COMPARATIVE EVALUATION OF CYCLIC FATIGUE RESISTANCE OF FOUR DIFFERENT NOVEL ROTARY FILE SYSTEMS: AN IN- VITRO STUDY.

DISSERTATION

Submitted to

BABU BANARASI DAS UNIVERSITY

LUCKNOW, UTTAR PRADESH

In the partial fulfillment of the requirement for the degree

of

MASTER OF DENTAL SURGERY

In the subject of

CONSERVATIVE DENTISTRY& ENDODONTICS

Submitted by

DR. SHALU SHUKLA

Under the guidance of

DR. SANDEEP DUBEY

DEPARTMENT OF CONSERVATIVE DENTISTRY & ENDODONTICS

BABU BANARASI DAS COLLEGE OF DENTAL SCIENCES,

LUCKNOW

Batch:2021-24 **Enrolment No.: 12103222930**

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DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation entitled **"Comparative evaluation of cyclic fatigue resistance of four different novel rotary file systems: An in Vitro Study"**, is a bonafide and genuine research work carried out by me under the guidance of **DR. SANDEEP DUBEY**, Reader as a Guide and **DR. PALAK SINGH**, Senior lecturer as Co-Guide in Department of Conservative dentistry & Endodontics, Babu Banarasi Das College of Dental Sciences, Babu Banarasi Das University, Lucknow, Uttar Pradesh.

Date: 19/02/24

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CERTIFICATE BY THE GUIDE

This is to certify that the dissertation entitled **"Comparative evaluation of cyclic fatigue resistance of four different novel rotary file systems: An in Vitro Study"** is a bonafide work done by **DR. SHALU SHUKLA**, under my direct supervision & guidance in partial fulfillment of the requirement for the degree of **Master of Dental Surgery (M.D.S.)** in the speciality of Conservative Dentistry and Endodontics .

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DR.SHALU SHUKLA

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LISTOFABBREVIATIONS

ANOVA	Analysisofvariance
3D	3 DIMENSIONAL
SEM	SCANINGELECTRONMICROSCOPE
Ni-Ti	Nitinol
Ni	Nickel
Ti	Titanium
DOM	DENTALOPERATINGMICROSCOPE
NCF	NUMBEROFCYCLESTOFRACTURE
RPM	ROTATIONPERMINUTE
FL	FRAGMENTLENGTH
ADA	AMERICANDENTALASSOCIATION
CM	CONTROLMEMORY
EXF7	EDGEFILEX7
OC	ONECURVE
XPS	XPENDOSHAPER
TRN	TRUNATOMY
CFR	CYCLICFATIGUERESISTANCE

AIM: The purpose of the currentstudy wasto inspect and comparethe cyclic fatigue resistance of Edge filex7 ,One curve ,Trunatomy ,Xp endoshaper NiTi file systems.

DESIGN: Invitrocomparativestudy.

MATERIALS AND METHODS: Sixty nickel-titanium endodontic files were tested in simulated canals with60 degreeangle of curvature.The Edge file X7 (25/.04), One curve (25/.04),Trunatomy (26/.04) andXp endoshaper(30/.04) files were assessed (n=15). All the files were rotated up to fracture occurred. The number of cycles to fracture (NCF) was determined and also, the length of the fractured file part was measured.

STATISTICAL ANALYSIS USED: One-way anova with post hoc tukey analysis was used to compare the no. of cyclesbetween groups. the distribution and homogeneity of the variables were examined using the shapiro-wilk test and respectively. shapiro wilk test was used to check which all variables were following normal distribution.

RESULTS: At60 degree ,Edge file X7 has heighest resistance to cyclic fatigue than One curve,Trunatomy and Xp endoshaper.no ststistically significant differences were found in the cyclic fatigue lives of Edge filex7,One curve ,Trunatomy and Xp endoshaper (p>o.o5). SEM images of the fracture surface of the different instruments showed typical features of fatigue failure.

CONCLUSION: within the condition of this study at 60degree with a 5mm curvature radius, the cyclic fatigueresistance of Edge file X7 was not significantly different from those of One curve ,Trunatomy and Xp endoshaper .

Cleaning and shaping of the root canal system is one of the most important steps inthe success of endodontic therapyand is required for an effective treatment.[1] It requires enlarging and shaping the intricate endodontic space for appropriate placement of obturating materialas well as disinfection. According to Kakehashi (1965) and Siqueira (2001) one of the major cause ofendodontic failure is persistent microbial infection within the root canal system. Therefore, comprehensive chemo- mechanical preparation is necessary to ensure the effectiveness of root canal treatment.[2,3]

Schilder's concept for root canal cleaning and shaping aimed to create a three-dimensional continuous funnel tapering in multiple planes with adequate apical enlargement while maintaining foramen position and size.[4] These goals were classified as mechanical or biological. The mechanical goals were to create a continuous tapering funnel from the access cavity to the apical foramen, to keep the main canal on its original course during root canal preparation, to keep the apical foramen in its original position, and to maintain the apical opening as small as possible. The biological goals were to limit instrumentation to the root canals only, to ensure that no necrotic or instrumentation debris was pushed beyond the apical foramina, to achieve optimal root canal debridement, and, eventually, to create a sufficient space between the root canals. [4]

Root canal instrument were mostly composed of carbon steel up until the 1960s and have subsequently primarily been constructed of stainless steel. These earlier instrument manufacturing from carbon steel alloys' have primary drawback of poor corrosion resistance. Procedures for sterilisation of these instruments resulted in negative physical changes and extensive corrosion damage.

Although carbon steel instruments were said to be stronger and harder than dentine, they are known to frequently result in iatrogenic mistakes when used for instrumentation in curved canals. The apical foramen deformation, anatomical deviation of the canal, and perforations were the most prevalent defects, and they all had a serious drawback a reputation for being extremely destructive.

