

## Original Article

# EVALUATION OF MECHANICAL EFFICACY OF WAVE-ONE™ AND F2 PROTAPER™ USING RECIPROCATING MOTION AND PROTAPER™ SYSTEM UP TO F2 USING ROTARY MOTION IN REDUCING E. FAECALIS COUNT

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### ABSTRACT:

**Background:** To evaluate the mechanical reduction of the bacterial population in the root canal using conventional full sequence ProTaper™ universal system in rotary motion, single- file F2 ProTaper™ and Wave-One™ single file in reciprocating motion. **Methodology:** 46 extracted human lower bicuspid with a single root canal were selected for the study. Conventional access preparations were made and root canals instrumented 1 mm beyond the apical foramen with K-type files up to size 20. To make both handling and identification easier, the teeth were then mounted vertically in plaster blocks, which were then packaged and sterilized in an autoclave for 20min at 121°C. Teeth were inoculated with pure culture of E.Faecalis grown anaerobically in brain heart infusion broth. The blocks were placed in self-sealing pouches and incubated at 37°C for 24h. Then 4 samples out of 46 served as controls (2 negative and 2 positive control) and remaining 42 teeth were divided into 3 groups. Group-1 instrumented with conventional full sequence of ProTaper™ universal system in rotary motion, Groups-2 instrumented with single-file F2 ProTaper™ in reciprocating motion and Group-3 prepared with Wave-One™ single file in reciprocating motion. All root canals were sampled before and after instrumentation. Canals were filled with sterile 0.85% saline solution and each sample taken by using three paper points. All procedures were performed by one operator. Paper points used to sample the canals were transferred to eppendorf tubes containing 1 ml of 0.85% saline solution and vortexed for 1 min. After 10-fold serial dilutions in saline, aliquots of 0.1 ml were plated onto Brain Heart Infusion agar and incubated at 37°C for 48 h. The colony forming units grown were counted. Data obtained from samples taken before and after instrumentation was converted to log and analyzed statistically for differences. **Results:** Conventional full sequence ProTaper™ universal system showed significantly more bacterial reduction as compared to single file F2 ProTaper™ and Wave-One™ in reciprocating motion. **Conclusion:** Conventional full sequence ProTaper™ Universal system used in rotary motion showed more bacterial reduction as compared to Single-file F2 ProTaper™ and Wave-One™ used in reciprocating motion.

**Keywords:** Enterococcus faecalis, reciprocating motion, rotary motion.

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### INTRODUCTION

Healing of peri-apical lesions depends on the reduction / elimination of bacteria, their end products and substrate from the root canal system. Towards achieving this goal

chemo-mechanical preparation of root canal is an absolutely essential step. This basically involves mechanical preparation of canal supplemented and assisted by irrigants which may be antibacterial in

nature. Occasionally, this strategy may not be successful and peri-apical infection may persist despite of adequate therapy.<sup>1</sup> The most common reasons for failures in root canal treatment are related to shortcomings of instrumentation, however, it is also possible, that some of the micro-organisms present within the environment of root canal may be resistant to conventional root canal treatment.<sup>2</sup> Since the total elimination of bacteria from the canal appears to be an illusion the success of root canal treatment is not more than 90%.<sup>1</sup> The nature of the bacterial flora in root canal infection is polymicrobial with a strong dominance of anaerobic bacteria. The most predominant type is *Enterococcus Faecalis* strain, along with which several Gram negative enteric rods such as *Enterobacter* sp., *Klebsiella* sp., *Pseudomonas* or Gram positive facultatives such as *Actinomyces* spp. may also be present. It has been recently suggested that the frequency of isolation of *E. Faecalis* strains is higher in endodontic retreatment cases compared to teeth treated for the first time.<sup>3</sup> This may be due to several virulence factors associated with *E. faecalis* that, permit adherence to host cells and extracellular matrix, facilitate tissue invasion, effect immune modulation and cause toxin-mediated damage. *E. Faecalis* has been reported to sustain an alkaline environment and to survive for prolonged periods without nutrition.<sup>4</sup> Traditionally, hand instruments were used to clean and shape the canals and to an extent were effective in reducing the bacterial population.<sup>5,6</sup> Nickel-Titanium (NiTi) hand and rotary instruments were introduced as they offered many advantages over conventional stainless steel files.<sup>7</sup> Several pitfalls such as transportation, ledging, perforation, instrument fracture and elevated cost associated with files used in a rotary motion instigated the use of reciprocating movement for files.<sup>8</sup> Further, the notion of using a single-file per canal ensured the prevention of cross-contamination associated with the inability to completely clean and sterilize endodontic

