



INVITRO EVALUATION OF MORPHOLOGICAL CHANGES OF HYFLEX AND PROTAPER ROTARY SYSTEMS IN MODERATE TO SEVERE CURVED CANALS

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Abstract:

Background & Objectives:

NiTi has been extensively used for biomechanical preparation so far but the problem with this is unexpected file fracture. Recently thermal treatment has come up to improve mechanical properties of the alloy. Controlled memory wire (CM) of HyFlex is one of the thermally treated alloys. Till now no studies were reported in evaluating the morphological changes of these files. Hence a study was conducted to evaluate the morphological changes of HyFlex and ProTaper after clinical use and to observe the rewinding of the flutes after the autoclaving in HyFlex group under stereomicroscope at 40X magnification.

Materials and Methods:

Hundred freshly extracted mandibular molars having moderate to severe curved canals were divided into two groups of 50 each. They were accessed and biomechanical preparation was done in mesiobuccal canals according to the manufacturer's instructions.

Group1: instrumented with HyFlex

Group2: instrumented with ProTaper

After each use the files were examined under stereomicroscope at 40 X magnification to observe unwinding. Scoring was given according to scoring criteria

Score1: No unwinding, reverse winding

Score 2: Unwinding or reverse winding and shortening of one spiral

Score 3: Unwinding or reverse winding shortening of two spirals

Score4: Unwinding or reverse winding and shortening of more than two spirals along the shaft examined.

Results:

- Spiral distortion was not observed in ProTaper group till 11th use while HyFlex group showed distortion at 3rd use, there is no statistical significant difference between the groups till 3rd use. ($p>0.05$).
- While from 4th to 10th use, HyFlex group showed higher spiral distortion when compared to ProTaper group ($p<0.05$).

Conclusion:

Based on the results of the study it could be concluded that HyFlex files showed visible verification and are easily distorted when compared to ProTaper group

Key words: NiTi, CM wire, Stereomicroscope.

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INTRODUCTION:

The main goal of root canal treatment is to eliminate the microorganisms. This can be achieved by proper chemo- mechanical preparation removing all the infected pulp tissue, bacteria and their by-products^{1,2}.

Traditionally, files and reamers were manufactured from either carbon steel or stainless steel. Authors have found that files made from nickel-titanium (Ni-Ti) alloy had greater elastic flexibility in bending and torsion, as well as greater resistance to torsional fracture than similar sized stainless steel files^{6,7} as it has a very low modulus of elasticity, which provides elastic flexibility to instruments. Despite this increased flexibility the greatest problems of NiTi files are their high cost and unexpected instrument fracture^{2,4,5}. The high cost of NiTi has forced many clinicians to reuse them, which in turn, lead to a higher incidence of instrument fracture².

Endodontic rotary instruments can fracture in two circumstances: torsional fracture and flexural fatigue^{11, 12}. Torsional fracture occurs when the tip or any part of the instrument is locked in a canal while the shaft continues to rotate. When torsional stress at the point of fracture of the instrument becomes higher than the torque at fracture of the instrument^{4, 2}, the instrument exceeds the elastic limit of the metal and shows plastic deformation followed by fracture¹³.

It is further categorized into two types:

- a) Dynamic torsional fatigue occurs from frictional forces caused by resistance of dentin to cutting by the file.
- b) Static torsional fracture occurs by continuous rotation of the file at one end while the other end stops spinning as seen or when a section of the file is locked in place while the handpiece continues to rotate¹².

ProTaper has been used extensively in rotary endodontics so far. Recently manufacturing processes (which are patented and not disclosed by manufacturers) involving heat treatments of the alloy have been developed in order to improve mechanical properties of the alloy for endodontic use¹⁷.

The CM-wire technology developed by Coltene Endo which is Hyflex is one of the first thermally treated NiTi alloys used for endodontic use¹⁸. These files can be multi used as the shape and strength of the straightened spirals can be restored during autoclaving¹⁹. These



files are 300% more resistant to cyclic fatigue which reduces the incidence of file separation²⁰.

These files have been manufactured utilising a unique process that controls the material's memory, making the files extremely flexible but without shape memory of other NiTi files. This gives the file the ability to follow the anatomy of the canal very closely, reducing the risk of ledging, transportation or perforation^{19, 17}.

So far no study has been done to evaluate morphological changes of HyFlex and ProTaper. Hence a study was designed to evaluate the morphological changes of HyFlex and ProTaper after subsequent clinical use before and after autoclaving under stereomicroscope at 40X magnification. The null hypothesis tested was that the shape and strength of the straightened spirals cannot be restored during autoclaving.

AIM:

To evaluate the morphological changes of Hyflex and ProTaper under stereomicroscope at 40X magnification before and after autoclaving.

OBJECTIVES:

1. To observe distortion of the flutes before and after use under stereomicroscope at 40X magnification.
2. To observe the rewinding of the flutes before and after autoclaving under stereomicroscope at 40X magnification.

