Buckling Resistance Evaluation Of Path Finding Endodontic Instruments – An In Vitro Study

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Abstract
Exploring the root canal is an important step in the treatment process because it is the first time the dentist or doctor sees the anatomy of the canal.
"Endodontic glide path means that there is a smooth path from the opening of the canal to the tip of the root" (West J., 2010). "Glide path preparation is the first step in chemo-mechanical preparation. It is a crucial step for figuring out the root canal anatomy and making sure the entrance into the apical part of the canal is smooth. The glide path can be made by hand or with nickel-titanium (NiTi) rotary files with a small tip diameter and taper" (Peter OA, Peter Cl., 2010).
Due to their tiny diameter, lack of rigidity, and presence of calcifications and other aberrations in the canal, small canals are difficult to navigate. These files frequently buckle or develop plastic deformation when subjected to vertical stresses.
Keywords: Root Canal, canal anatomy, chemo-mechanical, anatomy, nickel-titanium, calcifications, deformation

Introduction
The elastic lateral deformation of an endodontic instrument under a compressive stress in the direction of its axis is known as buckleing. Low buckling resistance instruments may experience elastic or plastic deformation that prevents them from advancing apically in the canal (Helio P. et al., 2012).

An important characteristic of pathfinding tools is resistance to buckling, which enables them to be advanced in the apical direction around anatomical obstructions while exploring constrained, curved canals. When using an endodontic instrument in a curved canal, cyclic fatigue fracture might happen. Cycles of tension and compression are continually produced at the point of maximal flexure as the instrument rotates along the curvature, eventually leading to fracture.
The amount of cycles an instrument can withstand under a particular stress scenario before fracture occurs is known as the cyclic fatigue resistance. Clinicians are quite concerned about cyclic fatigue-related fracture because it frequently occurs suddenly.
By changing the tip geometry, heat tempering stainless steel to increase stiffness, or utilising carbon steel to improve sharpness, manufacturers have attempted to solve this issue. "To increase rigidity and reduce deformation, changes in pitch, design, shape, and taper have also

been recommended. Access to the apical part of the canal as well as the location of the canal orifices may be facilitated by pathfinding tools with sufficient buckling resistance. They frequently wound watches and/or rotate in a clockwise direction. They should have increased resistance to torsional load for safety" (Helio P. et al., 2012)

Aims and Objectives

The objective of this study is to assess and compare the elastic lateral deformation-induced buckling resistance of several endodontic pathfinding devices. These are the goals:

(i) To assess the buckling resistance of three rotary pathfinding instruments and five endodontic hand pathfinding devices.

(ii) To assess how well hand files and rotary files resist buckling.

(iii) To compare the pathfinding files manufactured of various metals for buckling resistance.

Review of Literature

In 1997, James Wolcott Van T. Himel evaluated "the torsional characteristics of nickel-titanium U-type and stainless steel K-type.02 and.04 taper instruments. All three instrument designs were subjected to ANSI/ADA specification number 28-required torque tests. Twenty instruments in each of the three sizes (15, 25, and 35) were evaluated for each design. The maximal torque, the torque at failure, and the angular deflection were the three parameters that were measured. Instruments made of nickel-titanium U-type.02 and.04 taper and stainless steel K-type.02 taper met or surpassed specification standards for maximum torque".

Based on the findings of a 2005 study by Patio PV, Biedma BM, Liébana CR, Cantatore G, and Bahillo JG, they advise "using stainless steel hand files to prepare the apical third of curved canals before introducing rotary files. The study examined the fracture rate of Ni-Ti rotary instruments when following a manual glide path and using stainless steel hand files."

Endodontic pathfinders' dimensional parameters, pitch, and rigidity were compared by Michael J. Allen and Gerald N. Glickman in 2007. "Efficiency, wear, and distortion were evaluated using an in vitro simulation exercise. Images of the tip and SEM cross-sections were collected and examined. They came to the conclusion that a variety of parameters, such as tip design, spiralling degree, taper, cross-sectional design, heat tempering, metal type, operator abilities, and clinical settings, can affect pathfinder efficiency".

A 2009 study by Hélio P. Lopes, Alessandra A.P. Ferreira, and Carlos N. Elias examined the "impact of rotational speed on the number of cycles needed to fracture rotating NiTi instruments. The findings showed that as rotational speed was increased from 300 to 600 RPM, the measured number of cycles to fracture decreased by about 30%. The morphology of the fractured surface was invariably of the ductile type, and the helical shaft of the shattered instruments did not exhibit any plastic deformation. They came to the conclusion that the results for the F3 and F4 ProTaper instruments showed that the number of cycles to fracture was greatly decreased by increasing rotational speed".

