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Tackling with Buckling: Force –Heat – Weakness

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Abstract: Exploration of canal is first step of endodontic therapy giving a three dimensional picture of canal complexities. The aim was to compare the buckling resistance of endodontic pathfinding instruments. Five groups of endodontic files each containing 10 were tested for buckling resistance by application of load in axial direction using a Universal Testing Machine. The load required to generate a lateral displacement of 1 mm were recorded and analysed for statistical significance. The importance of stainless steel alloy and heat tempering was justification for the results showing higher resistance to buckling for C+ files followed by ProFinder and K-files. Nickel titanium instruments proved to have least resistance to plastic deformation under vertical loads.

Keywords: calcified canals, glide path, pathfinding instruments

I. INTRODUCTION

Instrumentation of the root canal system begins with the most important and basic step of canal negotiation. This step allows the clinician to gain first-hand knowledge of the complexity of the canal system. Multiple good quality radiographs help in the task but do not give a three dimensional overview of the canal system. During exploration, the clinician can verify the number of canals, establish unimpeded access to the most apical part of the canal, and gauge the anatomic apical canal diameter.(1)(2)

Typically, for this step, small files are preferred as they confirm to the canal anatomy and follow the canal intricacies. However, due to their small diameter, lack of rigidity and presence of calcifications and other aberrations in the canal, these files often buckle or develop plastic deformation under vertical loads.

Buckling can be defined as the elastic lateral deformation of an endodontic instrument when subjected to a compressive load in the direction of its axis.(3) Instruments with low buckling resistance may develop elastic or plastic deformation that hinders their apical progression in the canal. This behaviour is different from flexibility, which can be defined as the elastic deformation of the instrument induced by the application of a load perpendicular to the axis of the instrument.(4)

Manufacturers have tried to overcome this problem by altering tip geometry, by heat tempering stainless steel to increase stiffness, or by using carbon steel to enhance sharpness. Changes in pitch, design, shape and taper have also been advocated to increase rigidity and minimise deformation. Pathfinding instruments with adequate buckling resistance may facilitate both the location of the canal orifices and access to the apical third of the canal.(5)

This study was undertaken to compare buckling resistance of different endodontic pathfinding instruments.

II. MATERIALS AND METHODS

Ten samples each of five different pathfinding instruments (n=10) were selected for this study (Fig. 1). These include

1. C+ files (Maillefer/Dentsply, Ballaigues, Switzerland), which are stainless steel instruments with an apical diameter in D_0 of 0.10 mm.
2. K-file (Mani, Japan) with ISO size 10 having D_0 of 0.10mm.
3. ProFinder (Maillefer/Dentsply, Ballaigues, Switzerland) with D_0 of 0.10mm.
4. NiTiFlex files (Maillefer/Dentsply, Ballaigues, Switzerland) with apical diameter at D_0 of 0.15mm.
5. PathFiles (Maillefer/Dentsply, Ballaigues, Switzerland) with D_0 of 0.13mm.

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Figure 1Instruments used (from left to right) C+ files, ProFinder, K-file, NiTiFlex, PathFile

For testing buckling resistance a model devised by Lopes et al was used.(6) An increasing load was applied in the axial direction of each instrument by using a universal testing machine. The maximum load until buckling (elastic lateral deformation) was recorded. For this a cavity was machined in a metal block with a round bur and was 1 mm in diameter and 0.5-mm deep. A load was applied in the axial direction from the handle to the tip, with a speed of 3 mm/min until a lateral elastic (compressive) displacement of 1 mm occurred. The maximum load needed to induce the elastic displacement of the instrument up to 1 mm was regarded as the buckling resistance of the instrument. (Fig. 2) This was repeated for all the 50 samples from the five groups. Data were statistically evaluated by the one way analysis of variance (ANOVA) test and post hoc Tukey HSD Test using SPSS 16 software.

