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Reciprocating *versus* Rotary instruments: a review

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ABSTRACT

Objective: Literature started to point out essential parameters involving reciprocating instruments through clinical and laboratory essays. Looking into apical debris extrusion, incidence of instrument breakage, canal centering ability, apical zipping, a myriad of information has become available. The aim of this review is to revisit the literature and compare reciprocal and continuous rotation techniques.

Methods: A review of current literature may collect recent findings.

Conclusion: Reciprocating systems are similar in some aspects in comparison to rotational systems, with regards to cleaning ability, centered preparations, cleaning ability, reduction of *Enterococcus faecalis* and dentine defects. On the other hand, being single use and enhanced resistance to fatigue, together with novel methods to treat the alloy may lead to the thought that reciprocal systems are an excellent aid to root canal preparation. However, more needs to be understood about this new era of instruments to verify, long term and especially *in vivo*, the success and failure when these instruments are used.

Key words: Reciprocating systems; Rotational systems; Endodontics

Instrumentos reciprocantes *versus* rotatórios: revisão de literatura

RESUMO

Introdução: A literatura começou a apontar parâmetros essenciais envolvendo instrumentos reciprocantes através de ensaios clínicos laboratoriais. Pesquisando sobre a extrusão apical de detritos, incidência de instrumentos quebrados, capacidade de centralização do canal, uma infinidade de informações se torna disponível. O objetivo desta revisão é rever a literatura e comparar as técnicas de rotação recíproca e rotação continua.

Metodologia: Foi realizada uma revisão atualizada da literatura.

Conclusão: Os sistemas reciprocantes são similares aos sistemas rotatórios em alguns aspectos, como por exemplo; capacidade de limpeza, preparações centralizadas, redução de *Enterococcus faecalis* e defeitos dentinários. Por outro lado, ser de uso único, a resistência à fatiga e o tratamento que recebe a aleação, fazem do sistema resiprocante excelente no preparo do canal radicular.

Palavras-chave: Instrumentação reciprocante; Instrumentação rotatória; Endodontia

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INTRODUCTION

The popularization of use of nickel-titanium (NiTi) instruments for root canal preparation has brought greater predictability of this important phase of root canal treatment. Super-elasticity is the key for the superior properties of this alloy when compared to stainless steel instruments [1]. Engine-driven systems became a reality and constantly new systems are being launched in the dental market.

The risk of instrument fracture is probably the greatest disadvantage of NiTi regular use. If not removed, the piece that became retained may impair proper root canal system disinfection and cause failure [2,3].

The first rotary NiTi system was proposed by Dr. John McSpadden and reached the dental market in 1992. These instruments had 0.02 taper. In 1994 he added 0.04 and 0.06 tapers, which changed the ISO previous paradigm [4]. From then, various systems were used in a multitaper approach. The advantages were still not enough to avoid instrument fracture occurrence, A new type of instrumentation was suggested, based on alternated movement, known as reciprocation.

The principle of reciprocal movement is similar to a watch-winding hand motion, being used first with stainless steel instruments in 1958. Initially the available motors would alternate rotation equally clock and anticlockwise in 90^0 angulations. Later, new motors would allow smaller angulations of 30^0 clock and anticlockwise [4]. In 2008, a new concept of reciprocation was proposed by Dr. Ghassan Yared, using only one NiTi instrument, which at that stage was a 25/0.08 Protaper, and the clock and anticlockwise movements would alternate with different angulations for each move [5].

The proposed technique had a wide acceptance amongst endodontists, because it was advantageous with lower cost and time, as well as cyclic fatigue. The instrument in this technique should be used only once [6].

Staring from 2011, new systems were launched in the market, with new materials and designs, bringing up new perspectives of use in endodontology. Literature started to point out essential parameters through clinical and laboratory essays. Looking into apical debris extrusion, incidence of instrument breakage, canal centering ability, apical zipping, a myriad of information has become available. Therefore, a review of current literature may collect recent findings and help practitioners about this novelty. The aim of this review is to revisit the literature and compare reciprocal and continuous rotation techniques.

Cleaning and shaping

Shaping ability deriving from a preparation technique, either under rotary or reciprocating movement may influence the other steps of endodontic treatment: irrigation and root filling. Root anatomy, especially curvatures, is changed by endodontic instruments, with a tendency of rectification; however, ledges, zipping and other problems may arise and impose difficulties to the removal of infected tissue which could lead to failure. Predictability is one of the major aspects to be considered in root canal preparation.

You et al. [7] assessed Protaper shaping ability under continuous and reciprocating modes. They measured root volume, curvature and surface area through microtomography. They could not find differences between the techniques even with severe curves apically. Similarly, Franco et al. [8] tested FlexMaster system in Rotary and reciprocal movements. Minimal differences were found; Root centering ability was better with reciprocation, but taper was better achieved under continuous rotation.

