The effect of NiTi rotary systems activated with …. Vol.18 : No.2 : 28/12/ 2022
DOI: https://doi.org/ 10.32828/mdj.v18i2.981

MDJ

The effect of NiTi rotary systems activated with different kinematics on canal transportation and centring ability. A concise review

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Abstract

One of the most crucial steps in endodontic therapy is canal preparation. The root canal should have a flare shape from apex to coronal areas, with the apical foramen maintained in its original relationship to the surrounding tissues and root surface. Anatomical complexity causes most endodontic problems. Ledges, zips, perforations, and root canal transportation are more probable in curved canals because all preparation procedures and instruments deviate the prepared canal away from its initial axis. The type of kinematics employed, including continuous rotation, reciprocation movement, and adaptive movement, as well as root canal anatomy and instrument design features, all have been found as factors that may affect canal transportation. There are controversial results concerning the influence of kinematic on canal transportation. These results may be attributed to a lack of standardisation in file characteristics such as taper, size, and cross-section. Studies started using the same system under continuous rotation and reciprocation movement or adaptive motion to overcome these issues. This article reviews the effects of movement types on canal transportation and centring ability when all other variables are the same.

Keywords: kinematics; Root canal preparation; Transportation

1. Introduction

The success of root canal therapy depends on a number of parameters, with chemomechanical debridement being the most important. Preparation of the canal is one of the most crucial phases [1]. All following procedures, including irrigation and obturation, depend on how well the root canal was disinfected and shaped [1]. The root canal should have a flare

shape from apical to coronal regions, with the apical foramen remaining in its original spatial relationship to the surrounding tissues and the root surface, without changing the canal's original curvature [2]. To reduce canal instrumentation mishaps, widening the canal while retaining the original anatomy is necessary to overcome the majority of issues encountered during endodontic therapy of complex tooth anatomy [3]. When working with curved canals, preparation procedures and instruments have the potential to divert the prepared canal away from its initial axis; errors like ledges, zips, perforations, and root canal transportation may be more likely to occur [4-6]. Canal transportation increases the likelihood of blockage, perforation, and ledge formation, weakening the root structure and jeopardising root canal obturation, leading to a poor apical seal [7].

Many contributing factors, including root canal anatomy, instrument design feature (especially tip design), endodontic system speed, the metallurgy of root canal instruments, and the type of kinematics being used, such as rotation, reciprocation, and adaptive movement, have all been found to have an impact on canal transportation [1, 8-10]. For these reasons, new kinematics have been developed to keep the canal's original shape while improving the canal's centralisation [11].

2. Review search strategy

Three electronic databases were used (PubMed,Google Scholar and Scopus). The research involved dental publications and specified journals for endodontics. Only articles with English language were selected. Inclusion criteria were included studies that investigate the pure effect of different movements on canal transportation and centering ability regardless of the measurement method used. After accomplishment of search, the titles were screened and only papers that not meet the inclusion criteria were removed. Then articles were reviewed by authors.

Many studies regarding the effect of Nickle-Titanium (NiTi) instruments movement on canal transportation revealed no statistically significant differences in the apical third according to transport value between continuous and alternative rotation kinematics [12-15]. However, other studies have shown that alternative motion systems have higher transport values than continuous rotation systems [16-19]. Other studies have shown that continuous rotation systems have higher transport values than alternate motion systems [20-22].

All these studies lack standardisation due to differences in characteristic features of files such as taper, size, cross-section, alloy, single file concept or multiple file systems, so they failed to determine the best approach to use regarding the type of movement. Both Naseri et al., & Pedullà et al., stated that to overcome these issues and to allow studying the pure effect of movement patterns on apical transportation without interference from factors such as alloy type, file design, and instrumentation size, by using the same system under both continuous rotation and reciprocation motion or adaptive motion [23, 24]. This article aimed to review studies on the influence of using rotary NiTi systems designed for continuous rotation when operated in reciproc motion and vice-versa on canal transportation and centring ability.

3. An overview of Studies

Yared, in 2008 [25], was the first to use a file in two different motions. He conducted a study in which entire canal instrumentation was done by using only the F2 ProTaper file,

employing reciproc motion with varying angles of rotation in the counter-clockwise and clockwise directions, allowing for instrument progression with minimal apical pressure. This fundamental research represented a breakthrough in the kinematics of endodontic instruments.

