

A Clinical Study Evaluating the Postoperative Analgesia Following Continuous and Reciprocating Motion Amongst Three Rotary File Systems: An Original Research Study

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Abstract

Aim: This study aims to evaluate the postoperative analgesia following continuous and reciprocating motion amongst three rotary file systems.

Materials and Methods: The study evaluated postoperative analgesia in 60 patients (20-45 years old) undergoing root canal treatment due to moderate-to-severe pain from symptomatic irreversible pulpitis or necrotic pulp. The treatment involved local anaesthesia, rubber dam isolation, and conventional root canal preparation, with the working length confirmed via radiographic and electronic methods. Participants were divided into three groups based on rotary file systems: Group 1 used continuous multi-file systems (ProTaper Gold), Group 2 used continuous single-file systems (OneShape), and Group 3 utilized reciprocating single-file systems (WaveOne Gold). All groups followed a uniform irrigation protocol. Postoperative pain was assessed at 6, 12, and 24 hours using a Visual Analog Scale (VAS), and patients reported analgesic consumption (Ibuprofen 400 mg) if needed. The study aimed to compare the effectiveness of postoperative analgesic management between different rotary file systems, enhancing understanding of pain management in endodontics.

Statistical Analysis and Results: Participants were divided into three groups based on rotary file systems used: - Group 1 (ProTaper Gold, n=20): Pain scores at 6, 12, and 24 hours were 2.05 ± 2.07 , 1.37 ± 2.11 , and 0.47 ± 1.09 , respectively, indicating significant pain reduction over time. - Group 2 (OneShape, n=20): Pain scores were 2.04 ± 2.09 at 6 hours, decreasing to 1.30 ± 2.15 at 12 hours and 0.45 ± 1.05 at 24 hours, showing a similar trend in pain relief. - Group 3 (WaveOne Gold, n=20): This group reported lower initial pain scores of 0.75 ± 0.89 at 6 hours, with only 0.20 ± 0.35 at 12 hours and no pain (0.00) at 24 hours, highlighting the system's effectiveness in pain management. A one-way ANOVA analysis provided a comprehensive comparison of the analgesic effectiveness of the different rotary file systems, demonstrating significant findings clearly detailed in the study's tables.

Conclusion: The study concluded that all three rotary systems reduced postoperative pain, with WaveOne Gold showing a slightly greater analgesic effect. This suggests WaveOne Gold may offer unique benefits worth further investigation.

Keywords: Dental Caries, Biomechanical Preparation, Rotary File Systems, Postoperative Analgesia

Introduction

Dental caries, commonly known as tooth decay, is a significant oral health issue that, if not addressed promptly, can escalate into severe complications, including serious infections that affect the tooth's pulp. This situation often necessitates a root canal treatment, a prevalent endodontic procedure aimed at salvaging the affected tooth. During the root canal process, the dentist will remove the infected nerve tissue from the tooth's interior. This meticulous procedure involves several critical steps. Initially, the dentist disinfects the inner canals to eliminate any lingering bacteria and then seals the tooth to preserve its structure and functionality, thereby preventing the need for extraction.^{1,2} The progression of dental decay is typically the result of bacterial activity that breaks down both the enamel and the underlying dentin, ultimately reaching the soft pulp, which houses nerves and blood vessels. As this process unfolds, individuals

may experience symptoms indicative of irreversible pulp damage, including acute tooth pain, heightened sensitivity to hot or cold stimuli, and swelling in the gums surrounding the affected tooth.^{3,4} Dentists can assess the severity of decay through comprehensive clinical examinations and radiographic analysis using X-rays, which reveal the extent of infection and damage. Once the diagnosis is made, the root canal procedure is initiated. The first step involves anesthetizing the area surrounding the tooth to ensure patient comfort. Following this, a dental dam is employed to isolate the tooth, keeping it dry and free from saliva contamination. An access opening is then created in the crown of the tooth to allow direct access to the decayed pulp tissue.^{5,6} After the decayed pulp is removed, the dentist will thoroughly clean and shape the root canals to prepare them for filling. For the filling, a rubber-like material called gutta-percha is used, which occupies the empty canals and provides a

