

Reciprocation with different motions: an in vitro comparative study

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Abstract

A new clinical motion, designed to improve the safety and efficiency of NiTi instrumentation, has been proposed and positively evaluated in several studies: the “MIMERACI” technique. In the present study, the aforementioned technique was tested with a single-file reciprocating instrumentation system: EdgeOneR Utopia (Edge Endo, Albuquerque, New Mexico). The aim of the study was to determine whether the MIMERACI technique could reduce instrumentation stress (specifically torsional loads) by analyzing operative torque and comparing it to the traditional pecking motions recommended by manufacturers.

Twenty instruments were randomly divided into two groups of 10 each. Each instrument in both groups was used to instrument one artificial 3D upper molar tooth. All teeth had identical anatomy, and three canals were instrumented to ensure proper visualization. Group 1 instrumented the canals using the MIMERACI technique, while Group 2 used a pecking motion (21) (1–2 mm amplitude) with a series of three pecking strokes. A video camera mounted on a tripod continuously filmed and recorded both the instrument's progression inside the canal and the torque displayed by the motor.

Torque values for both groups were recorded and transferred to an Excel sheet (measured every 1/10 second). Data were statistically analyzed using ANOVA and Tukey's test at a 5% significance level. Group 1 (MIMERACI) demonstrated significantly lower average torque values (mean 0.25 N, SD 0.1) compared to Group 2 (pecking motion), which showed higher values (mean 0.45 N, SD 0.15). The maximum torque peak recorded was 1.4 N for the MIMERACI group and 2.2 N for the pecking motion group.

Keywords: Nickel-titanium, reciprocation, torque

Introduction

The goal of mechanical preparation in endodontics is to achieve well-cleaned and disinfected root canals by removing, ideally, all or the majority of inorganic and organic debris from the endodontic space. This is accomplished by creating an appropriate

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final enlargement and tapered shape, which facilitates irrigation and obturation procedures, making them more efficient. This objective should be attained in a predictable and safe manner, minimizing postoperative discomfort for patients by employing techniques that reduce the risk of extruding canal contents beyond the apex during the process (1-6).

To date, nickel-titanium (NiTi) rotary instrumentation has become the gold standard for canal preparation due to the favorable properties of the alloy and advancements in manufacturing processes. Over the last few decades, NiTi instruments have evolved significantly from their initial designs and materials. Innovative designs and new manufacturing techniques have been introduced to simplify procedures, reducing the number of instruments required and, consequently, the overall instrumentation time (7-10). Numerous new instruments and motors using reciprocating motion (instead of continuous rotation) have been commercialized to enhance clinical performance by improving resistance to breakage and simplifying procedures with single-file techniques. However, these new instruments and motions have been found to be slightly less efficient in cutting and advancing toward the apex. This limitation is partly related to their tip sizes, tapers, and increased rigidity. Additionally, they tend to extrude more debris and/or decrease the quality of clinical debridement (11-17). Since motor motion plays a critical role in determining progression, resistance to breakage, and apical debris extrusion, the clinical motion (how clinicians use an instrument inside the canal) may also have a significant impact. To address this, a new clinical motion, designed to improve the safety and efficiency of NiTi instrumentation, has been proposed and positively evaluated in some studies (18-20): the "MIMERACI" technique. MIMERACI is an acronym that stands for *M* = Manual Insertion, *ME* = Minimal Engagement, *R* = Remove (instrument from the canal), *AC* = And Clean flutes, *I* = Irrigate.

The MIMERACI technique can be used with both continuous rotation and reciprocating motion, as the resulting motion of any reciprocating NiTi file is a form of "non-continuous rotation" at a defined resulting speed. In this study, the MIMERACI technique was tested with a single-file reciprocating instrumentation system: EdgeOneR Utopia (Edge Endo, Albuquerque, New Mexico). The goal of the study was to evaluate whether the MIMERACI technique could reduce instrumentation stress (specifically torsional loads) by analyzing operative torque and comparing it with the traditional pecking motions recommended by manufacturers.

