significant advance, focusing on improvements in metallurgical properties and the design of turns, which facilitates the negotiation of complex anatomies and reduces operative time (Tomson et al., 2025; Huang et al., 2021). Despite these innovations, anatomical complexity—including isthmuses, lateral canals, and severe curvatures—remains a challenge, as isolated mechanical instrumentation is not able to touch all dentin walls, requiring synergistic integration with chemical irrigation protocols (Gomes et al., 2023; Boutsoukis et al., 2022). The present study seeks to discuss the nuances of these systems and their effectiveness in contemporary preparation.

2 METHODOLOGY

The present study is characterized as a narrative literature review, developed with the objective of synthesizing and analyzing the most recent scientific evidence related to mechanized and rotating systems in the preparation of root canals. The search was carried out in the PubMed database, using the descriptors "Root Channel Preparation", "Endodontics" and "Methods", combined by means of the Boolean operators AND and OR, according to the terminology of Medical Subject Headings (MeSH). Articles published in the last five years, available in full and written in English, that directly addressed the theme of instrumentation and biomechanics were included. Studies that did not have a direct relationship with the central theme, duplicate publications, and articles that did not address technological innovations in rotating or mechanized systems were excluded. The selection of studies was conducted in two stages: screening of titles and abstracts, followed by the evaluation of full texts to confirm relevance. The information extracted was organized in a descriptive way to compose the body of the work.



3 RESULTS AND DISCUSSION

The transition from manual instrumentation to NiTi's rotary and reciprocating systems allowed for more centralized preparation and less susceptible to procedural errors, such as steps or apical transports. Advances in metallurgy, specifically the heat treatment of NiTi, have given instruments greater flexibility and resistance to cyclic fatigue, allowing the management of narrow, curved channels with greater safety (Tomson et al., 2025). The effectiveness of therapy depends on the operator's ability to transform a difficult canal into an easier-to-manage space through initial negotiation and cervical enlargement strategies (Tomson et al., 2025; Huang et al., 2021).

The development of nickel-titanium (NiTi) files demonstrates an evolution in relation to stainless steel files, as the latter have less flexibility, making it difficult to access narrower and more curved channels, which can increase the risk of deviations and steps (Tomson et al., 2025; Huang et al., 2021). Unlike NiTi limes, especially those exposed to heat treatments, they have greater flexibility; in this way, it is possible to promote a more centralized preparation (Tomson et al., 2025). Mechanized NiTi systems, rotary or reproccating, enable more effective and standardized instrumentation (Boutsioukis et al., 2022). However, despite the advantages, no file system, manual or mechanized, can completely clean the canals; it is necessary to combine with irrigation and chemical activation for the biofilm to be removed (Gomes et al., 2023; Valizadeh et al., 2024).

However, there is a consensus that mechanical instrumentation leaves untouched areas, where bacterial biofilms can persist (Gomes et al., 2023). For this reason, the literature highlights that mechanized systems must be accompanied by auxiliary irrigation methods. The use of substances such as sodium hypochlorite (NaOCl) in varying concentrations is essential for the dissolution of organic tissue and elimination of pathogens (Cai et al., 2023). In addition, irrigant activation—whether by ultrasonic (PUI), sonic, or laser (SWEEPS) methods—has demonstrated superiority in cleaning areas where rotary files do not reach, such as the apical third and anatomical branches (Usta et al., 2024; Valizadeh et al., 2024).

It is possible to analyze that instrumentation has come to be understood as a means of providing access and a way for irrigators to act effectively, and not as the main way to disinfect root canals. Research shows that, despite the instrumentation system used, a good part of the canal is untouched after mechanical preparation, especially in more complex regions, which contributes to the persistence of biofilm in the canals



(Gomes et al., 2023; Boutsoukis et al., 2022). It is possible to analyze that a successful endodontic treatment is intrinsically linked to biomechanical preparation, the use of sodium hypochlorite, and auxiliary methods of irrigant activation, always respecting the complexity of the canal, the evaluation of the difficulty of the case, and the stage of infection (Tomson et al., 2025; Huang et al., 2021; Valizadeh et al., 2024).

The limitation of the instrumentation process of the root canal system is directly related to the anatomical complexity of these systems, which varyably present irregularities, isthmuses and branches that cannot be accessed by endodontic instruments, regardless of the file system or the technique employed. Studies show that limes should be understood only as a resource for accessing and modeling root canals, with the aim of facilitating the action of the chemical disinfection process, especially sodium hypochlorite, whose antimicrobial efficacy depends not only on its concentration, but also on its constant renewal and activation inside the root canals (Cai et al., 2023; Boutsoukis; Arias-Moliz, 2022). In this context, irrigation activation techniques, such as ultrasonic activation, sonic activation, and laser-based techniques, demonstrate greater efficiency in the removal of bacterial biofilm and dentin debris in hard-to-reach areas of the root canal system, reinforcing that biomechanical preparation associated with effective irrigation protocols must be carried out in an integrated manner for the success of endodontic treatment and to reduce the need for reinterventions (Usta; Erdem; Gündoğar, 2024; Valizadeh et al., 2024).

The evaluation of the difficulty of the clinical case, based on the root anatomy and the severity of the infection, is a determining factor for the choice of the appropriate instrumentation system (Huang et al., 2021). Contemporary systems that use reciprocating movements have gained prominence for their simplicity and efficiency in reducing apically extruded debris compared to continuous rotational systems, although both present satisfactory clinical results when applied correctly (Boutsoukis et al., 2022; Valizadeh et al., 2024).

4 CONCLUSION

Based on the literature analyzed, it is concluded that mechanized and rotating nickel-titanium systems constitute a relevant evolution in the biomechanical preparation of root canals, providing greater efficiency, safety and clinical predictability when compared to conventional manual instruments. Advances in the design and heat



treatment of these instruments have allowed better adaptation to the anatomical complexities of the root canal system, reducing the incidence of operative failures and optimizing work time.

However, it is evident that mechanical instrumentation alone is not sufficient to promote complete cleaning and disinfection of the canal system, since areas such as isthmuses, lateral branches, and the apical third often remain untouched. Thus, the association with effective irrigating solutions, such as sodium hypochlorite, as well as with methods of activating the irrigant, is essential for the success of endodontic treatment.

Thus, the choice of the instrumentation system must consider the complexity of the clinical case, the operator's experience, and the integration with appropriate irrigation and activation protocols, reinforcing that endodontic success is directly related to an integrated biomechanical and chemical approach based on scientific evidence.

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