Years later, Franco et al., Investigated the Shaping Ability of NiTi files (FlexMaster) either in continuous rotation or in reciproc (60° clockwise , 40° counter-clockwise) movement in endo training blocks. They established that compared to the reciproc motion group, the continuous rotation group produced the greatest canal enlargement in the most apical part of the canal. In continuous rotation, the instruments make a 360° turn in every cycle, while in the same timespan with reciproc motion, the instruments make a 20° turn, which means a higher number of rotations occur in continuous rotation, which results in significant enlargement [7]. Hwang et al., 2014 evaluated the shaping ability of Mtwo files used in both continuous rotation and reciprocation movement. They revealed that the transportation value of the Mtwo in the continuous rotation group was significantly greater than that of the reciprocation motion group at the cervical and apical levels [26].

In the same year, Wu & Zhu examined the impact of a single twisted file instrument in three different operating modes on the instrumentation of curved root canals in molars teeth: continuous rotation -500 revolutions per minute (rpm), reciprocation movement -300, and continuous rotation -300 rpm. They discovered that the " reciprocation movement 300" group had the highest mean of transportation values in every group at 3.0 mm from the apical end, and this difference was statistically significant, as well as a significant difference in the centring ratio between the two groups " reciprocation movement -300" and " continuous rotation -300" [27]. These discrepancies were most likely noticed because, at this point of the curvature, critical alterations in the relationship between flexibility and diameter caused the instrument to be placed under more stress [28]. Various factors explain why the reciprocal motor and single twisted file do not get the desired results. Firstly, reciprocating motor speed is limited to 300 rpm, which is lower than the required single twisted file instrument speed of 500 rpm. This discrepancy could account for some of the twisted file instruments' performance. Secondly, twisted file instruments are intended for 360° rotation, while clockwise and counter-clockwise rotation in the reciprocation movement may necessitate a specific helical design, like that of the Reciprocal instruments, which are designed for this purpose. The various cross-sectional designs could be one probable explanation; the S-shaped cross-section of the Reciproc instruments provides two blades for cutting, whereas the twisted file instrument has an equilateral triangular cross-section. Also, "zero" apical pressure should be used with twisted file because it will almost automatically progress into the root canal. However, "slight" but not "zero" apical pressure should be used with reciprocation movement, which seems inconsistent and may change the results [27].

In addition to that, Arslan et al. investigated the apical transportation of ProGlider and ProTaper Next utilising three different types of movement, 150° clockwise 30° counter-clockwise, 270° clockwise 30° counter-clockwise and 360° clockwise (continuous rotation) in 36 simulated curved resin blocks. They showed that both reciprocation movements resulted in lower transportation at 1 and 2mm levels than continuous rotation [29]. Pedullà et al., 2016 evaluated the shaping

ability of Twisted File Adaptive and Mtwo files in curved root canals activated by continuous rotation or adaptive movement in 32 human mandibular molars with severe curvature. Two separate mesial canals were chosen for further examination using micro-computed tomography adaptive movement improved significantly in centring ratio but not canal transportation compared with continuous rotation for both instruments (Twisted File Adaptive & Mtwo) in the middle and coronal third [24]. For both instruments and movements, there were no differences in canal transportation or centring ability in the apical portion of the canal. In the apical part, there was no statistically significant difference between groups, which could be explained by the fact that both Mtwo and Twisted File Adaptive instruments have a modified safety tip that does not cut, standardisation of the file's tip size, and the small file dimensions, which cause Twisted File Adaptive files to be only slightly more flexible than Mtwo files in the first millimetres from the tips of the files. [24-30].

Moreover, Naseri et al. used cone beam computed tomography analysis to compare the apical transportation and centring capabilities of single file instruments, WaveOne primary, when utilised once in continuous rotation and once in reciprocation motion to prepare the curved mesiobuccal root canals of human mandibular molars. This was done to determine which technique was superior. They found no significant difference between the two tested groups regarding apical transportation and the centring ratio at 1, 3, and 5 mm from the root apex. When all other influencing parameters are the same, they found that the movement pattern may not impact apical transportation and centring capabilities of single-file systems [23].