In order to investigate the stress-induced martensitic phase transformation in NiTi at the nanoscale scale, Jia Ye, Raj K. Mishra, Alan R. Pelton, and Andrew M. Minor carried out "quantitative nanocompression tests in 2009. They were able to gather concrete proof that the stress-induced B2-transformation does take place in NiTi, even in samples smaller than 200 nm. They discovered that the transition took place across a number of steps, showing sequential martensitic variant nucleation at progressively greater stresses. Even after a later heat treatment, the alteration in our nanopillars was irreversible when the nominal engineering strain value exceeded 20%."

In order to determine the impact of electropolishing surface treatment on the number of cycles before fracture of BioRace rotational nickel-titanium endodontic instruments, Hélio P. Lopes, Carlos N. Elias, and Victor T.L. Vieira conducted a study in 2010. "They came to the conclusion that electropolishing the surface of BioRace endodontic instruments considerably boosted the instruments' resilience to cycle fatigue."

In 2011, Luca Testarelli, Gianluca Plotino, and Dina Al-Sudani conducted research "to assess the bending characteristics of Hyflex instruments, which have a lower weight percentage of nickel (52 Ni%wt), and compare them to other nickel-titanium (NiTi) rotary instruments that are commercially available." They came to the conclusion that the new NiTi alloy is more flexible than the old NiTi alloy, and they emphasise the potential of the new manufacturing technique.

Pereira, E. S. J. A 2012 study by F. C. Peixoto, A. C. D. Viana, and Oliveira examined the "physical and mechanical characteristics of two types of nickel-titanium (NiTi) wire used to make rotary endodontic instruments. They came to the conclusion that the M-Wire possessed mechanical and physical characteristics that may make endodontic tools more pliable and fatigue-resistant than those created using NiTi wires that had undergone normal processing."

In 2012, Jung-Hong Ha and Sang- Shin Park looked into "how the size of the gliding path affected the screw-in effect and torque generation during root canal preparation. For securely shaping the canal, the construction of a wider glide path prior to NiTi rotary instrumentation seems acceptable. When utilising the ProTaper NiTi rotary instruments system safely, it is advised to establish # 20 glide path with NiTi file."

2013 saw a comparison of the buckling resistance of endodontic pathfinding instruments by doctors Nikhil B, Shaikh S, and Amit Pl. "Buckling resistance in endodontic instruments is crucial for navigating calcified canals. To increase buckling resistance, manufacturers have experimented with changing the metallic alloy, tip geometry, and taper of the instrument. As seen in the results, the introduction of nickel titanium alloy did not increase the resistance to buckling force. The usage of stainless steel alloys with increased apical taper and heat tempering is clearly beneficial for buckling resistance."

In 2014, a study was conducted by Lucila Piasecki, DDS, MSc, Dina Al-Sudani, DDS, MSc, and Alessio Giansiracusa Rubini, DDS, MSc "to compare the cyclic fatigue resistance of these two various manual Pathfinder instrument types when used in an M4 reciprocating handpiece in double curved artificial canals. According to the findings, when utilised with an M4 reciprocating handpiece in double-curved canals, both carbon and stainless steel instruments displayed a comparable level of fatigue resistance."

In 2014, A. M. Elnaghy and S. E. Elsaka compared the "ProGlider (PG; Dentsply Maillefer, Ballaigues, Switzerland) and PathFile (PF; Dentsply Maillefer) pathfinding nickel-titanium rotary instruments' resilience to cyclic fatigue, torsional stress, bending, and buckling. When compared to Path- File instruments constructed of traditional NiTi alloy, ProGlider NiTi pathfinding instruments produced from M-Wire alloy showed improved mechanical qualities, including higher flexibility, higher resilience to cycle fatigue, and higher tolerance to torsional stress. Buckling resistance was similar for both instruments."

Five nickel-titanium rotary path-finding instruments' cyclic fatigue resistance was compared in 2015 by Ismail Davut Capar and Mehmet Emin Kaval. "They come to the conclusion that the HyFlex GPF performed best in terms of cycle fatigue resistance, while the other instruments were ranked as follows in decreasing order of fatigue resistance: Scout Race > G-File > ProGlider > PathFile. The cyclic fatigue resistance of the HyFlex GPF instrument was the highest, and the curvature radius significantly affected the fatigue resistance. The curvature radius had a significant influence in the cyclic life span of the instruments."

In order to assess the wear and test the fatigue resistance of new rotary instruments made using electro discharge machining, F. Iacono, C. Pirani, L. Generali, and P. Sassatelli conducted a study in 2016. "They came to the conclusion that the spark-machined surface produced by the electro discharge machining production technique remains undamaged after numerous applications. Cyclic fatigue experiments showed that HyFlex EDM's fatigue lifetime was significantly impacted by the thermomechanical treatment processes."
In 2016, Zhuyu Wang, Wen Zhang, and Xiaolei Zhang conducted research "to assess the force produced by OneShape files during the creation of simulated curved canals as well as the cycle fatigue resistance. They came to the conclusion that the OneShape files had dependable flexibility and resistance to cyclic fatigue. In comparison to ProTaper F2 files, OneShape instruments performed better during the production of curved canals based on assessments of the forces created by files".