These issues were resolved by replacing them with stainless steel instruments, which are still in use today due to their advantages. These instruments are known for their rigid nature, exceptional strength, and good cutting efficiency. Theyalso offer limited flexibility when instrumenting curved canals.[5]

Numerous novelNiTi rotary instruments have recently entered the marketdue to advancement in technology. Nickel-titanium instruments are mainly manufactured from a 55-NiTi-alloy, thus they consist of approx. 55% nickel and 45% titanium by weight. This alloy is extremely flexible and NiTi instrumentshave demonstrated three times the elastic flexibilityin bending and torsion as compared to corresponding stainless steel instruments.[6] The fracture of endodontic instruments is not an uncommon mishap duringroot canal preparation. It mayoccur in 1%–6% of cases for stainlesssteelinstrumentsandapproximately0.4%–3.7%forrotaryNiTiinstruments.
[7,8]

Endodontic nickel-titanium (NiTi) rotary instruments show advantages over stainless steel instruments, such as their shorter treatment time, superior flexibility, and fewer canal aberrations NiTiendodontic filesprovide various benefits, including keeping the root canal's natural geometry and reducing the danger of perforation, ledge development, and zipping.[9-11]

At higher temperatures, NiTi rotary files have an austenite phase that, when cooled or stressed, can transform into a martensite phase. This phase transition allows for more flexibility. Thetransitionphasetemperaturesof filescan varydependingon thealloys and heat treatments used in the processing. [12]

Instrument separation is a common cause of treatment failure during endodontic management of infected teeth. It's a predicament that can make the patient extremely anxious in addition to causingthe clinician to experienceextremestress. Accordingto the American Association of Endodontists, the reported frequency rate for fractured instruments ranges from 0.7% to 6% of cases. [13]

Having said that according to literature Separation rates forNiTi rotary instruments have rates ranging from 1.3% to 10.0%. [14]

To use NiTi instruments safely in clinics, it is necessary to first understand the fundamental fracture mechanisms and how they relate to canal anatomy. They are prone to structural fatigue when used in a rotary motion, which can lead to fracture if the file's resistance exceeds a certain threshold. In the year 2000, Sattapan et al. discovered two types of fractures in rotary NiTi instruments:cyclic fatigue and torsional fracture.[15]

Torsional fracture occurs when the tip of an instrument is firmly engaged inside the rootcanalandthemotorcontinuestorotate.Thetorquewillexceedtheelasticlimit and the instrument will separate. Single overload of NiTi instruments has been identified as a major reason of fractures. It can also occur when the flutes of an instrument are packed with dentinal debris thereby increasing the torque above a critical limit. [16]

Cyclic fatigue occurs when a endodontic filerotates freely within a curved canal, creating tension/compression loops and eventually leading to breakage. When the instrument is static and then rotated, the outer half of the shaft is under tension, while the inner half is compressed. The instrument's susceptibility to cyclic fatigue risesover time due to repetitive use. [17]

Increasing the diameter of a rotary file proportionally enhances its resistance to cyclic fatigue, linked to the metal mass at the point of maximum tension. Lifespan of endododntic file is directly assosciated with the radius of root canal and its angle of curvature. Both in vitro and clinical studies confirm that heightened angle and radius severity result in a shorter lifespan for the instrument. [18]

Kaval et al. reported that incidence of file separation was predominantlyrelated to the cyclic fatigue in the range of 65–70% and a lesser extent by the torsional fatigue inthe range of 25–30%. similarly ubeda and pedullaConsidering that cyclic fatigue is the most common cause of instrument fracture.[19]

According to the study conducted by Cheung et al, the flexural fatigue failure was noticedtobetheprevalentmechanismforthefailureofinstrument. [20] Helaterinone of his related studies found that 93% failure of endodontic file is due to flexural fatigue. [21]

Accordingtopublisheddata,therearetwomethodsfortestingendodonticinstruments for cyclic fatigue: static and dynamic tests. The static test suggests that the tool is rotated until a fracture happens after being inserted to a predetermined depth into a model's simulated canal. The point of maximum stress in this type of testing is typically found in the curve's centre. Better knowledge about the effects of various instrument blade designs or the NiTi alloy's finishing on cyclic fatigue is gained with this type of test, which is crucial for instrument development and optimisation. In order to replicate a clinical setting, the dynamic test involves moving the instrumentin a simulated canal with a specific amplitude of vertical movements. A higher resistance to cyclic fatigue results from the instrument's movement-induced localizationofthe pointof maximumstressvaryingalongthefile.[22]According toLi et al. [23] a 1 to 3 mm vertical movement of the instruments increases the time to fracture by 15%.According to Keleş et al, fatigue resistance was significantly increased in the dynamic model for all instrument systems tested in their study.[24] However, temperature had no effect on the cyclic fatigue resistance results. Shen and Cheungalso gavepriorityto systems forlaboratorystudies that closelyimitatein vivo conditions. [25]

However,thedynamictest is moresensitiveto procedural errors becauseit is difficult to accurately determine the amplitude of axial movements, as well as the exact angle and path at which the instrument enters the artificial canal on the model . Accordingto Hülsmann et al.'s research, the majority of studies in the existing literature (88%), while only 12% were conducted on a dynamic model. [22]

To improveresistance to instrument separation during root canal treatment, manufacturers have tried different approaches such as modification of the design, especially by applying different cross-sectional designs andthe utilization of new alloys," innovative manufacturing techniques, and various actions of motion.[26]

The instrument design, particularlythe cross-sectional area, can also affect the fatigue behavior when subjected to torsion or bending.However, to date, the effect of the cross-sectional area on the fatigue resistance is controversial.

Researchers are actively engaged in a continuous quest to minimize the occurrence of instrument separation in root canal procedures. Recent advancements in endodontic instruments have significantly improved the efficacy of endodontic treatments, contributing to enhanced success rates.

Arotating file system called One Curve (Micro Mega, Besançon, France)is created with a 0.25 mm diameter. It has a changeable pitch, constant 6% taper, and variable cross-section (triple-helix section at the tip and an S-section closer to the shank). Ithas undergone a thermal treatment called C Wire on NiTi that gives the file a shape memory effect . To increase its resistance to cyclic fatigue, this file underwent electropolishing. [27]

EdgeFile X7 (EdgeEndo,Albuquerque, NM,) is a NiTi filesystemwhich has a constant taper, variable pitch ,it has maximum flute diameter at 1mm allows for minimal invasive preparationand parabolic cross section ,non cutting tip manufactured by a process called “FireWire™,”which potentially increases the flexibility and resistance to fatigue and reducesthe shape memory effect inherent of NiTi. [28]

