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Comparative Evaluation of Co-Relation of Visual Deformation and Tendency to Fracture; And Apical Cleaning Ability of Mtwo and Protaper With Stainless Steel Hand Files: An In-Vitro Study

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I. Introduction

Despite of the developments in field of endodontics, the basis of successful root canal treatment still remains the adequately cleaned and shaped root canals. The literature suggests several techniques for cleaning and shaping of root canals **(1-4,6),** but the technique that is best suitable and can be applied in all the cases has yet to be developed. The shaping ability of root canal instruments is determined by its ability to preserve original root canal curvature, without creating iatrogenic events, such as instrument fracture, external transportation, ledges or perforations (**2-6**).

Rotary NiTi root canal instruments with their advanced designs and improved working safety have revolutionised the field of endodontics. They ensure a canal preparation that is best suitable for chemical disinfection and obturation, along with relatively shortened working time. NiTi is an exotic metal with unique properties of shape memory and super-elasticity. It can negotiate canal curvatures while in continuous rotation without undergoing permanent deformation **(7).** On the other hand stainless steel instruments have a high stiffness that increases with increasing instrument size and hence apply high lateral forces within curved canals **(8)**.

Still intracanal file separation remains a major concern with NiTi instruments owing to their tendency to fracture without any visible signs of deformation, apparently within the elastic limit of the instrument **(9-13).**

Protaper system (**Tulsa Dental, Dentsply**) was introduced with unique properties of varying taper, helical angle and pitch along the length along its cutting blade. Its cutting edges are sharp (i.e. pointed in cross-section) as opposed to earlier introduced ProFile and GT instruments.

Mtwo instruments were introduced by **VDW Munich, Germany** to provide with an easy, efficient and safe concept of instrumentation. There are four sets of instruments for all canals and all of them shape the canals till the apex. With it came the latest concept of **Simultaneous Shaping(18)**.

One study measured the cyclic fatigue of ProTaper (Dentsply Maillefer, Ballaigues, Switzerland), FlexMaster (Vereinigte, Dentalwerke, Munich, Germany), Mtwo and ProFile; the results showed that Mtwo had the highest resistance to fatigue compared to the other instruments **(14, 15**).

The studies have been conducted on the shaping ability of various available NiTi rotary systems **(14,16);** but little has been studied regarding the co-relation of their visible deformation and subsequent fractures**(13).**

Also the, available literature reveals that rotary instruments shape coronal and middle third of the root canal effectively, and create a smooth surface profile **(17)**. But it has been reported that the apical third is the critical area of the root canal where the debris both inorganic and organic have been detected **(18-21)**.

The aim of the present study was to investigate the working safety in terms of deformation and fracture; and apical cleaning ability of Protaper and Mtwo rotary systems in comparison to stainless steel hand files. Protaper was included in the study because of its widespread clinical use and Mtwo because of its recent introduction and few research data available **(22-24).** The use of newer rotary system has influenced to undertake this study.

II. Methods And Materials

The study was conducted at Department of Conservative Dentistry and Endodontics, Himachal Dental College, Sundernagar, Himachal Pradesh.

A total of 60 freshly extracted human mandibular molars were selected for the use in study. The selected roots had a plane of curvature in only one direction and an angle of curvature that measured 40° or greater using Schneider's method **(25).** Based on the degree of curvature the teeth were assigned to one of the three groups. The teeth were sterilized and stored in sterile saline solution until use. Coronal access was achieved using diamond burs and the mesio-buccal canals were negotiated and selected for instrumentation, owing to highest incidence of curvatures reported in this canal of mandibular molars **(26, 27).** The working length was obtained by measuring the length of the instrument (size 10) at the apical foramen minus 1mm. One operator instrumented all canals, and before use, all files were visually inspected for distortion using 16X— magnification. No files exhibited distortion before use.

Records were maintained to evaluate the number of uses and changes in the file after each use. The photographs were taken to maintain an archival record of observations and defects. Canals were irrigated with 4 mL of sterile saline between each file size. Before use, each file was lubricated with Glide root canal lubricant (Miltex Inc, York, PA) to simulate the use of files in clinical scenario. The presence of a reproducible glide path with stainless steel hand files was ensured prior to use of rotary files. After each instrumentation, the root canals were flushed with 5ml saline solution. The apical preparation was limited to no.25 instrument in each group. All types of instruments were set into permanent rotation with a reduction handpiece powered by a torque-limited electric motor **(X-Smart, Dentsply).** For each file the torque control and the speed were adjusted according to manufacturer's instructions.