Bürklein et al. [9] tested the cleaning ability of Reciproc and WaveOne, which are reciprocating, compared to rotary MTwo and Protaper. They found that the four systems were efficient in maintaining root curvature. Rotary MTwo and reciprocating Reciproc seemed to perform better at cleaning the root canal walls. Apparently the movement did not influence the final result. Various other studies compared cleaning and shaping abilities using different instruments of rotation and reciprocation, such as Protaper, Mtwo, WaveOne, Reciproc, Twisted File, OneShape, F360, but they all allowed satisfactory preservation of original shape and limited differences between techniques [10,11,12].

Debris compaction and apical extrusion

Whenever a new instrumentation method is launched, it is expected that it is able to face contamination and cause minimal injury to periapical tissues, providing a favorable condition to repair and/or healing. These aspects are influenced by the ability of the instrument to remove organic debris and not compact them.

Although single instrumentation with reciprocating techniques perform faster, the amount of debris removal seems to be reduced [13,14]. Therefore one should consider the use of multitaper rotary instrumentation when preparing canals with high incidence of isthmuses and protrusions.

It is very unlikely that one can avoid apical debris extrusion, independently of the technique. This may lead to flare-ups. Al-Omari and Dummer [15] state that balanced force techniques reduce apical debris extrusion when compared to linear and continuous movements.

Bürklein and Schafer [16] compared apical extrusion from reciprocating WaveOne and Reciproc vs rotary Mtwo and ProTaper. They found that all systems caused apical extrusion, but rotary instrumentation had lower levels of extrusion. This contrasts with other studies that found better results with reciprocating instruments [17,18].

Reduction of *Enteroccocus faecalis*

One of the main purposes of root canal treatment is microbial reduction and prevention of recontamination of the root canal system. *Enteroccocus faecalis* is commonly found in cases of persistent apical periodontitis and is associated with endodontic treatment failure [19].

Ferrer-Luque et al. [20] tested *Enteroccocus faecalis* reduction using Mtwo, Twisted File and WaveOne, collecting samples form root canal walls with paper points before and

after instrumentation. Statistically reduction ability was not significant amongst groups. WaveOne had higher percentage of reduction, probably because of the taper, 0.08 compared to 0.06 of the other instruments. Machado et al. [21] and Martinho et al. [22] used endotoxins to test reduction and again no statistically significant diferences were found.

Oval canals were used in the study performed by Alves et al. [23]. They compared Reciproc and BioRace under molecular analysis using qPCR. They found both systems to be effective in reducing *Enterococcus faecalis*. Therefore the available literature may lead us to infer that the techniques under discussion do not interfere with the results on this bacterial species.

Canal Anatomy Interference

Canal volume is one of the variables used to assess dentine removal during root canal instrumentation. There is no consensus as to the ideal amount of dentine to be removed during preparation, but excessive instrumentation may lead to fragile root canal walls which could be more susceptible to fracture.

The amount of dentine to be removed in cervical and medium thirds should be enough to allow access to irrigating solutions to the apical third. When curvature comes into the equation, the final shape should allow rectification in such a way that stress is minimized and yet walls are kept strong enough to bear load and not fracture. At the apical third, especially at the foramen, preparation should not cause deviation or zipping and even perforations. These are associated with inefficient decontamination leading to persistent apical periodontitis.

Câmara et al. [24] assessed cross-sections of the three thirds of mesiobuccal canals prepared by one of three HERO systems (Hero 642, HeroShapers, Hero Apical), in continuous rotation. None of the systems was able to touch all the root canal walls. Another study [25] tested five Rotary systems and two manual systems (ProTaper, GT, ProFile, K-3, FlexMaster) and two manual NiTi systems (ProTaper, GT) as to the remaining dentine and canal diameter. Differences were not found amongst groups and all systems provided good preparation quality. Stern et al. [26] tested the centering ability of Rotary Protaper and Twisted Files and Protaper in reciprocating movement. Centering ability was provided by all techniques.

Several studies have compared rotary and reciprocating systems as to the occurrence of apical transportation and centering ability. Gergi et al. [27] compared Twisted File Adaptive, Reciproc and WaveOne, and found that Twisted File Adaptive showed the least apical transportation. This system is used in rotation until the instrument finds resistance, shifting automatically to reciprocation until the instrument is free again, returning to rotation. Also, they found this system to better maintain original anatomy with better centering ability [29]. However, Nazari et al. [29] found different results when comparing Reciproc and Twisted File Adaptive. According to this study, Reciproc provided less transportation than TF Adaptive.

Reciproc and MTwo have similar design, but one is meant to be used in reciprocation and the other in continuous rotation. In a study, MTwo seemed to provide greater apical transportation [30]. Other study compared Reciproc and BioRace and showed higher levels of transportation with the use of Reciproc [31].