TheXP-endo Shaper rotary files (FKG Dentaire, La Chaux-de-Fonds, Switzerland) wasintroduced asaresultofmanufacturers'continuouseffortstoimprove design and metallurgy. This file has an initial taper of 0.01 in its M phase while it is cool. It has a snake-like design and exclusive max wire technology. When exposed to body temperature (35°c), the taper changes to 0.04 according to the austenitic phase's molecular memory. These files have unique properties that make them less likely to cause dentin microcracks, easily adjust to imperfections in the canal, and have a remarkable resistance to cycle fatigue. [29]

The newly launched , Trunatomy endodontic file(TRN) (Dentsply Sirona) has been developed as a novel type of heat-treated NiTi instrument with a special design. The TRN shaping instruments are provided in three different sizes which are small (size 20/.04 taper), prime (size 26/.04 taper) and medium (size 36/.03 taper). According to the manufactures recommendations, the three shaping tools from TRN offer a narrow shape that improves performance since more room is made available by the instrument's distinctive design. When compared to the majority of other variable tapered instruments, the thin NiTi wire design is 0.8 mm, not up to 1.2 mm. Off-center parallelogram cross-section design is a feature of TRN instruments . It was created utilising a unique wire that had been heat-treated with NiTi in order toincrease the instrument's flexibility. The instrument geometry, regressive tapers, and slender design of the TRN instruments, combined with the heat-treatmentof the NiTi alloy, have been reported to protect the structural dentine and tooth integrity. [30]

Till date, limited research has been conducted to evaluate the influence of the design and metallurgical characteristics of nickel-titanium rotary instruments on their contribution to stress development during exposure to cyclic fatigue resistance.

Scanning Electron Microscopy (SEM) proved a beneficial method for evaluating of the cyclic fatigue resistance of rotary files. By employing SEM, researchers and practitioners can closely examine the surface characteristics of these instruments after subjecting them to repetitive stress cycles. SEM allows for the detailed analysis of microcracks,defects,andsignsoffatigue,offeringvaluableinsightsintothestructural integrity of rotary files. This information aids in understanding the factors that influence their fatigue resistance and contributes to the development of more robust and durable designs, ultimately enhancing the safety and efficacy of rotary files.[31]

Therefore,theaimofthis studyistoevaluateandcomparethecyclicfatigue resistance of four different novel endodontic rotary file systems.

AIM

The aim of the present study is to evaluate and compare thecyclic fatigue resistance of four different novel endodontic rotary file systems.

OBJECTIVES

1. Toevaluatethecyclicfatigueresistanceofedgefilex7rotaryfilesystem.
2. Toevaluatethecyclicfatigueresistanceofonecurve.
3. Toevaluatethecyclicfatigueresistanceofxpendoshaper
4. Toevaluatethecyclicfatigueresistanceoftrunatomy
5. Comparative evaluation of the cyclic fatigue resistance ofedge filex7, one curve ,xp endoshaper ,trunatomy.

1. **GrandeN.M, Plotino G , Pecci R,BediniR,MalagninoV.A,Somma Fetal (2006)** [32] Determined the effect of instrument design on the fatigue life of two different Ni-Ti rotary file system under cyclic fatigue stress in simulated canals. Atotalof260instrumentswererotateduntilfractureoccurred andthenumberof cycles to failure were recorded. They concluded that the metal mass at the point of maximum stress influenced the lifespan of Ni-Ti rotary instruments during a cyclic fatigue test and also stated that bigger the metal mass, the lower thefatigue resistance.
2. **Plotino G, Grande NM, Sorci E, Malagnino VA, Somma F (2007)**[33] Evaluated the cyclic fatigue resistance of M two NiTi rotary instruments when used with a brushing or no-brushing action in oval root canals.It was observed thatfatigue life of instruments of larger size can be reduced by using them with a lateral brushing or pressing movement. However, each file was successfully operated without intracanal failure, demonstrating that M two rotary instruments can be used safely in a brushing action in simulated clinical conditions up to 10 times in oval canals.
3. **Ounsi HF, Salameh Z, Al-Shalan T, Ferrari M, Grandini S, Pashley DH, et al (2007)[34]**Investigated the Protaper nickel-titanium rotary instruments resistance to cyclic fatigue subsequent to their initial in vivo use in straight or curved canals. They concluded that Protaper F3 instruments are highly susceptible to cyclic fatigue failure and should be reused with caution irrespective of whether they are initially used for shaping straight or curved canals.
4. **Kramkowski TR, Bahcall J (2009)** [35]Compared the cyclic fatigue characteristics of Profile GT and Profile GT series X. Files of 0.04 and0.06taper, 25 mm in length, and ISO sizes of 20 and 30 tips were compared.Cyclic fatigue was determined by recording the time until breakage of a file rotating ina simulated canal with an applied 45 ºor 60º curves. The files were operated in a cyclic fatigue model that simulated clinical rotary file usage with a constant cyclical axial motion. It wasconcluded that nosignificant difference was observedat 45º canal; and at 60ºcanal , Profile GT showedsuperior cyclic fatigue resistance in 20/.06 and 30/.04, and no distinction in 20/.04 compared to Profile GT Series X .

5. **KimH.C, Kim H.J. ,Lee C.J ,Kim B.M, Park J.K, Versluis A et al (2009)**[36] Evaluated effect of various cross sectional designs on the stress distributionin nickel-titanium rotary instruments(M-two with S-shaped ,NRT with modified rectangular cross section ,profile and HeroShaper with triangular based cross section) in simulated curved canal. They observed thatNi-Ti rotary instruments with S-shaped and modified rectangular cross sections such as M-two or NRT created higher stress differentials during simulated shaping of curved canals and sustained more residual stress and deformation than theinstruments with triangle based cross sections.
6. **Lopes HP, Ferreira AA, Elias CN, Moreira EJ, de Oliveira JC, Siqueira JF Jr etal (2009)**[37]Evaluated the effects of rotational speed on the number of cycles to fracture of rotary NiTi instruments.ProTaper Universal instruments F3 andF4wereusedinanartificialcurvedcanalunderrotationalspeedsof300rpm or 600 rpm. They found that F3 and F4 ProTaper instruments revealed that the increase in rotational speed significantly reduced the number of cycles to fracture.
7. **LopesHP,ChiesaWM,CorreiaNR,deSouzaNaveganteNC,EliasCNetal (2011)**[38]Evaluated the effects of curvature location along an artificial canal on cyclic fatigue ofM two rotary instrument, verifying the number of cycles to fatigue fracture (NCF) and morphologic characteristics of the fractured instruments. They concluded that the number of cycles to fracture of the M two instruments increased when the arc was changed from the middle to the apical part of the canal.
8. **Gao Y, Guttmann J. L, Wilkinson k ,Maxwell R. Ammon D et al (2012)**[39] Evaluated theimpact of raw materials (including stainless steel, conventional superelasticNi-Ti, M-WireNi-Ti, and Vortex Blue Ni-Ti) on fatigue resistance, torsional properties, flexibility, and Vickers microhardness of ProFile Vortex rotary instrument . They observed that Ni-Ti shape memory alloy appearedtobeasuperiormaterialoptioncomparedwithstainlesssteelforitsuse in the manufacturing andapplication of endodontic rotary instruments.
9. **Plotino G, Grande NM, Testarelli L, Gambarini G (2012)**[40]Evaluated the cyclicfatigueresistanceofReciprocandWaveOneinstrumentsinsimulated