Group A: All Mtwo instruments were used to full length of the canal using a gentle in and out motion. The sequence was;

I. A 0.04 taper size 10 instrument was used to full length of the canal.
II. A 0.05 taper size 15 instrument was used to full length of the canal.
III. A 0.06 taper size 20 instrument was used to full length of the canal.
IV. A 0.06 taper size 25 instrument was used to full length of the canal.

Once the instrument had negotiated to the end of the canal and had rotated freely, it was removed.

Group B : They were instrumented using Protaper system in following sequence,

I. **S1 (shaping file no. 1; taper .02-.011; size 17)** was introduced into the canal to two-thirds of the working length.
II. **Sx (auxillary shaping file**; **taper .035-.19; size 19)** was inserted into the canal with a brushing motion against the outer curvature upto two-third of the working length.
III. **S1, S2 (shaping file no.2; taper .04-.115; size 20), F1 finishing file no.1 (taper .07-.055; size 20) and then F2 finishing file no.2 ; (taper .08-.055; size 25)** were each used to the full working length in turn.

Instrumentation was deemed to have completed when the F2 file reached the working length and rotated freely.

Group C: It comprised of canals instrumented with stainless steel hand files till no. 25, using step-back technique to full working length with a in and out movement and circumferential filling manner. They were used in sequence with reciprocation, before stepping on to larger instrument, each time.

After each use, the instrument was viewed under dental operating microscope at 16X magnification for any visible signs of deformation. The selected instruments with representative features of deformation were viewed under stereo-microscope at a higher magnification. The number of instruments which fractured in each group, along with number of teeth instrumented after which they fractured was also recorded; and was subjected to inter-group comparison.

In second part of the study, after the complete chemo-mechanical debridement of the canal, the mesio-buccal roots were separated and the apical third was carefully sectioned. The representative samples of each group were coded and mounted on the aluminium stub, coated with Gold-Palladium sputter and was seen under scanning electron microscope, to evaluate the cleaning in apical third of the canal. Dentin chips, pulp remnants, large particles and aggregates appearing haphazardly on root canal wall were classified as debris. A surface film consisting of remnants of dentine and pulp tissue with a smeared structure appearance was defined as smear layer **(28).**

The scoring system given by **(Hulsamann et.al. 1997) (28)** was used to derive the results.

Debris Evaluation :

- **Score - 1;** Clean Canal Walls With Only Very Few Debris**.**
- **Score - 2;** Few Small Agglomerations.
- **Score - 3;** Many Agglomerations; Less Than 50% Of The Canal Wall Covered
- **Score - 4;** More Than 50% Canal Wall Covered.
- **Score - 5;** Complete Or Nearly Complete Covering Of The Canal Wall By Debris.

Smear Layer Evaluation

- **Score 1;** No Smear Layer, Orifice Of Dentinal Tubules Patent.
- **Score 2;** Small Amount Of Smear Layer, Some Open Dentinal Tubules.
- **Score 3**; Homogeneous Smear Layer Along Entire Canal Wall, Few Open Tubules.
- **Score 4;** The Entire Canal Wall Covered With Homogeneous Smear Layer, No Open Tubules.
- **Score 5;** A Thick, homogeneous smear layer covering entire root canal wall.

The results hence obtained were subjected to statistical analysis.

III. Observations

Instrument deformation and failure: The proportion of molar roots were statistically equivalent in the three groups ($p = 0.44$). The average curvature was also statistically equivalent in the four groups ($p > 0.9$). The resulting variables were expressed as either the percentage of files that were distorted and/or the percentage of files that were broken in each of the four groups.

Only one Mtwo no.20 (.06 taper) instrument separated in apical one third of the canal. The fractured instrument did not show signs of deformation prior to the fracture. The fractured Mtwo file when viewed under stereomicroscope at higher magnifications showed fatigue of apical part of the file following which it fractured (figure 1).

In **group B**, a total of 3 Protaper instruments separated. All of them fractured without any visual sign of deformation except for loss of luster. The surface of used Protaper file when seen under stereomicroscope, did not show any signs of deformation before it fractured. (figure 2).