In 2016, a study was undertaken by Ibrahim Ersoy, Elif Kol, Ahmet Demirhan Uygun, and Mehmet Tanriver to "compare the cyclic fatigue (CF) resistance of the F360, twisted files (TF), FlexMaster (FM), and RaCE instruments with 4% taper. 40 instruments in total were examined 8 mm from the tip. CF testing was performed on a stainless steel block with a simulated 1.5 mm-diameter canal and a 60° angle of curvature. The CF resistance of the F 360 files was the highest, while the TF files were more CF resistant than the FM and RaC. The FM and RaCE instruments were less fatigue-resistant than the NiTi rotary files thanks to the TF."

MATERIALS AND METHODS

The Department of Conservative Dentistry and Endodontics at the School of Dental Sciences Karad conducted the current study. The buckling resistance testing was done in Metallurgical Laboratory, Pune.

Materials:

Armamentarium:

(i) Aluminium Block.
(ii) Airotor Hand-Piece (NSK, Japan)
(iii) Round Bur

Fig 1: Armamentarium

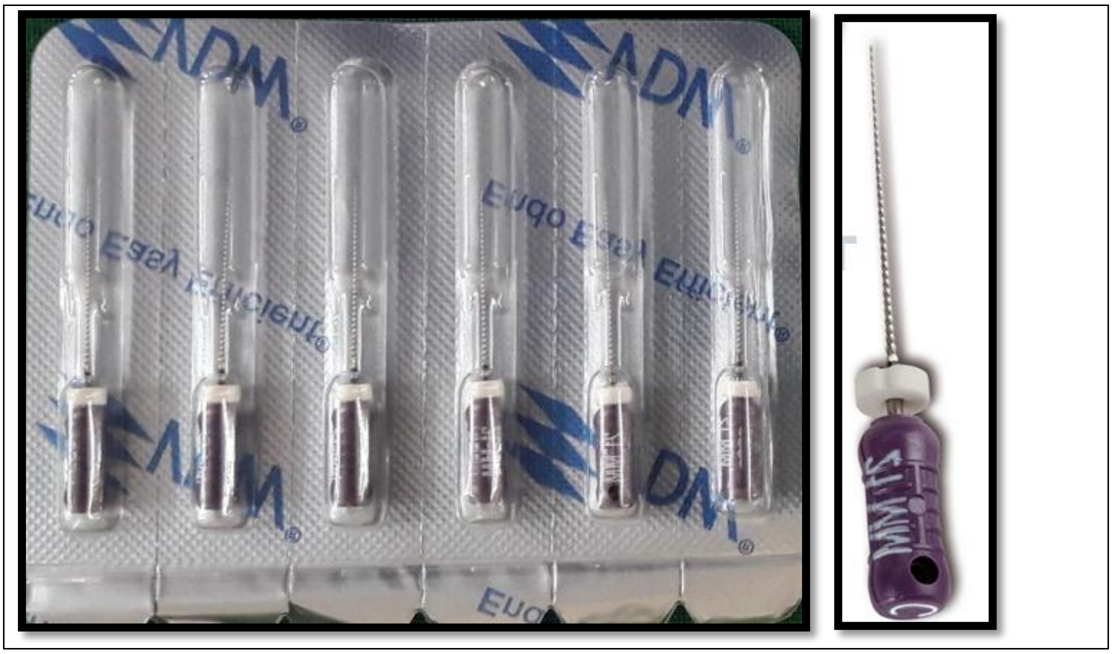
The pathfinding files were divided into 2 major groups based on the mode of use i.e, Hand instruments and Rotary instruments.

(a) Group I- Hand Pathfinding Instruments
(b) Group II - Rotary Pathfinding Instruments

Group I - Hand Pathfinding Instruments

Sub group 1- C pilot files (VDW, Munich, Germany)