seal against future bacterial invasion. After this, the tooth is typically restored with a crown or permanent filling, particularly in the case of posterior teeth, to reinforce its structure and provide protection against fracture. Root canal treatments boast a high success rate in preserving natural teeth, with modern advancements in technology significantly improving the efficiency of the procedure.^{7,8} Techniques such as rotary files and microscopic imaging have revolutionized endodontic treatment, enhancing both the speed and precision of the process. Particularly, back teeth, which are subjected to more significant forces during chewing, necessitate the placement of crowns afterward to prevent potential breakage. Biomechanical preparation (BMP) utilizing a rotary file system represents a considerable advancement in root canal treatment. This approach employs flexible nickel-titanium instruments powered by an electric motor to clean and shape the root canal more efficiently than traditional hand filing. This method offers several advantages, such as better maintenance of canal curvature and more effective removal of infected tissue.⁹ The clinical steps involved in rotary BMP include accessing the pulp chamber, accurately determining the canal's working length, creating a glide path to facilitate instrument navigation, and performing coronal pre-enlargement. This pre-enlargement helps minimize stress on subsequent files, making the overall cleaning and shaping process more effective and reducing the risk of file fracture.¹⁰ Notable rotary systems used in modern endodontics include ProTaper Next (PTN) and WaveOne Gold. The PTN system operates in a continuous rotating motion with an innovative off-centered design that enhances cutting efficiency, while WaveOne Gold utilizes a reciprocating motion to simplify the shaping process. Both systems incorporate advanced materials, such as M-Wire NiTi alloy for PTN and gold heat-treated NiTi wire for WaveOne Gold, which promote excellent flexibility and improved resistance to cyclic fatigue.¹¹ Postoperative pain is generally manageable, with most patients noticing a significant decrease in discomfort within the first 24 to 48 hours following treatment, independent of whether rotary continuous or reciprocating systems were utilized. Although initial use of multi-file rotary systems may lead to a slight increase in debris extrusion, overall patient comfort and recovery are typically improved after the instrumentation phase. This enhanced comfort further underscores the importance of utilizing advanced techniques in contemporary endodontic practice.¹² This study aimed to evaluate the postoperative analgesia following continuous and reciprocating motion amongst three Rotary file systems.

Materials and Methods

The study examined the efficacy of postoperative analgesia in patients undergoing root canal treatment, involving a total of 60 participants aged between 20 and 45 years. The cohort included both males and females who reported experiencing moderate-to-severe

spontaneous pain or pain during biting in right mandibular first premolar. This discomfort was linked to symptomatic irreversible pulpitis or necrotic pulp condition that necessitated therapeutic intervention through root canal treatment. To qualify for the study, participants were required to meet specific inclusion criteria. They needed to present cases that required primary root canal treatment on either single- or multi-rooted permanent teeth, with a particular focus on mandibular molars and premolars due to their clinical significance in endodontics. It was essential for patients to show a positive response during pulp sensibility tests, such as cold tests, particularly in cases considered vital. Additionally, their pain levels had to fall within a predetermined range on standardized pain assessment scales, such as the Numerical Rating Scale (NRS) or Visual Analog Scale (VAS), allowing for a uniform measure across the study. Participants were also required to be in good general health, categorized as ASA I or II, indicating they had no significant systemic health issues. The exclusion criteria were stringent, aimed at ensuring the integrity of the results. Pregnant or lactating females were excluded to prevent any potential risks to developing fetuses or infants. Individuals with known systemic diseases, chronic pain syndromes, or documented allergies to non-steroidal anti-inflammatory drugs (NSAIDs) and analgesics were also removed from consideration. Additionally, patients who had taken any form of analgesics, anti-inflammatory medications, or antibiotics within a 48 to 72 hour window leading up to the treatment were excluded, as these could impact pain perception and healing. Teeth that had previously undergone root canal therapy, displayed severe dental mobility, had periodontal pocket depths exceeding 5 mm, or showed signs of internal or external root resorption were not included in the study. Non-restorable teeth, as well as those with open apices or fractures, were also excluded to maintain focus on teeth amenable to the required treatment protocols. Prior to any treatment, each patient underwent a comprehensive clinical examination along with periapical radiographs to establish a clear diagnostic foundation. Initial pain levels were carefully recorded using a VAS scale ranging from 0 to 10, where patients could characterize their pain intensity. Following this assessment, standardized local anaesthesia was systematically administered to ensure comfort throughout the procedure. The clinical treatment process involved several key steps. Rubber dam isolation was employed to maintain a sterile field, followed by conservative coronal access to create an access opening. The working length of the root canal was confirmed using an electronic apex locator in conjunction with radiographic confirmation to enhance precision. A glide path was subsequently created using standard K-files to prepare the canal system for the rotary instrumentation. The study distinguished three groups based on the rotary file systems applied during root canal treatment: Group 1 utilized continuous rotary multi-file systems such as ProTaper Gold, Group 2