In **group C**, most of the SS files showed early signs of deformation manifested as unwinding of flutes, so they could be discarded easily without inviting fractures. None of the SS file fractured. The unfluting of the stainless steel files could be clearly seen under stereomicroscope (figure -3).

Percentage correlation of various groups in terms of fracture and deformation:

Protaper system shows highest incidence of fracture without any prior warning of visible deformation. The Mtwo system showed comparative lesser incidence of instrument fracture, along with perceptible visual deformations prior to failure. The percentage deformation for stainless steel hand files was much higher.

Apical Cleanliness; In second part of the study it was found that apical third of the canal is never clean with any of the system used. Mtwo instrumented teeth (Group A) showed nearly clean canals in apical third with small agglomerations of debris particles (**score 2**) and small amount of smear layer with several open dentinal tubules [**score 2** (figure - 4)].

Protaper (Group B) showed poorly clean canals with debris covering more than 50% or entire canal surface (**score-4 or 5**) and thick homogenous smear layer with few or more dentinal tubules [**score-4 or 5** (figure - 5)]

Stainless steel files (Group C) showed nearly clean canal with small agglomerations of debris particles or covering > 50% (**score – 2 or 3**) and small amount of smear layer with several, open dentinal tubules [**(score -2)** (figure - 6)].

Owing to ordinal nature of the scores the data was subjected to non-parametric Kruskal Wallis test. P-values were computed and compared with $p=0.05$ level. As can be depicted from, Mtwo resulted in significantly less debris ($p<0.5$) than Protaper and SS files.

The average debris score was 1.80 for Mtwo, 2.25 for SS files and three for Protaper. The results were statistically significant for smear layer,($p<0.5$). Mtwo showed 66.6% of the samples with score 2, Protaper had 35% of the samples with score 5. There was no specimen in group A or C with score 0.

IV. Discussion

The present study aimed to analyse the frequency of defects in NiTi rotary endodontic files and there tendency to clean apical one third of the root canals when compared with traditional hand files. The present study was conducted to draw conclusions that provide insight into the patterns of defects in an attempt to reduce the risk of instrument separation within the canals. Every effort was made to make the study dynamic and clinically relevant.

Out of all instruments used, one Mtwo, three Protaper instruments separated. A recent study on Mtwo rotary system have shown that clinical use significantly reduced cyclic fatigue resistance of Mtwo rotary instruments when compared with an unused control group. However, all the instruments had minimal instrument fatigue when discarded after controlled clinical use **(29).** The studies have shown that mTwo is most resistant to cyclic fatigue amongst rotary instruments**. (30,31).**

Cyclic fatigue and torque are the two factors which cause breakage of rotary nickel-titanium files **(32-33).** Cyclic fatigue builds up as file bends around curves. Torque increases as pressure is increased or as the file cuts over a longer distance. The amount of torque applied on the instrument mainly depends upon the file manipulation and design. The crown down technique creates less torque and less vertical forces. Ideally the file should never cut over a 1-2 mm surface.

Detecting the distortion without breakage is of utmost importance so as avoid intracanal separation of instruments **(14, 36**). However, the NiTi instruments fracture without any signs of warning deformation (**32-36**). This is attributed to shape memory effect and superelasticity property that is unique to the NiTi alloy. The visual deformations as viewed under magnifications could include bending, unfluting, loss of luster and fatigue of the instrument. All these signs are indicators of instrument fatigue and hence it subsequent discarding to

prevent mishaps. One of additional use of dental operating microscope, is viewing the surface of the instrument under magnification every time it is used in the canal.

Stainless steel instruments show visible changes in their surface topography after their use, hence are safe to use **(37).** But they lack the inherent flexibility of NiTi instruments and hence cannot be used in curved and calcified canals. This instrument rigidity is responsible for straightening of the canal, leaving significant portions of canals un-instrumented with irregular canal cross-sections, difficult to obturate.

Mtwo system appears to be safe in comparison to Protaper instruments and can be used in more number of cases. Only one Mtwo (No.20) instrument fractured after use in 7^{th} canal, that too after showing visual deformation. On the other hand, one S2, F1 and F2 Protaper files fractured after 5^{th}, 6^{th}, and 8^{th} use respectively, that too without visual signs of deformation. A single overloading event causing ductile fracture of ProTaper instruments is the most common fracture mechanism encountered under the clinical condition **(38).** Among the file systems, ProTaper had the largest differences (standard deviation) from the actual fracture locations. This might have resulted from its surface characteristics because ProTaper was also found to have the most prominent machining grooves that may act as stress concentration locations, accelerating the fatigue crack initiation**(40).**

Factors attributed to breakage of rotary files include canal curvature and other anatomic challenges, practitioner experience, frequency of use and speed of rotation (**39)**.