A study assessed six #25 systems (OneShape, Pro Taper Universal, Pro Taper Next X2, Reciproc, Twisted File Adaptive, SM2 WaveOne), finding no differences as to apical transportation, canal curvature and centering ability. Reciproc showed higher dentine removal ability [32]. OneShape, although showed lower centering ability, needed less time to prepare the canal than Reciproc and WaveOne [33].

The current literature does not provide solid evidence to infer that one system performs better to maintain original anatomy. Maybe centering ability is influenced by instrument design (taper, flexibility and cross-section). Operator factors, such as experience does not seem to influence quality [34, 35].

Dentine defects

The presence of microfractures and fissures in dentine may occur during instrumentation. The propagation of these defects by the incidence of repetitive load may lead to vertical fracture which may compromise tooth longevity. Bier et al. [36] showed greater microfractures when teeth were prepared with rotary instruments as compared to manual instrumentation. According to Kim et al. [37] the occurrence of defects could be associated with high torque and tapers.

Bürklein et al. [38] assessed dentine defects following the use of rotary Mtwo and Protaper vs reciprocating Reciproc and WaveOne. They found all techniques allowed the formation of defects, but this was more pronounced at the apical third with reciprocating instrumentation. On the other hand, Mahmoud et al. [39] compared Protaper in rotation and reciprocation, and reciprocating WaveOne in oval canals. They found the least defects and highest resistance to fracture when using WaveOne. This was confirmed by other study [40] that found Protaper to be more aggressive to produce microcracks when compared to WaveOne or manual Protaper. Again, more needs to be produced by the literature to allow better understanding the behavior of these instruments towards dentine.

Resistance to breakage

Although NiTi has numerous advantages against stainless steel, breakage is currently one of the greatest worries of practitioners. Instruments break with no apparent alterations, which make it more difficult to prevent accidents.

Instrument failures may be torsional and flexural. Torsional failures occur when instrument tip is stuck somewhere in the root canal wall and the motor keeps rotating the instrument into its long axis. Flexural failure occurs at the curvature generated by repetitive cycles of compression and tension, causing repetitive changes in the microstructure until it breaks [41]. It is estimated that 70% of breakages are flexural,

There have been changes since the year 2000 in structure and treatment of NiTi instruments [43-47]. Thermal treatment is one of these changes. Also, nitrogen ion implantation has improved mechanical properties of the instruments [48, 49]. New designs together with these changes are bringing new generations of instruments.

M-Wire is a new NiTi alloy, using a special thermal process. Some studies assessed the effect of this treatment on breakage. Gambarini et al. [50] compared GTX that uses M-Wire with traditional K3, but did not find any difference as to resistance to fracture. However, other studies showed greater cyclic fatigue resistance using GTX compared to Profile, Endosequence and GT [51,52,53]. Bouska et al. [54] compared two M-Wire systems (GTX and ProFileVortex) and three traditional systems (Twisted File, Endosequence and Profile). The best results were the ones using M-Wire technology followed by Twisted File.

A new development was the R-phase, which is an intermediate phase with distortion of the austenitic phase, as a result of the repetitive cycles of heating and refrigeration, generating a different format that is intended to enhance resistance to cyclic fatigue and superelasticity [47]. *Twisted file and* K3XF are amongst the instruments with this new technology. Pérez-Higeras et al. [55] compared K3XF and traditional K3 and Twisted File. R-Phase instrument K3XF showed greater resistance to fracture independently of the use, either in rotation or reciprocation.

Several studies report better behavior against breakage when reciprocating movement is performed. De-Deus et al. [56] compared Protaper F2 in simulated resin blocks in continuous or reciprocal rotation and reciprocation allowed greater resistance to breakage. You et al. [57] tested these instruments in extracted teeth and found that Protaper F2 could be used at least six times more under reciprocation than rotation, and time for preparation was also reduced under reciprocal movement.

Twisted File and Reciproc were also assessed under reciprocal and rotational motions, being both much more resistant to breakage under reciprocation [58,59].

WaveOne and Reciproc are the most used reciprocal instruments. Comparative studies between these instruments found different results. Plotino et al. [60] and Perez-Hilgueras et al. [61] found better resistance to breakage with Reciproc. Pedullá et al. [62] found no statistical significant differences, whereas Kim et al. [63] found greater flexural resistance with Reciproc and greater torsional resistance with WaveOne.

CONCLUSIONS

Reciprocating systems are similar in some aspects in comparison to rotational systems, with regards to cleaning ability, centered preparations, cleaning ability, reduction of *Enterococcus faecalis* and dentine defects. On the other hand, being single use and enhanced resistance to fatigue, together with novel methods to treat the alloy may lead to the thought that reciprocal systems are an excellent aid to root canal preparation. However, more needs to be understood about this new era of instruments to verify, long term and especially *in vivo*, the success and failure when these instruments are used.

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