employed continuous rotary single-file systems like OneShape, and Group 3 focused on reciprocating motion single-file systems, specifically WaveOne Gold. Each group received a standardized irrigation protocol, ensuring consistent volume and concentration of solutions such as 5.25% sodium hypochlorite (NaOCl) and 17% ethylenediaminetetraacetic acid (EDTA) between file changes, which facilitated effective cleaning and disinfection of the canal spaces. Obturation was performed in a single treatment visit utilizing gutta-percha along with an epoxy resin sealer, after which the access cavity was sealed with a temporary restoration to prevent contamination and maintain patient comfort. Postoperative evaluations were crucial to assessing the study's primary outcomes. Pain levels were meticulously monitored at intervals of 6, 12, and 24 hours following the root canal treatment using the VAS scale to quantify discomfort. Patients were also asked to report the number of analgesic tablets, specifically Ibuprofen 400 mg, consumed if they experienced significant pain, providing insights into the effectiveness of the analgesia provided. The overall aim of the study was to rigorously evaluate the comparative effectiveness of postoperative analgesic management following the application of continuous and reciprocating motion rotary file systems, thereby contributing valuable data to the field of endodontics regarding pain management strategies during and after root canal treatment.

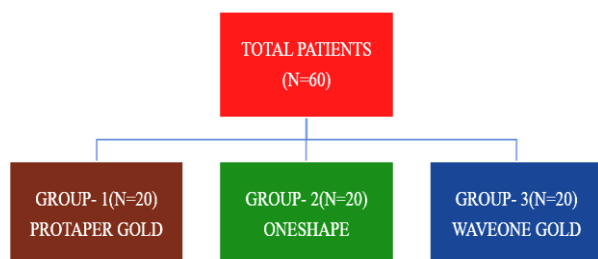
Statistical Analysis

SPSS Software Version 31.0 is a robust statistical analysis tool meticulously crafted for conducting comprehensive data analysis in the social sciences. For our research, we employed the chi-square test, a statistical method well-suited for assessing the significance of differences in proportions among various groups within our dataset. This approach allowed us to rigorously evaluate our findings and draw meaningful conclusions from the data we collected.

Results

The comprehensive study aimed to rigorously investigate the effectiveness of postoperative analgesia among patients who had undergone root canal treatment. It specifically focused on a carefully curated cohort of 60 individuals; all aged between 20 and 45 years, thereby targeting a demographic that frequently seeks dental care. This population included an equal distribution of male and female participants, all of whom reported experiencing moderate to severe spontaneous pain or discomfort, particularly while biting. The discomfort was localized mainly in the area of the right mandibular first premolar, an anatomical region frequently subject to endodontic procedures. To systematically evaluate the analgesic outcomes post-treatment, participants were categorized into three distinct groups, each based on the specific rotary file systems utilized during their root canal procedures: - Group 1 (n=20): This group underwent treatment