In the present study, X-Smart electric endo-motor was used. It has nine adjustment pre-set programes, with auto-reverse mode, integrated 16:1 reduction handpiece and torque range of 0.6 to 5.2N /cm.

The file design has its influence on torsional loading because cutting blades could act as stress concentrators. The radial land areas however, contribute to the strength of the instrument by the relative large peripheral mass. This is the reason that the Mtwo instruments are more resistant to fracture, even after more number of cycles of rotation **(30-32**). The greater taper enlarges the diameter of the instrument at the coronal curvature compared with the apical area, thus resulting in higher stress.

Due to its wide range of elastic deformation NiTi alloy may be strained much further than stainless steel before it is permanently deformed. Mtwo instruments have four types of instruments for all types of canal, all instruments go till apex and do simultaneous shaping. It has outstanding cutting efficiency and flexibility due to combination of S-shaped cross-section and deep cutting blades **(18).**

Sattapan etal (2007) suggested that files should be examined after each use to reduce the risk of separation in root canals. He also stated that minor defects both manufacturing errors and plastic deformation may not be detected by naked eye and recommended examination of atleast 10X. So various methods used were visual examination and microscopic examination at 10x magnification **(14).**

In the present study, a simple irrigation technique was used, with use of normal saline as an irrigant to avoid influences of different irrigation solutions. Previous studies have shown limited efficacy of instruments in cleaning the apical third of the root canal. The presence of deep grooves and depression on dentine walls in the apical third may well explain the presence of less-instrumented areas.

In general there are some clues that the flute design of rotary files may be a key factor for cleaning efficiency of these instruments. According to recent studies the instruments with sharp cutting edges seem to be superior in cleaning the root canals **(19)**.

The reason for better cleaning abilities of Mtwo as evident from lower scores for both debris and smear layer, obtained in the present study, may be attributed to the instrument design (**18).** It has two sharp cutting edges and a relatively small core diameter. This file diameter together with the increasing pitch length from tip to the shaft may enhance the debris removal capacity of Mtwo and hence provide for larger space for dentin removal. It has minimum radial canal wall contact and has safer and faster preparation. The inter-group differences were statistically significant.

Hence within the limits of the study it can be stated that, visible defects due to torsional fatigue do occur in NiTi instruments and they should be definitely looked for before and after use to minimize the risk of instrument separation that complicate the endodontic therapy. This additional use of magnification need to be addressed in endodontics.

V. Conclusion

Hence within the limitations of this study it can be concluded that

- NiTi instruments tend to fracture more as compared to stainless steel instruments, that too without signs of deformation. The incidence of fractures is more with Protaper instruments.
- Apical cleaning ability of Mtwo files is better than other the two groups; the results were worst for Protaper rotary systems.

Figure Legends

Figure 1: deformation of Mtwo files seen under stereomicroscope.

Figure 2: Deformation Of Protaper Files Seen Under Stereomicroscope.

Figure 3: deformation of SS files seen under stereomicroscope.

Figure 4: SEM picture of apical 3rd prepared with Mtwo rotary system showing nearly clean canal with small agglomerations of debris [Score 2] and small amount of smear layer with several open tubules [Score 2).

Figure 5: SEM picture of apical 3rd prepared with protaper system showing poorly clean canals with debris covering >50% [Score 4 or 5] and thick homogenous smear with few open tubules [score 4 or 5].

Figure 6: SEM picture of apical 3rd prepared with stainless steel hand files with small amount of debris score [2 or 3] and small amount of smear layer with several open dentinal tubules [score 2]

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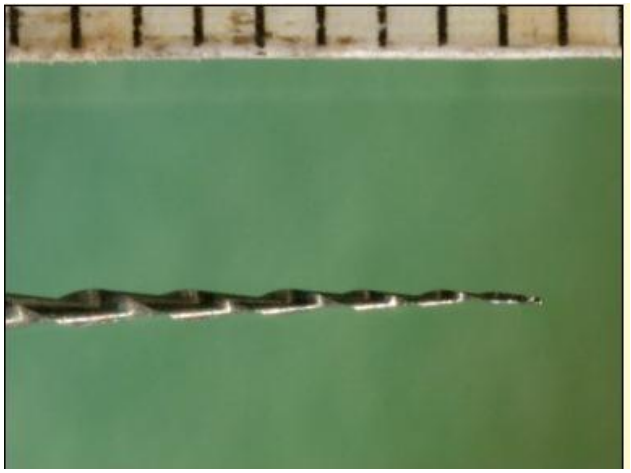