Materials and methods

This study was performed using Edge-ONE R Utopian nickel-titanium reciprocating instruments, size 25. Twenty instruments were randomly divided into two groups of 10 each. To avoid torque variations due to differences in anatomy, instrumentation was conducted in vitro on 3D artificial teeth with identical anatomy. Each instrument shaped only three canals in one 3D upper molar tooth (Orodeka, Jining City, China) to ensure better visualization of the instrument inside the canals, resulting in a total of 30 canals per group. Following the creation of a glide path with a manual k-file size 10, the first group instrumented the canals using the MIMERACI technique, as previously described. Irrigation was performed with distilled water after each step, before reinserting the instrument into the canal. The second group instrumented the canals using a pecking motion (21) with an amplitude of 1-2 mm and a series of three pecking motions before removing the file from the canal. Irrigation was performed after each file. All instruments were used in a reciprocating motion at a speed of 400 rpm, with a maximum torque of 5 N and reciprocating angles of 30°-150°, using a recently commercialized brushless motor (EndoMaster, Perfect Medical Instruments, Shenzhen, China). This motor

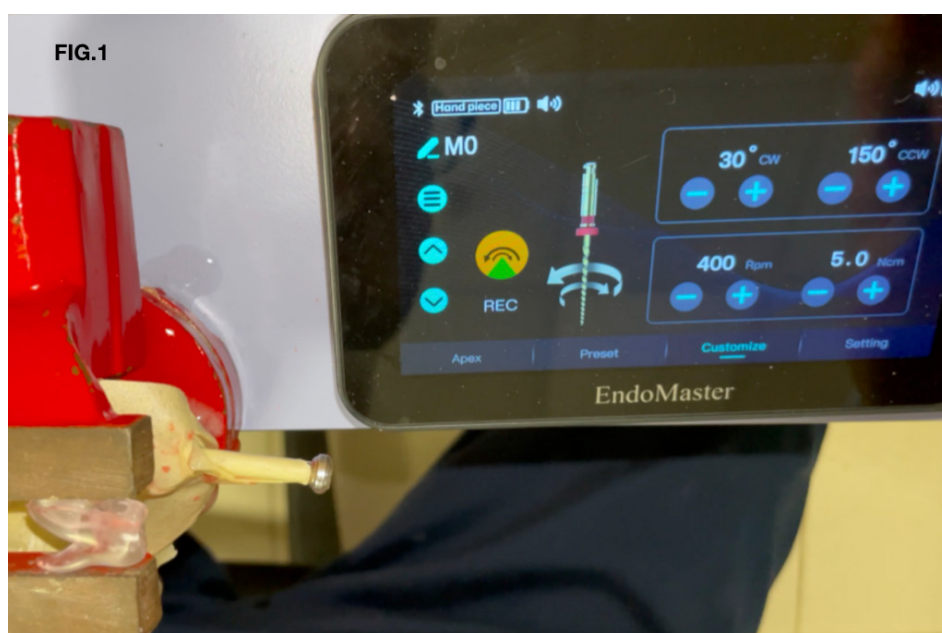


Figure 1. The setting of the test, including the motor, the motion and the 3d tooth



Figure 2. Video recording the torque values during instrument progression inside canal

has a portable handpiece connected via Bluetooth to its base device (Figure 1). The base device features a display for programming motions and real-time visualization of the torque applied by each instrument as it progresses through the canal.

A video camera mounted on a tripod continuously recorded both the instrument's progression inside the canal and the torque displayed by the motor (Figure 2). The recorded footage was later used to analyze torque values every one-tenth of a second during video editing. All torque values for both groups were recorded and transferred to an Excel sheet (torque every 1/10 second) and visualized in graphical form (Figs. 3-4).

All data were statistically analyzed using ANOVA and Tukey's test at a 5% significance level.