utilizing a continuous rotary multi-file system known as ProTaper Gold. The effectiveness of postoperative analgesia in this cohort was assessed meticulously at three critical time intervals: 6 hours, 12 hours, and 24 hours following the completion of the root canal treatment. The statistical analysis revealed an average pain score of 2.05 ± 2.07 at the 6-hour mark, indicating a moderate level of discomfort experienced by participants at this early stage. At the 12-hour assessment, this score decreased to 1.37 ± 2.11 , reflecting an encouraging trend in pain alleviation. By the 24-hour follow-up, further improvement was noted, as the average pain score dropped to 0.47 ± 1.09 . Such findings suggest a significant and progressive reduction in pain levels over time within this group, affirming the effectiveness of the analgesia protocol employed. - Group 2 (n=20): Participants in this group were treated using a continuous rotary single-file system named OneShape. The evaluation of postoperative analgesia mirrored the methodology applied in Group 1, with assessments occurring at 6, 12, and 24 hours post-treatment. The results demonstrated a mean pain score of 2.04 ± 2.09 at the 6-hour mark, indicative of discomfort levels that were relatively similar to those experienced by Group 1 participants. This score showed a gradual decline, falling to 1.30 ± 2.15 at the 12-hour mark, and further decreasing to 0.45 ± 1.05 by the 24-hour evaluation. These results underscored a comparable trend in the reduction of pain over time, thus reinforcing the effectiveness of the OneShape system in managing postoperative discomfort. - Group 3 (n=20): The final cohort was treated with a reciprocating motion single-file system called WaveOne Gold. Consistent with the assessments of the other two groups, postoperative analgesia was evaluated at the same intervals. Remarkably, the results from this group indicated a notably lower initial pain score, starting with a mean of 0.75 ± 0.89 at the 6-hour mark. This represented a significant advantage over the previous groups. At the 12-hour assessment, only a slight decrease was observed, with a pain score of 0.20 ± 0.35 . Fascinatingly, by the 24-hour mark, participants reported no pain at all (0.00), highlighting the exceptional effectiveness of the WaveOne Gold system in managing postoperative pain. To further substantiate these findings, a comprehensive analysis was conducted across all three groups utilizing one-way ANOVA, which is elaborately detailed in Table 5 of the study. This statistical approach enabled an in-depth comparison of analgesic effectiveness across the different rotary file systems utilized in the root canal procedures, thereby enhancing our understanding of their relative performance in managing postoperative pain effectively. Overall, the structural organization of the study was thoughtfully designed, with clear categories to facilitate a better comprehension and illustration of these significant findings, which are further supported by accompanying tables that delineate the outcomes of the research.

Table 1: The study has been organized into three distinct categories for better clarity and understanding.**Table 2:** Group-1 (n=20) Patients underwent root canal treatment, and postoperative analgesia was evaluated using the Continuous Rotary Multi-file ProTaper Gold method. Analgesic effectiveness was assessed at 6, 12, and 24 hours, followed by statistical analysis

File system	Mean	SD	P value
Continuous Rotary Multi-file ProTaper Gold	6 hours		
	2.05	2.07	0.67
	12 hours		
	1.37	2.11	0.04*
	24 hours		
	0.47	1.09	0.49
*p<0.05 significant			

Table 3: Group-2 (n=20) Patients underwent root canal treatment, and postoperative analgesia was evaluated using the continuous rotary single-file systems OneShape method. Analgesic effectiveness was assessed at 6, 12, and 24 hours, followed by statistical analysis

File system	Mean	SD	P value
Continuous rotary single-file systems OneShape	6 hours		
	2.04	2.09	0.18
	12 hours		
	1.30	2.15	0.56
	24 hours		
	0.45	1.05	0.01*
*p<0.05 significant			

Table 4: Group-3 (n=20) Patients underwent root canal treatment, and postoperative analgesia was evaluated using the reciprocating motion single-file systems, specifically WaveOne Gold method. Analgesic effectiveness was assessed at 6, 12, and 24 hours, followed by statistical analysis

File system	Mean	SD	P value
Reciprocating motion single-file systems, specifically WaveOne Gold	6 hours		
	0.75	0.89	0.16
	12 hours		
	0.20	0.35	0.02*
	24 hours		
	0.00	0.00	0.00*
*p<0.05 significant			

Table 5: Estimation amongst all studied groups using one-way ANOVA

Variables	Degree of Freedom	Sum of Squares $\sum$	Mean Sum of Squares $m\sum$	F	Level of Sig. (p)
Between Groups	7	2.782	2.824	1.2	0.01*
Within Groups	60	2.630	2.371		—
Cumulative	494.18	65.092	*p<0.05 significant		