root canals. Reciproc instruments resisted cyclic fatigue significantly more than Waveone instruments. These differences could be related to the different cross-sectional design and/or the different reciprocating movement of the two instruments.

10. **Kim HC, Kwak SW, Cheung GS, Ko DH, Chung SM, Lee W (2012)**[41] Compared the Protaper F2 in its recommended continuous rotation mode withthe Reciproc and Waveone reciprocating files, which were also operated using the recommended motions, both tested under a custom- made static device. The results showed that the NCF (number of cycles to fracture) of the Reciproc was higher than those of the other files, and both reciprocating files demonstrated significantly higher cyclic fatigue resistance than the Protaper F2 file.
11. **AriasA, Perez-Higueras JJ, dela Macorra JC (2012)**[42]Evaluated thecyclic fatigueresistanceofnew M-WirereciprocatingWaveOneandReciprocfilesat2 levels. Sixty Reciproc and 60 WaveOne new files were fixed to a specifically designed device and tested and they concluded thatReciproc files were more resistant to cyclic fatigue than WaveOne files at both distances from the tip.
12. **Gavini G, Caldeira CL, Akisue E, Candeiro GT, Kawakami DA (2012)**[43] Evaluated the resistance to flexural fatigue of Reciproc R25 nickel-titanium files used in continuous rotation motion or reciprocation motion, in dynamic assays device.The files run on a ring's groove of temperate steel, simulating instrumentation of a curved root canal with 40° and 5 mm of curvature radius. Theyconcluded that reciprocation motion improves flexural fatigue resistance in nickel titanium instrument Reciproc R25 when compared with continuous rotation movement.
13. **Kim HC, Kwak SW, Cheung GS, Ko DH, Chung SM, Lee W.etal (2012)**[44] Evaluated the fatigue resistance of continuous rotation systems (Reciproc and WaveOne). Cyclic fatigue test with a simultaneous pecking motion was performed with the file system it was observed that both reciprocating files demonstrated significantly higher cyclic fatigue and torsional resistances.

14. **Pedullà E, Grande NM, Plotino G, Gambarini G, Rapisarda E (2013)** [45] Comparedthe resistance to flexural fatigue of Reciproc R25, WaveOnePrimary, Mtwo, and Twisted File instruments used in continuous rotation or in 2 differentreciprocatingmotions.Forty-fiveinstrumentsforeachbrandwere

divided into 3 groupson the basis of the motion tested: continuous rotationand reciprocal motionand "WAVEONE ALL" mode.and they observed that Reciprocal motion showed a significantly higher cyclic fatigue resistance in all brands compared with continuous rotation. No differences were found between the 2 reciprocating motions.

15. **Khurana P, Khurana KK (2013)**[46], Evaluated the effect of rotational speed and angle of curvature in curved root canals on the fracture of different nickel-titanium rotaryinstruments that is Profile, Protaper, and K3 files. And divided in to three groups Instrumentation was performed using the Profile, Protaper, and K3 rotary instrument at 3 rotational speeds of 150, 250, and 350 rpm They concluded that instrument fracture was associated with rotational speed and the angle of curvature.
16. **Lopes HP, Chiesa WM, Correia NB, Navegante NC, Elias CN, Moreira EJ, et al (2013)**[47]Evaluated the influence of different features of canal curvature geometry on the number of cycles to fracture of a rotary nickel-titanium endodonticinstrumentsubjectedtoacyclicfatiguetestinasimulatedcanal at60 degree and they concluded that curvature geometry including the radius and arc lengths and the position of the arc along the root canal influence the number of cycles to fracture of rotary nickel-titanium instruments when subjected toflexural load.
17. **Al-Hadlaq SM(2013)**[48]Evaluatedthecyclicflexuralfatiguefailureresistance of tip size International Standards Organization 25 Twisted files (TFs) with two tapers 0.04 and 0.06 and to compare them with the Profile (PF) rotary NiTi files of similar tip size and taper. The findings of this study indicate that size 25/0.04 and 25/0.06 TFs had similar resistance to cyclic flexural fatigue failure. In addition, TFs were not superior, in terms of resistance to cyclic flexural fatigue failure, to PF of similar tip size and taper.
18. **Kiefner P,BanM,De-DeusG(2014)**[49] Comparedcyclicfatigue resistanceof two geometrically similar nickel–titanium instruments, used in conditionssimilar to clinical use in reciprocatingand continuous rotarymotion Four groups of eighteen instrumentsReciproc and Mtwofiles size were tested in reciprocatingandcontinuousrotarymotion,employinganovelexperiment

device.and they observed that Reciprocating movement showed increasedcyclic fatigue resistance of NiTi instruments.

19. **Dagna A, Poggio C, Beltrami R, Colombo M, Chiesa M, Bianchi S (2014)**[50] Evaluated the cyclic fatigue resistance of three single-use nickel–titanium (NiTi) instruments. Forty files each of OneShape (OS), Reciproc R25 (R25), WaveOne Primary (WO) file, and ProTaper (PT) F2 (as control) were tested in four curved artificial canals with different angles and radii of curvature. And they observed thatOne Shape and WO files showed similar cyclic fatigue resistance values, higher than PT F2.
20. **Pérez-Higueras JJ, Arias A, de la Macorra JC, Peters OA(2014)** [51] Compared Cyclic fatigue resistance of Protaper universal (PTU) and Protaper next (PTN) instruments Groups S1-12, X1-12, and F1-12 werefrom the tip because S1, X1, and F1 instruments have the same diameter at that level were tested in stainless steel curved canaland they concluded that PTU S1 was significantly the most resistant instrument at 5 mm from the tip. However PTN files were significantly more resistant to CF than PTU instruments at all theother tested levels.
21. **Elnagy AM (2014)**[52] compared the cyclic fatiue resistance of Protaper Next Files (PTN) with Twisted files (TF), Hyflex CM (HF) and Protaper universal (PTU). In an artificial canal. A scanning electron microscope was used to characterize the topographic features of the fracture surfaces of broken files. He concluded that the new Protaper Next had greater resistance to cyclic fatigue when compared with Protaper and HyflexCM, but not twisted files.