Results

In Group 1 (MIMERACI), a significantly lower average torque value was recorded (mean 0.25 N, SD 0.1) compared to Group 2 (pecking), which showed a higher value (mean 0.45 N, SD 0.15). The maximum peak torque for the MIMERACI group was 1.4 N, while it reached 2.2 N in the pecking motion group.

The average instrumentation time per canal was slightly higher for Group 1 (mean: 24 seconds) compared to

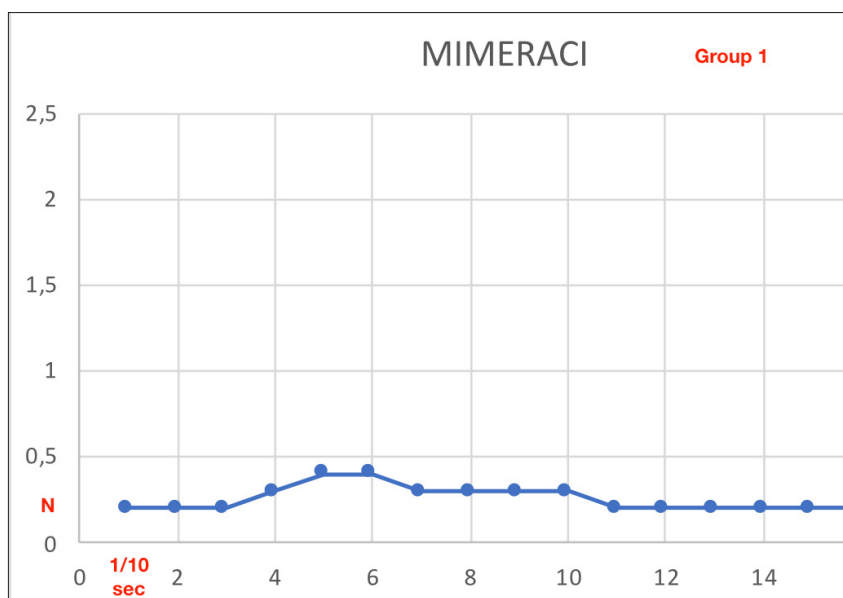


Figure 3. Graph showing operative torque values using the MIMERACi technique (Group 1)

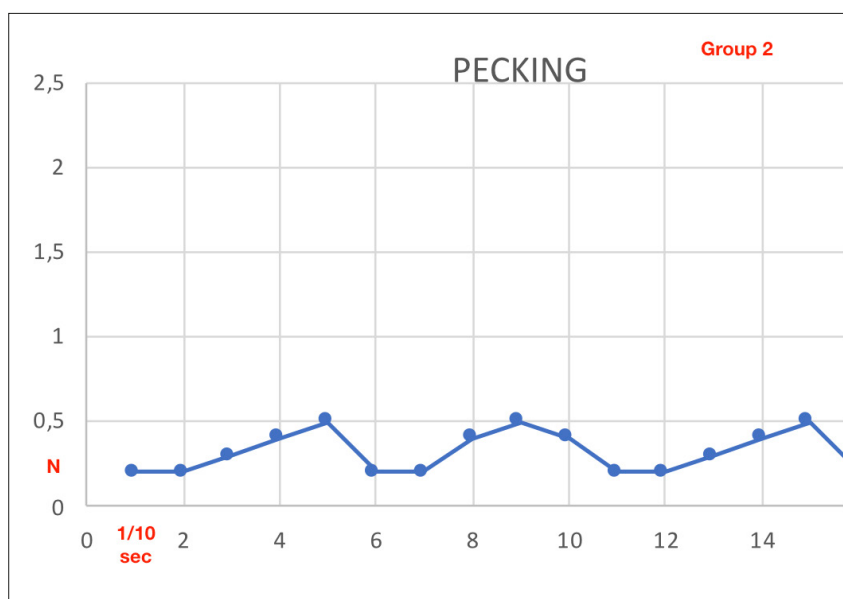


Figure 4. Graph showing operative torque values using pecking technique (Group2)

Group 2 (mean: 18 seconds). However, excluding irrigation, the actual instrumentation time was similar for both groups (14 seconds each).