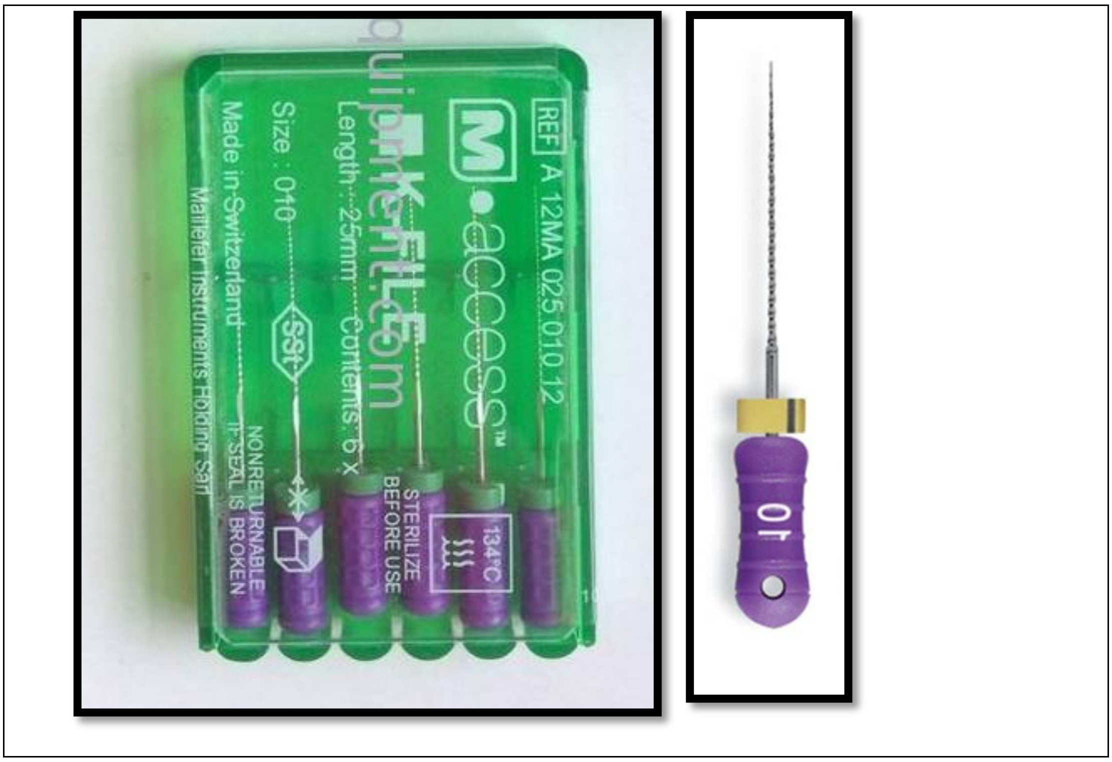
Fig 2: C pilot files



C pilot files(VDW, Munich, Germany)- “These are stainless steel instruments with a tip diameter in D0 of 0.10 mm and a length of 21 mm; the instrument taper is 0.02 mm/mm along the entire shaft.”

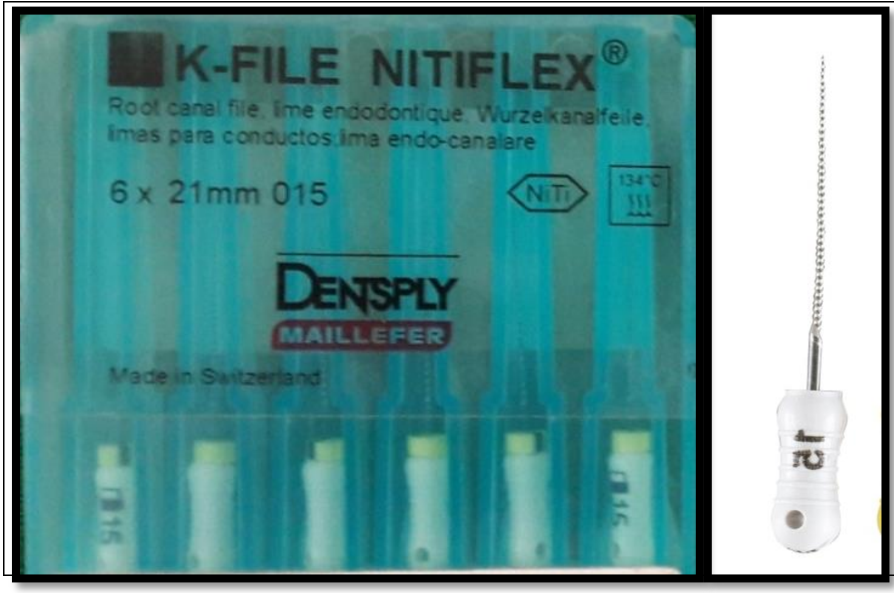
Sub group 2- K file (Dentsply Maillefer)

Fig 3: K files



K file (Dentsply Maillefer) “These are stainless steel instruments with a tip diameter in D0 of 0.10 mm and a length of 21 mm; the instrument taper is 0.02 mm/mm along the entire shaft.”

Sub group 3 – NITI flex files (Dentsply Maillefer)
Fig 4: NITIFLEX File: NITI flex files (Dentsply Maillefer)



"These are Nickel-titanium instruments with a tip diameter in D0 of 0.15 mm and a length of 21 mm; the instrument taper is 0.02 mm/mm along the entire shaft".

Sub group 4- Pathfinder CS (SybronEndo)
Fig 5: Pathfinder CS

Pathfinder CS (SybronEndo) "These are Carbon steel instruments with a tip diameter in D0 of 0.7 mm and a length of 21 mm; the instrument taper is 0.02 mm/mm along the entire shaft".