MATERIALS AND METHODS:

Hundred freshly extracted mandibular molar teeth having moderate to severe curved canals were taken and stored in 10 % formalin until used. The degree of curvature was determined by Schneider's method using digital radiography.

Access cavity preparations were done in all teeth and were arranged in two groups of 50 each. Patency of the canals was determined by a 10# K- type hand file, until the tip was visible at the apical foramen. Working length was calculated to be 0.5 mm from the apical foramen and was recorded.

Before starting the procedure the endodontic files were imaged using stereomicroscope of magnification 40X with the notification of any flaws if present.

Group 1: 50 teeth instrumented with Hyflex in continuous motion.



Group 2: 50 teeth instrumented with ProTaper in continuous motion which acted as a control.

5.25% NaOCl, 17% EDTA & Saline irrigation was done throughout the instrumentation. 6 sets of instruments were used to prepare 50 canals per group. In HyFlex group the sequence of instrumentation was (8%/25#, 4%/20, 4%/25). Total 18 instruments from Hyflex and 30 ProTaper instruments were evaluated. To standardize the apical preparation in ProTaper group instrumentation was done till F2 which is of similar (25#) size as Hyflex. After each instrumentation debris was removed from each file with 2- inch × 2- inch cotton gauze moistened with isopropyl alcohol and the file was then inspected for signs of plastic deformation ,distortion or breakage under magnifying loupes 3x and then subjected to stereomicroscope at 40 x magnification and were classified into four categories

Score1: No unwinding, reverse winding

Score 2: Unwinding or reverse winding and shortening of one spiral

Score 3: Unwinding or reverse winding shortening of two spirals

Score4: Unwinding or reverse winding and shortening of more than two spirals along the shaft examined.

After every use the instruments were subjected to autoclaving at 121degree centigrade and under 15 lbs. pressure for 20 minute and observed under stereomicroscope at 40 x magnification.

Results obtained were analysed statistically using McNamara’s Chi square test.

RESULTS:

TABLE1: HYFLEX SPIRAL DISTORTION SCORES AT TIP

SCORE	NUMBER OF USES											
	1 ST	2 ND	3 RD	4 TH	5 th	6 th	7 th	8 th	9 th	10 th	11 th	12 th
1	18	18	18	12	11	10	10	6	0	0	0	0
2	0	0	0	0	0	1	1	5	11	11	5	5
3	0	0	0	6	7	7	7	7	7	7	6	6
4	0	0	0	0	0	0	0	0	0	0	7	7



TABLE 2: HYFLEX SPIRAL DISTORTION 5mm FROM THE TIP

SCORE	NUMBER OF USES											
	1 ST	2 ND	3 RD	4 TH	5 TH	6 TH	7 TH	8 TH	9 TH	10 TH	11 TH	12 TH
1	18	18	18	11	10	10	10	5	0	0	0	0
2	0	0	0	1	1	1	1	5	10	10	5	4
3	0	0	0	6	7	7	7	8	8	8	6	7
4	0	0	0	0	0	0	0	0	0	0	7	7

TABLE 3: PROTAPER SPIRAL DISTORTION AT TIP

SCORE	NUMBER OF USES											
	1 ST	2 ND	3 RD	4 TH	5 TH	6 TH	7 TH	8 TH	9 TH	10 TH	11 TH	12 TH
1	30	30	30	30	30	30	30	30	30	30	23	22
2	0	0	0	0	0	0	0	0	0	0	7	8
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 4: PROTAPER SPIRAL DISTORTION 5mm FROM THE TIP

SCORE	NUMBER OF USES											
	1 ST	2 ND	3 RD	4 TH	5 TH	6 TH	7 TH	8 TH	9 TH	10 TH	11 TH	12 TH
1	30	30	30	30	30	30	30	30	30	30	30	30
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0

- Spiral distortion was not observed in PROTAPER till 11th use while HYFLEX showed distortion at 3rd use, there is no statistical significant difference between the groups till 3rd use. ($p > 0.05$).
- While from 4th to 10th use, HYFLEX showed higher spiral distortion when compared to PROTAPER ($p < 0.05$).



DISCUSSION:

Number of usages of an endodontic instrument may be an important factor controlling instrument failure which in turn is directly related to pre-existing surface defects and to those generated during canal instrumentation. Moreover, topographic features control the adhesion on material's surface of biological components, serving as potential sites for microorganisms, blood cells, and tissues debris. Hence, it is important to understand the nature, type, and incidence of these surface defects of Ni-Ti instruments²⁶. As there is no study or information available to specify how many times rotary instruments can be used safely, this study was planned aiming at evaluation of morphological changes of Hyflex and ProTaper under stereomicroscope at 40X magnification.

As per the manufacturers claim, Hyflex files regains its shape after sterilisation which could be a clinical useful feature. So the observation was done before and after autoclaving .