22. . **Reddy P.Y, Kavita S. Subbarao C.V(2014)** [53] Compared the cyclic rotations needed to fractureof three rotary Ni-Ti file in simulated curved canals in 45 degree curvature namelyProfile, K3 Endo, RaCeand Correlated the incidence of instrument fracture with the adequate time period for which instrument was in the root canal and its fracture resistance in the curve canalsand they found that profile demonstrated least cyclic fatigue compared to other two groups.

23. **Capar ID, Ertas H, Arslan H (2015)** [54]Comparedthe cyclic fatigue resistancethatweremanufacturedwithdifferentalloyswastested:ProTaper NextX2(M-Wire),OneShape(conventionalNiTi),Revo-SShapingUniversal

(conventional NiTi) and HyFlex(controlled memoryNiTi wire). Four groups of NiTiendodonticinstrumentsweretestedinsteelcanalswitha3mmradius anda 60° angle of curvature.and theyrevealed that the HyFlex files had the highest fatigue resistance and the Revo-S had the least fatigue resistance among the groups

24. **Capar ID, Kaval ME, Ertas H, Sen BH (2015)** [55] , Compared the cyclic fatigue resistance of current nickel-titanium rotary path-finding instruments by using five types of nickel-titanium rotary path finding instruments were used in steel canals with a 90° curvature and a curvature radius of 3 mm and 5 mm. And it was concluded that the cyclic fatigue resistance of the Hyflex GPF instrument was the maximum, and the curvature radius had a significant effect on thefatigue resistance.
25. **Sekar V, Kumar R, Nandini S, Ballal S, Velmurugan N (2016)**[56]Evaluated the cyclic atigue resistance of RaCe and Mtwo rotary files in continuous rotation and reciprocating motion. A total of 60 new rotary Mtwo and RaCe filesandA cyclic fatigue testing device was fabricated with a 60 angle of curvature and a 5-mm radius. All instruments were rotated or reciprocated until fracture occurred. They concluded thatMtwo and RaCe rotary instruments showed a significantly higher cyclic fatigue resistance in reciprocating motion compared with continuous rotation motion.
26. **Neelakantan P, Reddy P, Gutmann JL (2016)**[57] Compared the cyclic fatigue of a rotary(one shape) and reciprocating (Reciproc) single file system in a simulated s-shaped canal in static and dynamic models. The instrumentswere tested in a custom-made device under static and dynamic loads to determine the number of cycles to fracture (NCF). The length of the fractured segments was also measured and theyconcluded that the single file reciprocating system (Reciproc) had a longer fatigue life than the single file rotary system (oneshape).

27. **Pedullà E, Lo Savio F, Boninelli S, Plotino G, Grande NM, La Rosa G, etal (2016)** [27]Evaluated the cyclic fatigue resistance of the new Hyflex EDM OneFile manufactured by electrical discharge machining and compare the findings with the ones of Reciproc R25 and WaveOne Primary.Cyclic fatigue resistance was tested measuring the number of cycles to failure in an artificial stainless-steel canaland theyconcluded thatThe new Hyflex EDM instruments have higher cyclic fatigue resistance and angle of rotation to fracture but lower torque to failure than Reciproc R25 and WaveOne Primary files.
28. **de Almeida-Gomes F, de Matos HR, Nunes RF, Arrais AM, Ferreira-Maniglia C, de Morais Vitoriano M etal (2016)** [58] Compared the cyclic fatigue resistance of nine types of endodontic instruments of nickel–titanium. Reciproc (RC) R25; WaveOne (WO) Primary; Unicone (UC); ProTaper Universal F2(PTF2); ProTaper Next X2 (PTX2); Mtwo; One Shape L25 25/0.06 were subjected to a cyclic fatigue resistance test on a mechanical apparatus. The mean fracture time was analyzed statistically andIt was observed that thegroups PTX2, RC, R25, UC L25 25/0.06, and WO Primary presented greater cyclic fracture resistance than the other groups .
29. **Varghese NO, Pillai R, Sujathen UN, Sainudeen S, Antony A, Paul S (2016)**[59]Compared thecyclic fatigue resistance of ProTaper Next (PTN), WaveOne, and Mtwo files in continuous and reciprocating motion incustom fabricated cyclic fatigue testing device with a 70° angle of curvature they observed thatWaveOne files showed maximum resistance to cyclic fatigue Due to their cross-sectional diameter coupled M-Wire technology and PTN with Mtwo files exhibiting least resistance.
30. **ÖzyürekT,YılmazK ,Uslu G(2016)** [60] Evaluated the resistance of old and new generation One Shape single file systems that work with continuous rotation to cyclic fatigue under a dynamic model. Twenty pieces of old generation and 20 pieces of new generation One Shapefiles were included inthe study The files were used at 400 rpmfor OGOS andNGOS . Two files from each group were examined with a SEM device to determine the fracture type.. They concluded that NGOS had a significantly higher cyclic fatigue resistance compared with OGOS .