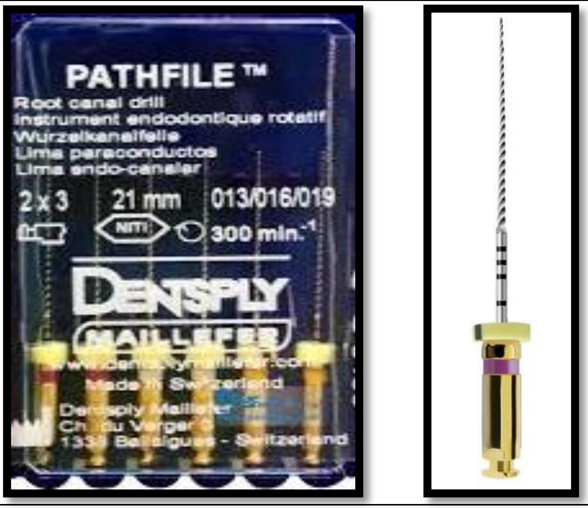
Sub group 5-Pathfinder SS (SybronEndo)
Fig 6:Pathfinder SS

Pathfinder SS (SybronEndo) – "These are stainless steel instruments with a tip diameter in D 0 of 0.7 mm and a length of 21 mm; the instrument taper is 0.02 mm/mm along the entire shaft."

Group II- Rotary Pathfinding instruments

Sub group 1- Path file (Dentsply Maillefer)

Fig 7: Path file



Path file (Dentsply Maillefer)- "These are Nickel- titanium instruments with a tip diameter in D0 of 0.13 mm and a length of 21 mm; the instrument taper is 0.02 mm/mm along the entire shaft."

Sub group 2 - G file (MICRO-MEGA)

Fig 8: G files

G-file (MICRO-MEGA)- "These are Nickel-titanium instruments with a nominal tip in D0 of 0.12 mm and a length of 21 mm; the instrument taper is 0.03 mm/mm along the entire shaft".

Sub group 3- Proglider. (Dentsply Maillefer)

Fig 9: Proglider

Proglider (Dentsply Maillefer) – "These instruments are manufactured from M–wire alloy with a tip diameter in D 0 of 0.16 mm and a length of 21 mm; the instrument taper is 0.02 mm/mm along the entire shaft".

Equipment used:
Universal testing machine (Star Testing System)
Fig 10: Universal testing machine model no. UNITEST 10

Method

Twenty endodontic files from each of eight subgroups were evaluated for buckling resistance employing an axial load on a universal testing machine. A universal testing machine will apply an increasing axial load to each instrument during the buckling test. (DL 10.000; Eheadmic,sao Joedos Pinhais, PR).

There will be a record of the maximum load before buckling. We'll employ a 20 N load cell. The instrument tip will be in touch with the bottom of a small concavity formed in an aluminium block, and the instrument handle will be fastened to the head of the universal testing machine. The concavity will be 0.5 mm deep and 1 mm in diameter after being machined with a round bur.

Up until an elastic lateral displacement of 1mm occurs, the load will be delivered axially at a pace of 1mm/minute from the handle to the tip. The greatest load that will cause the instrument to move elastically up to 1mm per minute will be regarded as the instruments' buckling resistance.

Results

This study compared several pathfinding endodontic instruments' buckling resistance and evaluated it. The two main kinds of pathfinding files, hand instruments and rotary instruments, are dependent on the manner of operation. Using a universal testing machine, an additional load was delivered in the axial direction to each instrument for the buckling test.

Table No 1: Buckling load results reported at 1mm deflection of the file.
Table 2: Descriptive Statistics (Minimum value, Maximum value, Mean, SD) for Buckling load among overall groups.
Table 3: Descriptive Statistics (Minimum value, Maximum value, Mean, SD) for Buckling load among individual group.
Table 4: Comparing All 8 subgroup instruments for Buckling load values by ANOVA (Analysis of Variance).
Table 5: Individual group Comparison (one to one) Buckling load values among 8 pathfinding instruments by Tukeys Post Hoc Test.

Table 1: Descriptive Statistics (Minimum value, Maximum value, Mean, SD) for Buckling load among overall groups

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
BUCKLING LOAD	160	0.200	2.100	0.74969	0.373724