In both groups, no tested instrument showed signs of deformation, and no fractures were recorded.

Discussion

The core concept of the MIMERACI technique is to progress slowly (a maximum of 1 mm or 1 second at a time) within the canal. After each 1 mm or 1-second progression, the instrument is removed from the canal, the flutes are cleaned, and irrigation is performed. This ensures that the instrument maintains minimal engagement, generates less debris, and that any debris trapped in the flutes is predictably removed using a sponge. Additionally, the frequent irrigation helps to eliminate debris that may have been pushed apically or left in the coronal or middle parts of the canal before the instrument reaches the apex. This is particularly important in reciprocating techniques, where the non-cutting (disengaging) angle tends to push debris apically. By reducing the progression and the time the instrument remains in the canal, less debris is generated, and the risk of apical extrusion is minimized. Moreover, if a significant amount of debris is generated, it can become trapped in the flutes, reducing the cutting efficiency and increasing the torque required for the reciprocating instrument to progress. Manual insertion allows for controlled engagement, as the instrument will cut and progress only 1 mm deeper per activation. The MIMERACI approach involves a single step that is repeated multiple times until the instrument reaches the working length. This method aims to reduce metal stress and enhance root canal debridement.

In previous studies (10–17), reciprocating single-file techniques (mostly involving Reciproc and WaveOne instruments) were found to exhibit greater resistance to in vitro breakage but were associated with a more significant inflammatory response and post-operative

pain compared to rotary nickel-titanium crown-down instrumentation techniques. This difference is primarily attributed to the fact that single-file techniques typically use a relatively rigid instrument with a larger taper (usually 07/08 taper, size 25). Since these instruments are often employed without preliminary coronal enlargement, their progression toward the apex results in greater flute engagement, necessitating increased force (higher torque) to advance. In many cases, achieving the working length with these instruments involves applying apical force, which can act as a piston to propel debris through a patent apical foramen. This increases the risk of iatrogenic errors, such as canal transportation or blockage.

To address these limitations, more flexible and resistant NiTi reciprocating instruments have recently been developed, allowing safer apical progression in complex curvatures. However, using a more ductile and softer alloy can reduce cutting efficiency and may result in flute deformation if the instrument is subjected to excessive stress. These issues can make the instrumentation process slower and more expensive, as deformed instruments must be discarded and replaced. EdgeOneR Utopia is a new reciprocating instrument made with a proprietary heat treatment that significantly enhances flexibility and resistance to mechanical stress (both flexural and torsional) while maintaining good cutting efficiency (22–23). Despite these favorable characteristics, the alloy's flexibility and ductility may benefit from a dedicated technique that maximizes advantages while keeping disadvantages clinically negligible.

In the present study, the MIMERACI technique resulted in significantly lower torsional loads (as measured by operative torque) and lower peak torque values. None of the tested instruments showed signs of deformation, and no fractures were recorded.

Evaluating the precise clinical impact of the advantages provided by the MIMERACI approach remains challeng-

ing. However, a technique that produces less debris and Results in less post-operative pain is likely to be preferred over traditional approaches involving pecking motions. Another notable advantage is the reduction in operative torque, which further minimizes metal stress and the risk of intracanal separation. Additionally, it may decrease the likelihood of microcracks in dentin. The MIMERACI technique also offers a more predictable approach that is less reliant on the operator's tactile awareness during pecking motions, which can vary significantly in terms of amplitude, depth, and frequency. The controlled and consistent progression of this technique allows clinicians to advance the instrument minimally (by only 1 mm) in a safer and more controlled manner when necessary. This is particularly beneficial when instrumenting complex apical curvatures, where file tip dimensions and taper may create a taper-lock effect.

Based on the Results of this study, it can be concluded that, despite the favorable characteristics of modern instruments, clinicians may benefit from adopting a dedicated handling technique, such as MIMERACI, to improve the safety and efficacy of the root canal shaping procedure.

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