31. **Topçuoğlu HS, Düzgün S, Aktı A, Topçuoğlu G (2017)** [61] Evaluated the cyclic fatigue resistance of WaveOne Gold (WOG), Reciproc and WaveOne (WO) nickel–titanium files in an artificial root canal with a double (S-shaped) curvature. They examinedWaveOne Gold primaryfiles exhibited greater cyclic fatigue resistance than Reciproc R25 and WO primary in an artificial canal with an S shape.
32. **Uslu G, Özyürek T, Yılmaz K, Gündoğar M (2017)**[62] Compared the cyclic fatigue resistances of R- Pilot, HyFlex EDM and PathFile NiTi glide path files which were subjected to static cyclic fatigue testing using double-curved canals until fracture occurred (TF).The NCF values revealed that the R-Pilot had the greatest cyclic fatigue resistance, followed by the HyFlex EDM and PathFile .
33. **Yılmaz K, Uslu G, Özyürek T.(2017)** [63]Evaluated the cyclic fatigue resistances of ProGlider (PG), One G (OG), and HyFlex EDM (HEDM) nickel titaniumglidepathfiles insingle-anddouble-curvedartificialcanals.Sixtyfiles were subjected to cyclic fatigue test by usingdouble-curved canals and 60 filesby using single-curved canal . They observed that HEDM glide path files were found to have the highest cyclic fatigue resistance in both of single- and double-curved canals.
34. **Yılmaz K, Özyürek T.(2017)**[64] Compared the fatigue resistance of Tango-Endo, WaveOne GOLD, and Reciproc NiTi instruments under static modelvia artificial canals with different angles of curvature.which weremade of stainless steel with, 45°, 60°,and90° angles ofcurvaturesand aradius ofcurvatureof 5 mm. They concluded that TangoEndo files were found to have significantly higher values than WaveOne GOLD.
35. **GündoğarM,ÖzyürekT.(2017)**[65]Comparedthecyclic fatigue resistancesof Reciproc Blue, HyFlex EDM, WaveOne Gold, and OneShape single-file NiTi systems. Thirty files from each groupwere rotated in artificial canals, and they observed thatThe cyclic fatigue resistance of HyFlex EDM files was higherthan the cyclic fatigue resistances of OneShape, Reciproc Blue, and WaveOne Gold files.

36. **Nagarjuna P, Mangat P, Dayal C, Tomer AK, Chauhan P, Rana S et al (2017)**[66] Evaluated the cyclic fatigue resistance of reciprocating and rotary single-file system [Wave One Gold (WOG), Reciproc, Hyflex electrical discharge machining (EDM) file systems] utilizing cyclic fatigue testing device. Each file was tested in the simulated root canal until instrument fractureoccurredand they observed that Hyflex EDM exhibited the greater cyclic fatigue resistance when compared with other rotary and reciprocating file.
37. **Goo HJ, Kwak SW, Ha JH, Pedulla E, Kim HC (2017)**[67]Comparedthe cyclic fatigue resistances of heat-treated and conventional nickel-titanium rotary instruments.Cyclic fatigue resistance was tested by pecking and rotating instrumentsin artificial canal with a 7.8-mm radius and 35° angle of curvature until fracture and theyfound that CM-wire instruments showed higher flexibility and cyclic fatigue resistance than M-wire
38. **Topçuoğlu HS, Demirbuga S, Düzgün S, Topçuoğlu G (2018)**[68] Evaluated the cyclic fatigue resistance of Reciproc Blue, WaveOne Gold, and SmartTrack ninty fileswere tested in artificial canals with 45° and 60° angles of curvature. The results of the present studyshowed that Reciproc Blue and SmartTrack files exhibited greater CFR than WaveOne Gold only in canals with a 60° angle of curvature.
39. **Rubio J, Zarzosa JI, Pallarés A (2018)**[69] Compared the cyclic fatigue resistancebetweenF360, F6SkyTaper,Hyflex EDM,iRace,Neoniti,OneShape Protaper Next, Reciproc, Revo-S andWave One Gold The instruments were mechanized with a X-Smart Plus endo motor holding the instruments steadywith a clamping mechanism, with passive adjustment and without pressure in a stainless-steel block.. The observed thtaCM-Wire (Hyflex EDM and Neoniti) were superior in resistance to the other systems for cyclic fatigue.
40. **Shalan, L &Mohammad H, Alislam S (2018)** [70] Evaluated the cyclic fatigue resistance for the new reciprocating glide path file: Wave one gold glider, Proglider, Pathfile and path glider komet. Forty instruments were used in this study divided into four groups : G1: Path file, G2: Path glider komet, G3 :Wave one gold glider, G4: Proglider. The instruments were tested for their cyclic fatigueresistance byan artificial canal 60° angle ofcurvatureand theyconcluded

that . Wave one gold glider reciprocating path glider instruments had thehighest cyclic fatigueresistance with high flexibility.

41. **Serafin M, De Biasi M, Franco V, Angerame D.(2018)** [71] Evaluated the difference in cyclic fatigue resistance between OneCurve (OC) and OneShape (OS) endodontic single-file NiTi systems in a severely curved artificial canal.testdevice which was electrically heated to maintain the environmental temperature at 37 °C. they found thatOCendodontic instruments resisted to cyclic fatigue better than OS.
42. **Palma PJ, Messias A, Cerqueira AR, Tavares LD, Caramelo F, Roseiro L**,**et al (2018)**[72]Compared the resistance to cyclicfatigue of three nickel–titanium rotary file systems, ProTaper Next, HyflexCM, and Hyflex EDM, in a mechanical model featuring axial movement. Files were tested in an artificial root canal with 45° angle and 5 mm radius apical curvature being submitted to back-and-forth movements until fracture.and they concluded that . EDM instrumentsperformed better to cyclic fatigue followed by CM and then PTN.
43. **Özyürek T, Gündoğar M, Uslu G, Yılmaz K, Staffoli S, Nm G**,**et al (2018)[73]**Evaluated the cyclic fatigue resistances of HyFlex EDM (HEDM), WaveOne Gold (WOG), Reciproc Blue (RB), and 2Shape (TS) NiTi systems having different metallurgic properties fileswere rotated in artificial canals which were made of stainless steel with an inner diameter of 1.5 mm, 45°, and 90° angles of curvatures When comparing the TTF of all the instruments testedin the artificial canal with 45° curvature and , 90° curvature RB had statistically thehighest cyclicfatigue resistancefollowed byHEDM and TSwhiletheWOG showed the lowest cyclic fatigue resistance.
44. **Azim AA, Tarrosh M, Azim KA, Piasecki L (2018)**[74] Compared the cyclic fatigue resistance of XP Shaper (XP), HyFlex EDM One File (EDM), protaper universal F2 and WaveOne Gold Primary(WOG) all were tested for their cyclic fatigue resistance in a simulated 90° curved canal at a 37°C water bath temperatureand they concluded that XP has a very high resistance to cyclic fatigue compared with WOG, EDM, and F2 PTU.