instruments.<sup>9</sup> Thus the concept of using a single NiTi finishing file namely F2 Pro taper in a reciprocating movement to prepare the canal in a crown-down manner was first proposed by Dr. Ghassan Yared.<sup>10</sup> The use of only one NiTi instrument was thought to be more cost-effective, due to reduced armamentarium as also because the learning curve could be greatly condensed. Subsequently different researchers have used the same file with combinations as diverse as four-tenth of a circle clockwise and two-tenth of a circle counter clockwise in order to facilitate better canal preparation.<sup>11</sup>

The recently introduced Wave-One™ file by Dentsply envisaged the use of reciprocating action to prepare the canal to an adequate size and taper using a single-file, keeping the original canal centred within the enlargement. This file worked in a similar but reverse “Balanced Force” action using pre-programmed motor to move the files in a back and forth “reciprocal motion”. The files were manufactured using M-Wire technology, improving strength and resistance to cyclic fatigue by up to nearly four times in comparison with other brands of rotary NiTi. These files were designed to have a reverse cutting action. However, the files only shaped the canal, but did not clean the root canal completely.<sup>9</sup> Thus, this study will help to evaluate mechanical reduction of the bacterial population in the root canal following the use of Pro Taper™ system up to F2 in a rotary movement, single file F2 Pro Taper™ in a reciprocating movement and the Wave-one™ system. Thus, the null hypothesis tested was that there was no difference in the bacterial reduction on using the three above mentioned systems.

## MATERIALS & METHODS

46 extracted vital human lower bicuspid with a single root canal, extracted for orthodontic reasons with completely formed apices were selected for the study. Conventional access preparations were made and the root canals instrumented 1

mm beyond the apical foramen with K-type files up to size 20 normal saline was used for periodic irrigation. Working length was established at the apical foramen. After root canal preparation, the enlarged apical foramen was sealed by means of epoxy resin to prevent bacterial leakage. To make both handling and identification easier, the teeth were then mounted vertically in plaster blocks, which were then packaged and sterilized in an autoclave for 20min at 121°C. Two of the teeth were segregated at this stage to act as negative controls. A pure culture of *E. Faecalis* (ATCC 29212), grown anaerobically in brain heart infusion broth (BHI) which had its optical density adjusted to approximately  $1.5 \times 10^8$  colony forming units  $\text{mL}^{-1}$  was used to contaminate the root canals of the remaining teeth. Each root canal was inoculated with 10 $\mu\text{L}$  of the *E. Faecalis* suspension using sterile 1 mL insulin syringes in a laminar air flow cabinet. At this stage, two more teeth were segregated to act as positive control since they were not to be instrumented.

Initial sampling with sterile paper points was carried out in all the teeth in order to verify the negative control as also to establish base line readings for all the artificially contaminated teeth. Paper points used to sample the canals were transferred to eppendorf tubes containing 1 ml of 0.85% saline solution and vortexed for 1 min. After 10-fold serial dilutions in saline, aliquots of 0.1 ml were plated onto Brain Heat Infusion Broth and incubated at 37°C for 48 h. The colony forming units grown were counted. The remaining 42 teeth were divided into 3 groups by randomization:

**GROUP I (n=14):** Using the standard protocol as recommended by the manufacturer of Rotary Pro Taper™ (Dentsply Maillefer) for crown-down preparation, the canals were prepared up to F2 Pro taper™ instruments in a pure pecking motion (no lateral pressure) using an endodontic electric motor and 16:1 reduction gear contra-angle hand piece at the respective preset speed and torque

values. The sequence was SX, S1, S2, F1 and F2, and irrigation with 1.5ml of 0.85% saline solution after each file size. However, total volume of 7ml of 0.85% saline solution with the help of 5ml plastic syringe was used in each canal. A new set of file was used for each sample.