Additionally, a none significant difference in canal transportation was found with Twisted File Adaptive instruments used in different kinematics as follows: Adaptive movement, 150° clockwise –30° counter-clockwise, 210° clockwise –30° counter-clockwise, 270° clockwise –30° counter-clockwise, and continuous rotation, in shaping the mesiobuccal root canals of extracted human mandibular molars at the three examined levels (1, 4, and 7 mm from the apical foramen) [31]. The superior flexibility of TF adaptive instruments might result in a non-significance in canal transportation with different movement kinematics [31, 32].

In 2017 González-Chapela et al., [33] compared alternating versus continuous rotation, root canal transportation and centring ratio with the ProTaper Next in 50 mesial canals of mandibular molars using cone beam computed tomography imaging. In each of the three cross sections that were investigated, they found no statistically significant difference between the tested groups in terms of canal transportation or the centring ratio. Root canals could be shaped better with alternating motion because it would reduce the screwing effect usually caused by instruments operating in a continuous rotation motion. The screwing effect usually extends the instrumentation beyond the apex and causes canal transportation [34]. Because PTN instruments have an off-centre rectangular cross-section and asymmetric rotating motion, alternating movement's ability to reduce the screwing effect was not apparent when used with these instruments [33].

Furthermore, Elnahas et al., 2018, studied the effect of type movements on the shaping ability of two systems (Reciproc and Neoniti) in curved root canals by using cone beam computed tomography scanning, in which each group was subdivided according to the motion subgroup A: Reciprocation movement; Subgroup B: Continuous rotation, a none

significant difference was found in term of canal transportation among the subgroups at three studied levels (2, 4, and 8 mm) from the root apex. At the 6mm level, Neoniti

this study, Neoniti C1 (taper 0.12) was not used for coronal pre-flaring, which resulted in more friction that worsened with continuous engagement of dentine during the continuous rotation motion of Neoniti with more incidence of apical transportation [36, 37].

Recently, Kataria et al., 2021 compared the rotational and reciprocal shaping abilities of Azure and Fanta AF One. This research was carried out on 40 simulated root canals in resin blocks, with a curvature of 30 degrees and lengths of 16 millimetres. It showed that reciprocation motion was significantly lower transportation levels in both systems [38]. With continuous rotation, the preparation centre usually shifts in a clockwise direction, but this shift is minimised in reciprocation [39].

Rebeiz et al., 2021 used a novel heat-treated NiTi system called the Endostar E3 Azure to prepare 40 endodontic resin blocks, which operated in continuous rotation rotating at 300 revolutions per minute in one group and operated in reciprocation movement with a range of 150° clockwise and 30° counter-clockwise in the second group. Canal's transportation was analysed by the method of superimposing two-dimensional photographs. The reciprocation movement was significantly less canal transportation at 5 mm and 7 mm for the (20/06) and (25/0.6) [10]. Moreover, reciprocation movement was more respectful of the original canal shape at all levels than continuous rotation. Reciprocation motion allows instruments to remain in the canal's centre, allowing for more consistent shaping than continuous rotation, thus resulting in a more symmetrical enlargement of its inner and outer portion [7].

continuous rotation produced significantly more canal transportation than Neoniti reciprocation movement in the mesiodistal direction [35]. In

4. Conclusion

Until now, no endodontic instrument can meet all of the parameters for optimum root canal instrumentation. Endodontic motors have been revolutionised in terms of torque control and changeable kinematics in various directions to improve their ability to shape canals; This review article concluded that:

1-Even with standardised other parameters, some NiTi systems with full rotation showed significantly better root canal shaping when used in reciprocation movement and vice-versa.

2- Other NiTi systems showed a non-significance difference in the shaping ability when used in different kinematics.

3- The design features of files play an essential role in the results.

So, it is still controversial, and further investigation is needed.

Acknowledgments

The authors would like to thank Mustansiriyah University (www.uomustansiriyah.edu.iq), Baghdad, Iraq, for its support in the present work.

Financial support and sponsorship: Nil.

Conflicts of interest: The authors declare that they have no conflicts of interest.

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