Discussion

Wang J et al reviewed in their study that dental caries, more commonly referred to as tooth decay, stands as the primary cause prompting patients to undergo root canal treatment (RCT). This condition progresses through several distinct stages, ultimately necessitating RCT when decay infiltrates the tooth's protective layers. In the initial phase, early-stage cavities are confined to the enamel, the hard outer layer of the tooth, and the underlying dentin, which is softer and more susceptible to decay. At this point, the issue can typically be remedied with simple dental fillings, which restore the tooth's structure and function.^{13,14} Pohl S et al reported in their study that however, if dental caries go untreated, the situation deteriorates. Bacteria can penetrate deeper into the tooth, reaching the pulp chamber that houses the nerves and blood vessels. This invasion leads to pulpitis, a painful inflammation of the pulp characterized by acute discomfort and increased sensitivity to hot or cold stimuli. If this condition remains unaddressed, it can escalate to pulp necrosis, where the pulp tissue becomes dead and infected. This infection may further extend beyond the tooth, potentially resulting in a periapical abscess or a bone infection at the tip of the root, posing significant health risks.^{15,16} Ng YL et al included in their study that the root canal procedure is designed as a means to salvage a compromised tooth by meticulously removing all infected internal tissue. Modern techniques in RCT prioritize minimally invasive approaches to preserve as much of the tooth's structure as possible. The treatment

process usually initiates with the administration of local anaesthesia to ensure comfort. The dentist will then isolate the affected tooth using a rubber dam, which keeps the area dry and free of saliva during the procedure. Once the tooth is isolated, the dentist drills a small access hole to reach the infected pulp chamber. Specialized instruments are employed to meticulously clear out the necrotic nerve tissue, while thorough disinfection of the canals is performed to eliminate bacteria.^{17,18} P PK et al reported in their study that after ensuring that the interior of the tooth is completely clean and dry, the canals are filled with gutta-percha, a biocompatible material, and then sealed to prevent any future bacterial reinfection. To restore the tooth's structural integrity, a permanent filling or a custom crown is placed over the treated tooth, as teeth without pulp may become brittle and more prone to fracture. The biomechanical preparation (BMP) of the root canal is a critical aspect of the procedure. It involves both mechanical instrumentation and chemical irrigation, which work in tandem to effectively remove necrotic tissue and pathogens while shaping the canals for optimal sealing. Advancements in dental technology, particularly the introduction of Nickel-Titanium (NiTi) rotary file systems, have markedly improved the efficacy and efficiency of root canal treatments.^{19,20} Pérez-Higueras JJ et al reviewed in their study that these innovations enhance cutting performance and reduce operator fatigue, making the procedures quicker and more comfortable for patients. Various file systems have been developed, each with unique features tailored to meet diverse clinical demands. For instance, the Protaper Next system utilizes asymmetric rotary motion along with M-Wire technology to increase flexibility and enhance debris removal from the canals.^{21,22} Similar concepts were addressed by recent studies across the world.²³⁻⁴³ Gürlér K et al included in their study that on the other hand, WaveOne Gold employs a reciprocating motion and sophisticated metallurgy, allowing for superior canal shaping with just a single file. Lastly, Reciproc Blue is specifically designed to promote optimal canal centering and efficiency, providing a single-file solution particularly beneficial for navigating curved canals. Clinical studies have shown that most patients report only mild discomfort or none at all following the completion of the root canal procedure, regardless of which file system was used. Pain management approaches typically involve the administration of analgesics, which work similarly across different systems. It is important to note that factors such as the operator's technique, the initial diagnosis, and the extent of the infection play a more crucial role in patient comfort and post-treatment recovery than the specific instruments used during the procedure.^{44,45}

Conclusion

In the context of their study, the authors conducted a clinical investigation aimed at evaluating the effectiveness of postoperative analgesia following the

use of three different rotary file systems in endodontic treatments. Specifically, the study focused on comparing the outcomes of multi-file continuous rotary systems, single-file continuous rotary systems, and single-file reciprocating systems. The results concluded that all three rotary systems were effective in reducing postoperative pain; however, the WaveOne Gold system showed a slightly greater reduction in analgesia compared to the other methods. This suggests that while the use of these rotary systems generally leads to improved postoperative comfort for patients, WaveOne Gold may have specific advantages that warrant further exploration. The authors concluded that additional research is necessary to deepen the understanding of these findings and to further assess the differences in analgesic outcomes among the various rotary file systems.

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