Based on the results it was observed that ProTaper showed no spiral distortion before and after autoclaving till 11th use near the tip region and at 5mm from the tip. This is in accordance with the study stating that the maximum usage of ProTaper was 12-16 canals sparingly²³ and 10 canals according to other studies^{26, 15}.

It is important to take the effect of heat sterilisation on the Niti instrument. Repeated sterilisation was found to cause changes in the torsional and bending properties³¹.

Opposing to this old observation the manufacturer claimed that Hyflex files regains shape and strength after sterilisation²². This is referred to as Phoenix effect, which allows the permanently deformed Hyflex instrument to regain its original shape by providing Heat (autoclave or glass bead sterilisation). This property is unique for root canal instruments and it seems to be similar to shape memory effect which is widely used in orthodontic wires. Unfortunately the actual thermal treatment of CM-wire is not disclosed by the manufacturer, and no data available regarding the transition temperatures for better understanding.¹⁷

In our study, Hyflex after 1st use with score 1(no unwinding) has changed to score 2(unwinding of one spiral). On observation after autoclaving score 2 has reverted back to score 1. This is in accordance to the manufacturer's claim^{30, 28, 20, 19}. This could be explained as the property of the material. According to a study the differential scanning calorimetry curves showed that Hyflex instruments had an austenite transformation completion or



austenite finish (Af) temperature exceeding 37 °C. The austenite-finish temperatures of HyFlex instruments (with or without defects) after multiple clinical uses were much lower than in new instruments ($P < 0.05$). The enthalpy values for the transformation from martensitic to austenitic on deformed instruments were smaller than in the new instruments at the tip region ($P < 0.05$). X-ray Diffraction results showed that NiTi instruments had austenite and martensite structure on both new and used HyFlex instruments at room temperature. According to manufacturer the instruments of martensite phase can be easily deformed, yet they will recover their shape on heating above the transformation temperatures²².

Similarly after 2nd use, score 1 has changed to score 2 then reverted back to score 1 upon autoclaving. However the regain in the spirals has happened till 3rd use only. This is in accordance with a study^{32,22}.

The different crystal structures observed in NiTi alloys impart different properties. When the material is in its martensite form, it is soft and ductile and can be easily deformed. Superelastic NiTi is highly elastic, whilst austenitic NiTi is quite strong and hard. For instance, the martensite phase is less stiff and more pliable, possessing an elastic modulus of 31 to 35 GPa compared with 84 to 98 GPa for austenite. This could explain the reason for flexibility in accordance to the previous studies stating that HyFlex instruments are bendable and very flexible^{21,33}.

According to one study these files are manufactured with low percent in weight of Nickel(52%wt) and there is thermal treatment involved in the manufacturing. So it is not easy to determine whether the improvement in the flexibility is due to unique composition, the property thermal proportion, or both^{21,34}.

This plastic deformation of HyFlex file we observed in our study could be a useful warning signal as, such files are more likely to be discarded before separation during clinical use²².

The other probable reason for greater spiral distortion could be the rotational speeds. Instruments rotated at higher rotational speeds are more susceptible to distortion and fracture²⁶. According to a study the speed at which instruments operate seems to have no effect on the number of cycles to fracture, but higher speeds reduce the period of time required to reach the maximum number of cycles before fracture. The recommended RPM for ProTaper is 350 and Hyflex is 500^{26,40}.



In this study no HyFlex file got fractured even after 12th use claiming its resistance to cyclic fatigue. Authors have stated that the risk of file separation is very low for Hyflex²². The probable reason could be the composition of the alloy having the mixture of martensite and austenite in it and the superiority of martensitic phase to absorb energy³².

Based on the results of our study regarding distortion, HyFlex showed spiral distortion after 4th use. These results are confirmed by another study in which HyFlex showed distortion after 3rd use. In the ProTaper group no spiral distortion was observed except for S1(20%) which is in accordance with previous studies²⁶. There was a little warning sign (i.e unwinding) before a ProTaper file might separate in use. This observation has also been agreed by a few authors^{26, 9,42}.

There have been two methods described in the endodontic literature to identify the mode of instrument separation. One is lateral-view examination², but that fails to indicate the actual mechanism involved in the fracture process. The other is a detailed, systematic (so-called 'fractographical') examination of the topographical features of the fracture surface to reveal the failure history of the part^{23,10,36,37}. But as a limitation in our study we have used lateral examination described by the authors.

Recently it has been postulated that the reciprocating motion increases the cyclic fatigue of the instrument^{38, 39,40,2,13}. Future possible research could be the incorporation of this motion in the present studied rotary systems and observation of stress distribution along the instrument using FEA¹¹.

CONCLUSION:

Based on the results of this study manufacturer's claim has to be tested and Hyflex did not regain its shape and strength after subsequent use as per the manufacturer's claim but the only thing is that it alerts the operator with visible verification whereas in ProTaper it is not.

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