45. . **Adiguzei M, Isken I, Pamukcu I .I (2018)**[75] Compared the cyclic fatigue resistance of XP-EndoShaper, HyFlex CM, FlexMaster and Race rotary instruments .The instruments were evaluated in artificial canals with a 3-mm radius of curvature and 60° angle of curvature to the center of the 1.5-mm-wide canalby testing them at body temperature and they concluded that XP-EndoShaperresisted to cyclic fatigue better than other tested rotary files.

46. **ElnaghyM.R,E.ElsakaS(2018)**[76]Evaluatedandcomparedtheresistanceto cyclic fatigue of the new One Curve (OC) instrument in double (S-shaped) and single curvature , 2Shape (TS), Vortex Blue (VB), ProFile Vortex (PV), and RaCe (RC) instruments were tested inside artificial canals with a singlecurvature and double curvature while immersed in saline at 37°C ± 1°C. canals compared with other nickel-titanium rotary instruments it wasconcluded thatthe fatigue resistance of VB was greater than that of other instruments. OC and TS instruments displayed superior cyclic fatigue resistance than PV and RC instruments.

47. **Topçuoğlu HS, Topçuoğlu G, Kafdağ Ö, Arslan H (2018)** [77]Compared the cyclic fatigue resistance of R-pilot and Waveone Gold Files by comparing60 new R-PILOT and WaveOne Gold Glider files were tested in artificial canals with 45° and 60° angles of curvature. Cyclic fatigue resistance was determined by recording the time to file fracture in the artificial canals. He concluded that Waveone gold glider files exhibited greater cyclic fatigue resistance than R-pilot files in artificial canals with a 60° angle of curvature.

48. **Silva EJNL, Vieira VTL, Belladonna FG, Zuolo AS, Antunes HDS, Cavalcante DM et al (2018)** [78]Evaluated the cyclic and torsional fatigue resistance of the XP-endo Shaper and TRUShape instruments.Cyclic fatigue resistance was tested by measuring the number of cycles and time to fracture in an artificial stainless steel canal with a 60° angle and a 5-mm radius of curvature and they concluded thatThe XP-endo Shaper instruments showed a highercyclic fatigue resistance and angle of rotation to fracture but lower torque to failure than TRUShape instruments.

49. **Serafin M, Biasi M D,Franco V,Angerame D(2019)**[79]Evaluated the difference in cyclic fatigue resistance between One Curve (OC) and One Shape (OS)endodonticsingleNi-Tifilesysteminseverlyartificialcurvedcanalsin

which an artificial canal was created which was milled in stainless steel block files used. The test device was electrically heated to maintain the environmental temperature at 37 °C.It was concluded that One Curve endodontic instruments resisted to cyclic fatigue better than One Shape due to NiTi alloy used in manufacturing.

50. **Rubio J, Zarzosa JI, Pallarés A (2019)**[80]This research aimed to assess and compare the resistance to cyclic fatigue and the length of broken fragments among nine different endodontic files: F360, F6 SkyTaper, Hyflex EDM, iRace, Neoniti, One Shape Protaper Next, Reciproc, Revo-S, and Wave One Gold in an artificial simulated canal Systems utilizing CM-Wire, such as Hyflex EDM and Neoniti, demonstrated superior resistance to cyclic fatigue compared to the other systemsHowever, when it came to the length of separated fragments, F360 (conventional NiTi) and Reciproc (M-Wire) exhibited significantly better resistance.

51. **DiNardoD,GambariniG,SeracchianiM,MazzoniA,ZanzaA,GiudiceAD et al(2020)** [81] Evaluatedthe role of the cross -sectional design of the instrument regarding the cyclic fatigue resistance by comparing two nickel- titanium (NiTi) rotary instruments : 40 new NiTi instrumentsS-One (s cross section)and AF Blue (triangular cross section)were tested in the present study. Both instruments were rotated at 300 rpm and with a torque setting of 2 Ncm) using an endodontic motor in the same artificial canal at 90° angle of curvature with3 mm radius with the same heat-treatment and grinding procedure which result inincrease resistance to cyclic fatigue in s one therefore theyconcludedthatcrosssectionplays an importantroleinincreasingthe cyclic fatigue resistance of NiTi rotary instruments.

52. **Pedullà E, La Rosa GRM, Virgillito C, Rapisarda E, Kim HC, Generali L (2020)** [82]

Evaluatedthe influences from different access angles and curvature radii on cyclic fatigue resistance of nickel-titanium rotary filesby Two file systems (2Shape , HyFlex CM were used. A total of 192 instrumentswere evaluated at 3 insertion angles (0°, 10°, and 20°) and 2 radii (5 mm and3 mm) instainless steel artificial canalswitha60°curvature.Aninclinedinsertionintothecanalsdecreasedcyclic fatigue resistance of thermal-treated instruments with a .04 taper at all radii of curvature tested.it was concludedthatthe synergistic effect of a small radius of curvature and access angulation of heat-treated instruments decreases their fatigue resistance.

53. **Ruiz-Sánchez C, Faus-Llácer V, Faus-Matoses I, Zubizarreta-Macho Á,Sauro S, Faus-Matoses V etal (2020)**[83]Evaluated the influence of NiTi alloy in endodontic rotary instruments on cyclic fatigue resistance. ProTaper Universal, ProTaper Next (PTN)ProTaper Gold (PTG) ProFile Vortex Blue(PVB) were selected. A cyclic fatigue device was designed to conduct the static cyclic fatigue tests with stainless steel artificial root canals systemsat 60 degree curvature .and they found that The NiTi CM-Gold wire alloy of the ProTaper Gold endodontic rotaryfiles resulted in greater resistance to cyclic fatigue than ProFile Vortex Blue, ProTaper Next, and ProTaper Universal endodontic rotary files.
54. **Gündoğar M, Uslu G, Özyürek T, Plotino G (2020)**[84] Compared the cyclic fatigue resistance of VDW.ROTATE, TruNatomy, 2Shape, and HyFlex CM nickel-titanium (NiTi) rotaryfilesweresubjected to static cyclic fatigue testingat body temperature (37°C) in stainless-steel artificialandconcluded that VDW.ROTATEfileshadthehighestcyclicfatigueresistance,andtheTruNatomy and 2Shape files had the lowest cyclic fatigue resistance in artificial canals atbody temperature.
55. **Sharroufna R, Mashyakhy M (2020)**[85] Evaluated the effect of repeated autoclave sterilization on the cyclic fatigue resistance of heat-treated NiTi rotary endodontic instruments. (EdgeFile X7, EFX7 ; Vortex Blue, VB; and TRUShape, TS) were selected AND subjected to 10 cycles of autoclave sterilization was concludedthat Repeated cyclesofautoclavesterilization increased the NCF ofthe new heat-treated files, with EFX7 showing statistically significant superior results compared with other files tested.
56. **Faus-LlácerV,Hamoud-KharratN,MarhuendaRamosMT,Faus-MatosesI, Zubizarreta-Macho Á, Ruiz Sánchez C,etal (2021)**[86] Compared the influence ofthe geometrical cross-section design on thedynamiccyclic fatigueresistance of NiTiendodonticrotaryfiles.Acyclicfatiguedevicewas usedtoconductthestatic cyclic fatigue tests with stainless steel artificial root canal system at 60 degree curvatureandtheyconcludedthatthedoubleS-shapedcross-sectionofMtwo