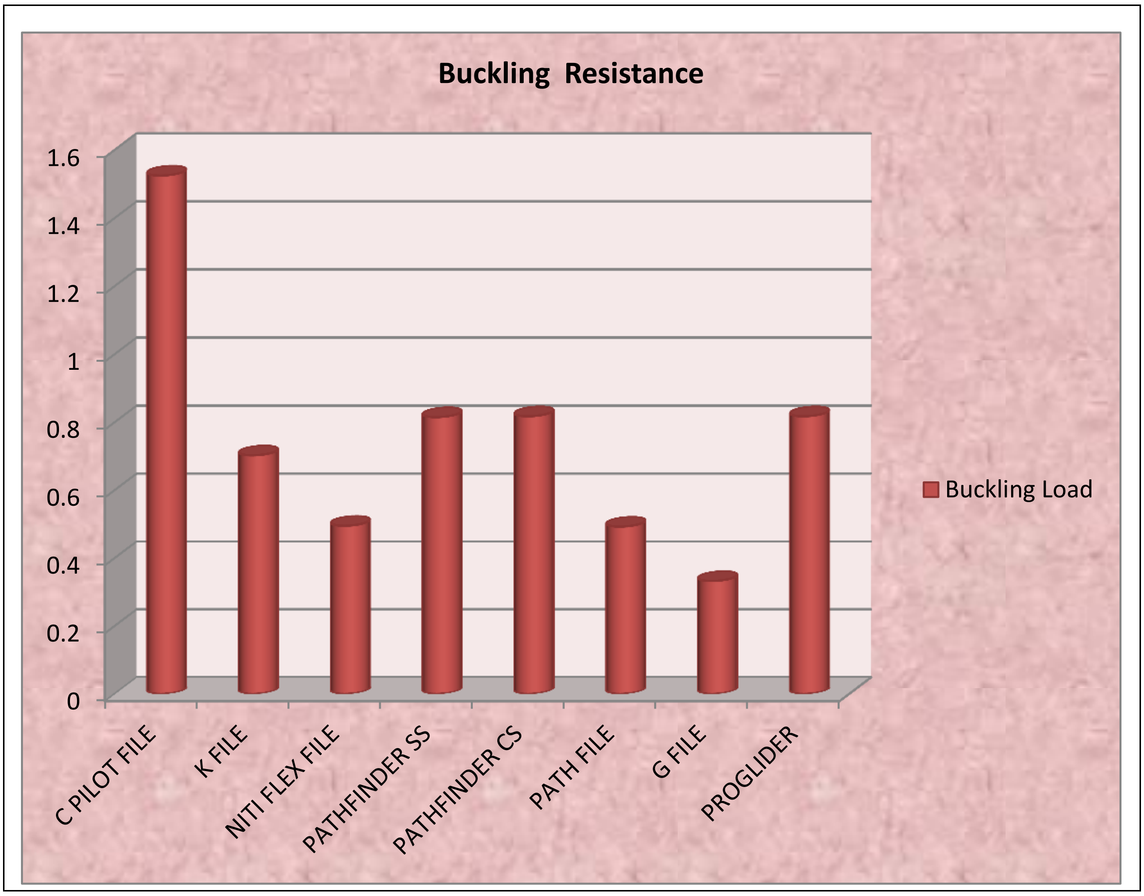
Table 2: Descriptive Statistics(Minimum value, Maximum value, Mean, SD) for Buckling load among individual group

Descriptive Statistics						
GROUP		**N**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
C PILOT FILE	BUCKLING LOAD	20	1.100	2.100	1.52500	0.285851
K FILE	BUCKLING LOAD	20	0.300	1.250	0.70250	0.243589
NITI Flex FILE	BUCKLING LOAD	20	0.350	0.550	0.49500	0.055961
PATHFINDER SS	BUCKLING LOAD	20	0.500	1.050	0.81500	0.132883
PATHFINDER CS	BUCKLING LOAD	20	0.700	0.900	0.81750	0.063401
PATH FILE	BUCKLING LOAD	20	0.350	0.600	0.49250	0.061291
G FILE	BUCKLING LOAD	20	0.200	0.550	0.33250	0.093577
PROGLIDER	BUCKLING LOAD	20	0.600	1.150	0.81750	0.141677

Table 3: Comparing All 8 Subgroup instruments for Buckling load values by ANOVA (Analysis of Variance)

ANOVA					
BUCKLING LOAD					
	Sum of Squares	**Df**	**Mean Square**	**F**	**Sig. p value**
Between Groups	**18.437**	**7**	**2.634**	**106.183**	**<0.001**
Within Groups	**3.770**	**152**	**0.025**		
Total	**22.207**	**159**			

Graph 1: Showing Mean Buckling Resistance of various Pathfinding Instruments.



Discussion

"The goals of Endodontics as stated so clearly by Schilder, Root canal system must be cleaned and shaped: cleaned of their organic remnants and shaped to receive a three dimensional hermetic filling of the entire root canal space. The goal for cleaning and shaping of the root canal system is to obtain a continuously tapering funnel from the coronal access to apex that flow with the shape of the original canal .Preparation of canal especially the apical segment, without weakening the remaining dentin or perforating the root is essential to proper infection control and obturation and to long term success" (Ibrahim Ersoy. et al., 2016).

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In endodontics, “glide path preparation has been defined as a series of clinical procedural steps that aim to enlarge or preshape the root canal from its orifice to its physiological terminus before using greater tip diameter and tapered shaping files. Glide path is the presence of a smooth path from the canal orifice to the root apex. Glide path preparation is considered as the first phase of mechanical preparation and is accepted as a critical stage for assessing the root canal anatomy and ensuring the smooth entrance into apical portion of the canal .Glide path can be prepared manually or by using various rotary files with small tip diameter and taper”.