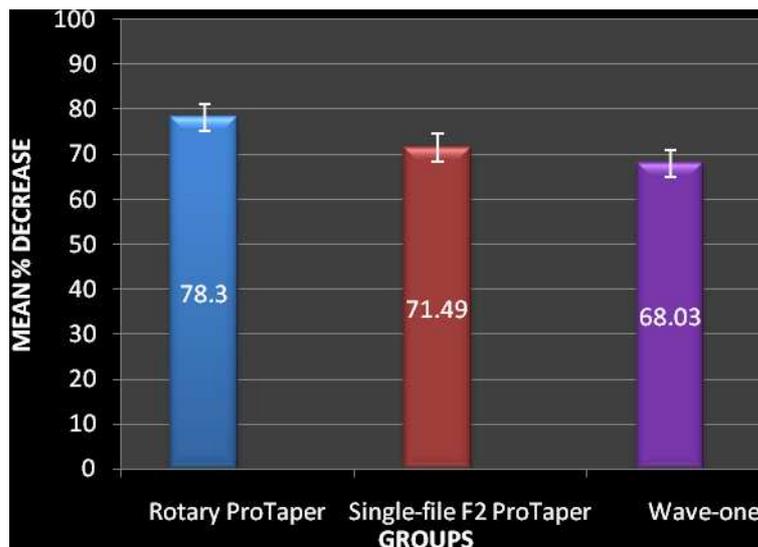
**GROUP II (n=14):** F2 Pro Taper™ Rotary Ni-Ti files were used for the canal preparation in reciprocating motion specifically in a clockwise (CW) 144 degree and counter-clockwise (CCW) 72 degree movement. The F2 was used in conjunction with a 16: 1 reduction ratio contra-angle connected to endo-motor (i-Endo dual endomotor) which allows the reciprocating movement. The rotational speed was set at 400 rpm. The F2 instrument was used in the canal with a slow pecking motion and an extremely light apical pressure until resistance was encountered (i.e. until more pressure was needed to make the F2 advance further into the canal). The instrument was pulled out of the canal, cleaned and re-inserted. Irrigation was done with 1.5ml of 0.85% sterile saline solution using 5ml plastic syringes. However, total volume of irrigating solution to be used for each canal was 7ml of 0.85% saline solution. This step was repeated until the F2 reached the working length.

**GROUP III (n=14):**- The Wave-one™ (Dentsply Maillefer) primary files with tip size 25 and 8% apical taper were used. Subsequently, the Wave-One™ file was used in a reciprocating action (30° clockwise and 150° counterclockwise) (X-Smart™ Plus Motor, Dentsply Maillefer). The file was stopped as the resistance was felt, irrigated and re-inserted. The sequence was repeated until the file reached working length. The canals were irrigated with 1.5ml 0.85% saline solution periodically. A total volume of 7ml of 0.85% saline solution was used in each of the canals. All root canals were sampled after instrumentation. Canals were filled with sterile 0.85% saline solution and each sample taken by using three paper points. All procedures were performed by one operator. Paper points

used to sample the canals were transferred to eppendorf tubes containing 1 ml of 0.85% saline solution and vortexed for 1 min. After 10-fold serial dilutions in saline, aliquots of 0.1 ml were plated onto Brain Heart infusion broth and incubated at 37°C

for 48 h. The colony forming units grown were counted. Data obtained from samples taken before and after instrumentation were converted to log and analyzed statistically for differences.