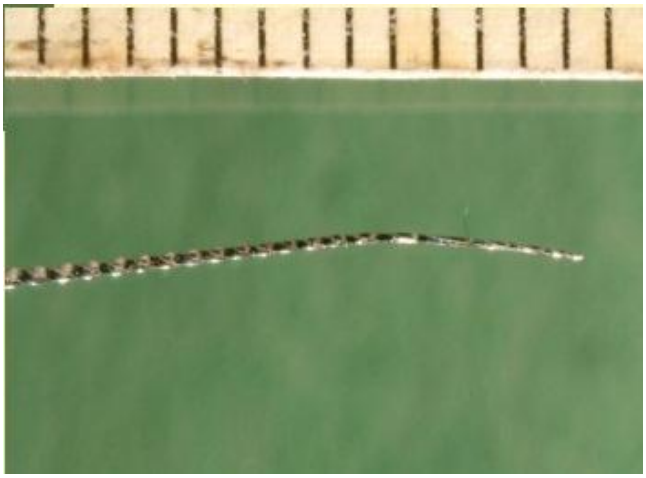

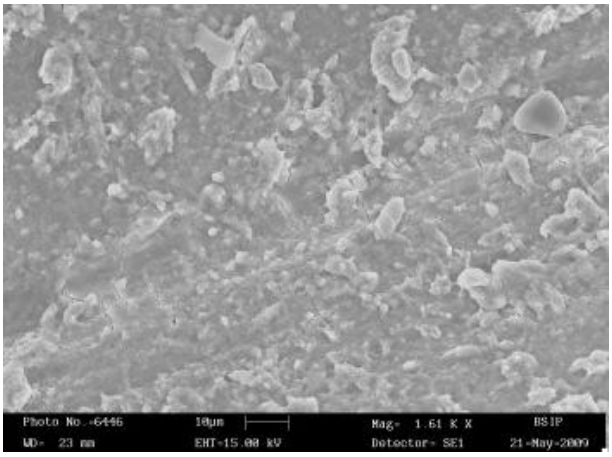
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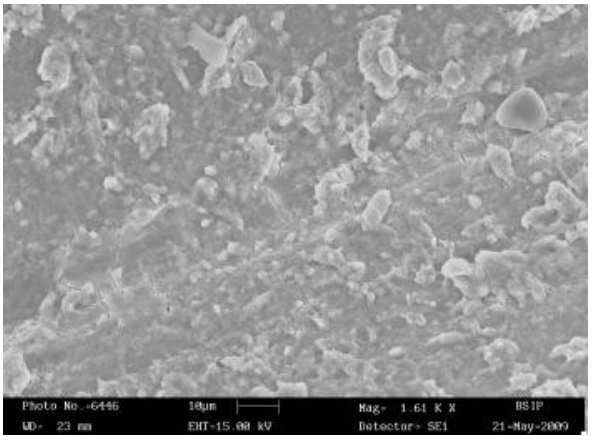
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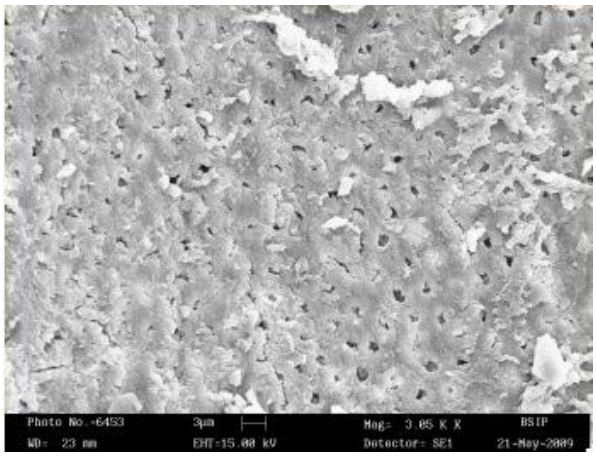
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