“Glide path creation has been extensively recommended as a mandatory clinical step to improve the safety and efficiency of rotary instruments by preventing the taper lock phenomenon, thus increasing the instrument’s life span by diminishing fracture rates and preventing shaping errors” (Gustavo De-Deus., 2016).

“Flexibility is an important feature of instruments and can be defined as the elastic bending of an endodontic instrument when subjected to a load applied to its extremity in the direction that is perpendicular to its long axis. The instrument should be flexible enough to be taken beyond the curvature during negotiation and then be operated along curved canal walls without promoting iatrogenic alteration of the canal shape” (Michael J. Allen, Gerald N. Glickman., 2007).

“Buckling can be defined as the lateral deformation of an endodontic instrument when subjected to a compressive load in the direction of its axis. Instruments with low resistance to buckling are expected to develop elastic or plastic deformation that hampers their apical advancement in the canal. Such behaviour is different from flexibility because the latter is related to the application of a load perpendicular (and not parallel) to the axis of the instrument .Resistance to buckling is an important property of path finding instruments, allows to advance in the apical direction around anatomic impediments during exploration of narrow curved canals” (Michael J. Allen, Gerald N. Glickman., 2007).

“Cyclic fatigue fracture occurs when an endodontic instrument is operated in a curved canal. As the instrument rotates along the curvature, cycles of tension/ compression are repeatedly generated at the point of maximum flexure until fracture occurs. The cyclic fatigue resistance comprises the number of cycles that an instrument can endure under a specific loading condition until fracture occurs. Fracture by cyclic fatigue is a great reason of concern for clinicians because it can usually develop unannounced” (Michael J. Allen, Gerald N. Glickman., 2007).

“Torsional fracture occurs when the instrument’s tip becomes immobilized in the canal and a rotation load is applied to the opposed extremity of the instrument in such a way that this load exceeds the resistance to torsional fracture of the instrument. Torsional strength is related to how much a file can twist before fracture and is desirable in the preparation of narrow and constricted canals as the file is subjected to high torsional loads. Similarly, in curved canals, the resistance to bending influences instrumentation" (Ninan E., & David W. 2013)

Since the early 1990s, "several instruments system manufactured from nickel-titanium have been introduced into the endodontic practice.Nickel-titanium (NiTi) alloys have become the most popular shape memory alloys that have a wide range of biomedical applications owing to their unique ability to recover their original shape after undergoing large deformations (up to 8%) through heating, known as shape memory effect, or through removal of the load, known as super elastic effect. Endodontic instruments made of NiTi alloys have been widely selected by endodontist for removing dead or infected tissue and shaping canals to facilitate obturation because they have much greater flexibility owing to their low elastic modulus and superelasticity compared with traditional files made of stainless steel" (Capar I.D.., 2015). "NiTi files present several advantages compared with stainless steel files, such as higher flexibility, fewer canal aberrations, and a shorter procedural duration" (Ibrahim Ersoy. et al., 2016).

Recently, "there has been an increasing interest and renewed focus on reciprocation, which may be defined as any repetitive up-and-down or back-and-forth motion. However, all current market version reciprocating motors produce a file movement where the clockwise (CW) and counterclockwise (CCW) degrees of rotation are equal. Equal bidirectional movement requires undesirable inward pressure, limits cutting efficiency, and does not optimally auger debris out of the canal" (Clifford J. Ruddle., 2013).

"The latest advancements in canal preparation techniques have moved toward the long-hoped-for *single-file* concept. ReDent-Nova (Israel) recently introduced the Self Adjusting File (SAF), available in the United States through Henry Schein Dental. This file has a compressible open-tube design that is purported to exert uniform pressure on the dentinal walls, regardless of the cross-sectional configuration of the canal" (Clifford J. Ruddle., 2013).

"Even though there has been considerable improvement in file design, manufacturing methods, and preparation techniques on endodontic rotary instruments made of NiTi alloys, rotary instrument intracanal separation caused by cyclic fatigue has remained a primary concern in the practice of endodontics, especially for root canals with severe curvatures. The mechanical performance of NiTi alloys is extremely sensitive to their microstructures and associated thermomechanical treatment history" (Clifford J. Ruddle., 2013).

Consequently, one of several viable options To enhance the microstructure of NiTi alloys by novel thermomechanical processing or new manufacturing techniques has resulted in NiTi instruments with better alloys, which are said to boost the instruments' cyclic fatigue resistance. Recently, a novel NiTi wire (dubbed M-Wire) was created using a secret thermomechanical processing technique. When compared to goods constructed of traditional superelastic NiTi alloys, M-Wire considerably enhanced cyclic fatigue resistance on endodontic rotary tool items. All three crystallographic phases—deformed and microtwinned martensite, R-phase, and austenite—are present in M-Wire.