**Graph 1:** Bar graph showing the total percentage reduction of each group.



**Graph 2:** Bar graph showing variations in the bacterial load before and after instrumentation.



## DISCUSSION

The success story of endodontic treatment to a very great extent relies on the elimination of causative micro organisms within the canal. Complexity of internal anatomy of canal presents a challenge to the total elimination of micro organisms within. Special reference should be made to anatomical irregularities such as fins, ramifications, isthmus, delta, lateral canals, and accessory canals which are not detected by radiographs and might harbour micro-organisms.<sup>12</sup> The same have been found to penetrate into 300µm into dentinal tubules from SEM studies.<sup>13</sup> From a historical perspective, reduction in the bacterial population subsequent to mechanical instrumentation without the chemical agents has been documented in studies dating as far back as 1981.<sup>13</sup> The instruments and instrumentation techniques have evolved from hand files to mechanized and ultrasonic files.<sup>14</sup> In the last two decades several developments have taken place in NiTi rotary files used in both rotary and reciprocatory motion with each claiming to be more effective than its competitors.<sup>15-20</sup> Several techniques have been used to evaluate the effectiveness of canal preparation such as morpho metric analysis, scanning electron microscopy(SEM), immunologic methods, molecular biology method and bacteriologic evaluation.<sup>20</sup> Morphometric analysis of residual debris even though being quantitative is restricted to area of the cross-section and hence may not completely represent the thoroughness of the instrumentation. The same is true as regards SEM analysis of canal surface post-instrumentation. Immunological methods help to detect the target organism but also detect dead micro-organisms which may confound the interpretation of the results. Molecular biology on the other hand is qualitative and semi-quantitative, but assays in this method are laborious and costly.<sup>21</sup> Since the fundamental objective of instrumentation techniques is essentially the elimination of all micro-organisms in the root canal, a quantitative analysis of the

reduction in bacterial population can be construed logically as a measure of the effectiveness of instrumentation and thus used to compare the relative efficacy of different techniques.<sup>14</sup> The plate culture method was utilized because it was equally efficient when compared to other techniques like polymerase chain reaction technique.<sup>1</sup> As opposed to Mitis Salivarius agar which was used for growth of E.Faecalis in earlier studies, in the present study Brain heart infusion agar which is highly nutritious and permits targeted growth of E.Faecalis was used. In the present study, conventional sequence of ProTaper™ universal showed significant reduction (78.3%) in bacterial population as compared to single-file F2 ProTaper™ (71.49%) and single-file Wave-One™ (68.03%) used in a reciprocating motion. The results are in agreement to recent article by Machado et al.<sup>22</sup> Even though it has been accepted that 35% of the internal dentin surfaces are left untouched after instrumentation with Ni-Ti instruments.<sup>23</sup> Currently, there is only one investigation which assessed the cleaning efficiency of a single-file F2 ProTaper™ system used in a reciprocating motion and conventional full sequence of ProTaper™ universal in round and oval shaped canals.<sup>24</sup> The single-file ProTaper™ F2 technique resulted in significantly more pulp residuals in oval-shaped canals than conventional full sequence ProTaper™ universal system<sup>24,25</sup> which is reflected in terms of bacterial load in our study. The results are in contradiction to those of Burklein et al<sup>26</sup> who found that the cleaning ability of Wave-one™ is significantly superior to Pro Taper™, however this may be due ascribed to the fact that canals with generally round cross section may have been used in the study. The efficacy of various instruments in cleaning root canals also depends on their cross-sectional design. Wave-One™ and conventional full sequence of ProTaper™ Universal have a completely different design in their tip region. Wave-One™ single-file is characterized by three cutting edges with radial lands to support the blades

and a relatively small chip space. Whereas, Single-file F2 ProTaper™ have a triangular convex cross-section presenting no active cutting edges and a neutral rake angle which scraps the dentin surface.<sup>26</sup> The suboptimal results in cleaning efficiency achieved in oval shaped canals prepared by the single-file F2 ProTaper™ technique in the study by De-Dues et al<sup>24</sup> might have a 2-fold basis: 1. the reduced number of files and 2. the reciprocating movement kinetics are in line with the results of the present study wherein there was a significant difference between conventional full sequence ProTaper™ universal and single file F2 ProTaper™ along with Wave-one™. Moreover, if we consider the resultant canal shape after using conventional full sequence ProTaper™ universal it would show tip size of no.25, a taper of 8% at apical 3mm and increasing taper upto 11.5% at a level of the canal orifice.<sup>27</sup> Whereas in case of Wave-One™ the resultant canal shape would show a tip size of 25 and a uniform taper of 8%. Thus, the null hypothesis was rejected.

The same would be true with regards to the canal shape achieved using single file F2 ProTaper™. Thus, it would be safe to assume that the quantum of the root dentin, and by association the micro-organisms within, evacuated from the canal would be greater in case of conventional full sequence ProTaper™ Universal as compared to the other two. The above explanation to some extent may explain the results achieved in the present study.

## CONCLUSION

In the present study, ProTaper™ Universal system used in rotary motion showed significantly more bacterial reduction as compared to Single-file F2 ProTaper™ and Wave-One™ used in reciprocating motion.

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