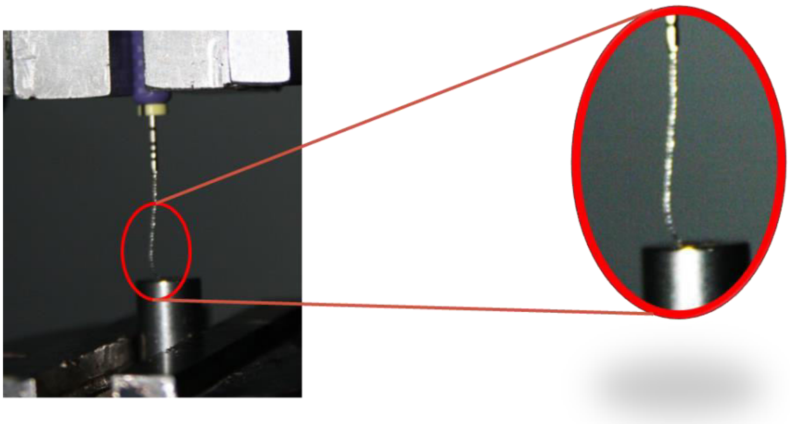

Figure 2 Buckling of instrument under Universal Testing Machine

III. RESULTS

The results indicated that there was a highly significant difference between K file vs. C+ files, NiTiFlex files and PathFiles (P<0.001). PathFiles and NiTiFlex files showed no significant difference among each other. C+ files had maximum resistance to buckling followed by ProFinder and K files (Table No.1).

Table 1 Mean Scores of Buckling Resistance

Instrument	Size at D_0(mm)	Mean load (N)
C +	0.10	1.29 ±0.32*
K- file	0.10	0.93±0.14
ProFinder	0.10	1.00±0.09
PathFile	0.13	0.36 ±0.06
NiTiFlex	0.15	0.41±0.05

*Mean Score ± Standard Devaiation

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Nickel titanium based files had the least resistance to buckling force with NiTiFlex files faring marginally better than PathFiles.
In descending order of buckling resistance the following inference can be drawn.
C+ >ProFinder> K File >NiTiFlex>PathFiles

IV. DISCUSSION

The importance of high buckling resistance is seen in negotiation of constricted curved canal. Most small instruments (sizes ISO 06, 08 and 10) essential for negotiating these canals have poor resistance to buckling and are unable to negotiate these calcified canals.(2) These factors can lead to iatrogenic problems like ledges and perforations during the exploration of narrow curved canals and then jeopardize the treatment outcome.(5)(7)
The instruments tested in the study were of different taper, size and metallic alloy but all belonged to the category of pathfinding instruments. Also, these factors of instrument design and metallurgy help explain our results.
The C+ files used in the study have a taper of 0.04mm/mm in the apical 4mm of the instrument. Due to greater taper, it has a stronger core which can resist higher force directed apically during negotiating constricted and calcified canals. Similar to this the ProFinder file also has a higher taper in apical portion of the instrument followed by a decrease in taper. The decrease in taper is essential as it will not compromise in the flexibility of the instrument. Having an instrument with greater taper throughout will give a higher resistance to buckling but will not solve the problem; as the instrument will become rigid and cause iatrogenic errors like stripping, ledging or zipping of the canal.
Another added advantage is that the three instruments (ie. C+, ProFinder and K-file) are manufactured by twisting of stainless steel alloy followed by heat tempering. The process of heat tempering increases the rigidity by work-hardening.
The PathFile and NiTiFlex instrument are both manufactured of nickel titanium alloy. Although these instruments are useful in exploration of canals and establishing a glide path, their use in negotiating calcified canals is limited. This can be attributed to the fact that nickel titanium metal has lower modulus of elasticity compared to that of stainless steel alloy.

V. CONCLUSION

The importance of buckling resistance in endodontic instruments in negotiation of calcified canals is high. Manufacturers have tried altering the metallic alloy, tip geometry and taper of the instrument to achieve higher buckling resistance. The advent of nickel titanium alloy does not improve the resistance to buckling force as observed in the results. It is evident that use of stainless steel alloy with greater apical taper and heat tempering improves buckling resistance.

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