One of these innovations in the production of endodontic tools is controlled memory (CM) NiTi wires. Manufacturers claim that a new method is used to regulate the memory of the material during the production of CM NiTi wires, giving them increased resistance to flexural fatigue and torsional failure. At 37°C or room temperature, the CM wires showed no signs of SE; but, when heated to 60°C, they did. Due to the unique heat treatment history of CM wires, they displayed unusual phase transition behaviour and mechanical characteristics when compared to SE wires.

This study compared several pathfinding endodontic tools' buckling resistance and evaluated them. The two main kinds of pathfinding files, hand instruments and rotary instruments, are dependent on the manner of operation. A universal testing machine will apply an increasing axial load to each instrument during the buckling test.

In Group-I (Hand pathfinding instruments):
Intergroup comparison was done using Tukey's Post hoc Test. The C pilot file showed higher buckling resistance (1.52N) than other pathfinding instruments. As C pilot file has modified square cross-section, has a larger area to resist buckling, these instrument are manufactured by twisting a stainless-steel wire which has a higher modulus of elasticity. Both Pathfinder SS (0.81 N) and Pathfinder CS (0.82N) showed better buckling resistance than K file(0.70 N)and NITI flex instruments (0.49 N) however showed lower buckling resistance than C-Pilot file (1.52N). However pathfinding CS is more stiffer than stainless steel alloy it showed lower buckling resistance than C –pilot file ,as it has modified square cross-section, has a larger area to resist buckling, these instrument are manufactured by twisting a stainless-steel wire. K file showed better buckling resistance than NITI flex. NITI flex showed least buckling resistance (0.49 N) in this group because of lower modulus of elasticity.

In Group-II (Rotary pathfinding instruments):
Intergroup comparison was done using Tukey's Post hoc Test. Pro-Glider, which is manufactured by M wire NiTi as single-file glide path system, showed higher buckling resistance (0.82 N) than Path file (0.49 N) and G file (0.33 N)which are made up of conventional austenite NiTi alloy. "ProGlider's gradually increasing taper structure provides larger metal core mass and ProGlider file has higher apical tip diameter than Path file and G-File file has" (Gustavo De-Deus., 2016).

Therefore, compare all 8 Pathfinding instruments for Buckling load values by ANOVA (Analysis of Variance). The C pilot file (1.52 N) showed highest buckling resistance than other pathfinding instruments. Moreover, "the G file (0.33 N) instrument had the lowest resistance to buckling, and this may be related to the fact that these instruments are made of NiTi alloy, which has a lower modulus of elasticity in relation to the stainless steel alloy".[1]

[1] *Ibid*

“There are multiple factors that can influence pathfinder efficiency including tip design, degree of spiralling, taper, cross-sectional design, heat tempering, metal type, operator skills, and clinical conditions. File geometry, cross-sectional thickness, and the properties of the metal from which a file is constructed should dictate the degree of rigidity. The NiTi instruments performed less favourably in the buckling resistance test than the stainless-steel, carbon-steel, and M wire instruments. This is unquestionably connected to the NiTi alloy's reduced elasticity modulus.” (Allen M.J., Glickman G.N., 2007)

The NiTi rotary pathfinding instruments PathFile and G file may be considered less than suitable for initial exploration because in many cases the resistance to buckling is an important property of the pathfinding instrument, allowing it to be conducted beyond constrictions and other anatomic impediments. Maybe you should use them after inserting a stainless steel device only a few millimetres into the little channel.

Summary and Conclusions

When a concerted effort is made to create a reliable glide path, the effectiveness of root canal preparation is significantly increased. Additionally, there is a lower chance of unfavourable instrument fractures. Root canal shape has been assisted by the development of methods and tools especially intended for the creation of a glide path, which offer a variety from which the clinician may select in accordance with the pertinent design elements and performance traits.

These techniques can be particularly difficult in curved and small canals; as a result, problems or mistakes during the procedure are not unusual. The appropriate size and flexibility for instruments used for canal negotiation is to allow for safe and effective advancement in the apical direction. Additionally, when employing rotary equipment, “they should create an initial expansion of the canal that is smooth and cantered from its orifice to the physiologic terminal, the so-called glide route, which is crucial for continued proper sculpting of the root canal.”

Resistance to bending, buckling, cyclic fatigue, and torsional stress are mechanical qualities that might potentially affect how well tools used in root canal negotiating work (Mechanical Behaviour).

Access to the apical part of the canal as well as the identification of the canal orifices may be facilitated by pathfinding tools with sufficient buckling resistance.

This study compared the maximum force required to cause buckling of pathfinding devices and evaluated the buckling test for endodontic equipment. Despite the fact that the devices examined in this study varied in size, taper, and metallic alloy, they are all advised for canal negotiation. They were compared here for this purpose.

Amongst the different types of alloys evaluated for buckling resistance, the C pilot file showed highest buckling resistance which is made up of stainless steel alloy and has higher modulus elasticity. G files showed least buckling resistance, which are made up of conventional austenite NiTi, and lower modulus of elasticity. “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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