NiTi endodontic files shows higher cyclic fatigue resistance than the rectangular cross-section of T Pro E1 NiTi endodontic files, the convex triangular cross-section of T Pro E2 NiTi endodontic files, and the triangular cross-section of TPro E4 NiTi endodontic files

57. **Koçak S, Şahin FF, Özdemir O, Koçak MM, Sağlam BC (2021)**[87]conducted a comparative study to evaluate the cyclic fatigue resistance of ProTaper Next, Hyflex CM, 2Shape, andTF Adaptive nickel-titanium endodontic file systems with various alloy properties and production methods and investigated thatfractured cross-sectional surface of files due to cyclic fatiguebyscanningelectronmicroscopy(SEM).Anditwasconcluded thatfactors such as production patterns, alloyproperties, and the phase in which the files were produced might affect the lifespan of file systems.. The HyflexCM demonstrated better cyclic fatigue resistance than TF Adaptive, ProTaper Next, and 2Shape file systems.

58. **Vieira TM, Cardoso RM, Alves NCC, Emanuel Acioly Conrado deMenezes S, Batista SM, etal (2021)**[88] evaluated the cyclic fatigue resistance of blue heat-treated instruments with different kinematics. Twenty-four endodontic instruments of the same brand were used for each of three experimental groups: Vortex blue (VB), RECIPROC Blue(RB) , and X1 Blue (XB). The instruments were randomly distributed and subjected to temperatures of 20°C and 37°C. The fatiguetest was performed using astainless steel device. and theyconcluded that RB instruments displayed greater cyclic fatigue resistance at the tested temperatures compared with the VB and XB instruments.

59. **Faus-Llácer V, Kharrat NH, Ruiz-Sánchez C, Faus-Matoses I, Zubizarreta-Macho Á, Faus-Matoses V (2021)**[89] Analyzedthe effect of the taper and apical diameter of nickel–titanium (NiTi) endodontic rotary files on the dynamic cyclic fatigue resistance50NiTi endodontic rotary files were submitted to a custom-made dynamic cyclic fatigue device until fracture occurred. It was concluded that increased apical diameter and taper of NiTi endodontic rotary files decreased their dynamic resistance to cyclic fatigue.

60. **Pedullà E, Kharouf N, Caruso S, La Rosa GRM, Jmal H, Haikel Y,Mancino D etal (2022)**[90]evaluate the torsional, dynamic, and static cyclic fatigueresistanceofthereciprocating OneRECI,WaveOneGold,rotary One

Curve , and ProTaper Next X2instruments. A total of 120 nickel-titanium instrumentswereusedStaticanddynamicfatigueresistancewasmeasuredasthe time to fracture in an artificial stainless steel canal with a 60° angle and 5-mm radius of curvature at intracanal temperature. Under these experimental conditions, One RECI exhibited suitable mechanical properties with the highest cyclic fatigue resistance and angle of rotation among the tested instruments.

61. **Al-Obaida, Mohammad I., Abdulmohsen A. Alzuwayer, Saqer S. Alanazi, andAbdulrahmanA.Balhaddadetal(2022)**[91] Determinedthe cyclicflexural fatigue resistance of four nickel–titanium (NiTi) rotary files used as a single canal preparation technique: WaveOne, Reciproc, Protaper F2, and Unicone medium instruments were tested inwide V-shaped groove in a stainless-steel block with a 40° and 5 mm radius of curvature.and theyconcluded that WaveOne illustrate a superior cyclic flexural fatigue resistance when instrumenting root canals with the lowest possibility to cause instrument separation.
62. **Gouédard C* Pino ,L Chirani A R , Chirani ,S.A, ChevalierV (2022)**[92] Compared the cyclic fatigue resistance of One Curve (C wire) and F6 Skytaper and 2 instruments with thermomechanically treated NiTi: Protaper Next X2 (M wire) and Hyflex CM (CM wire). In the context of this investigation, under the specified conditions of a 60° angle and a 5 mm curvature radius, the cyclic fatigue life of One Curve demonstrated no statisticallysignificant variance when compared to F6 Skytaper and Hyflex CM. However the cyclic fatigue lives of these 3 instruments were statistically significantly longer than that of Protaper Next.

63. **Zanza A, Russo P, Reda R, Di Matteo P, Donfrancesco O, Ausiello P, etal (2022)**[93]According to this, since there are no data on this topic, the aim of the study was to mechanically and metallurgically evaluated the mechanical and metallurgical property of an ZenFlex (ZF),instrumentby comparing it with Vortex Blue (VB) and EdgeSequel Sapphire (EES). A scanning electron microscopywas performed to verifythe causes of fracture after mechanical tests (cyclic fatigue and torsional tests) and theyconcluded that VB showed the best mechanical performance during static tests in comparison to ESS and ZF.

64. **Morsy, D.A (2022)**[94]Comparedthe cyclic fatigue resistance of EdgeFile X7, EdgeOne, WaveOne Gold and WaveOne rotary files using artificial canals with different angles and radii of curvature i.e (angle 60° radius 2.5mm and radius 5mm and angle 90° radius 2.5mm and radius 5mm). And they concluded that WaveOne Gold and EdgeOne showed superior comparable cyclic fatigue resistance which was higher than that of WaveOne while EdgeFile X7 showed the least cyclic fatigue resistance.
65. **Farah Ramadan (2023**)[95] Compared cyclic fatigue resistancefor three different nickel-titanium (NiTi) rotary files.i.e Race Evo, OneCurve and Tia Tornado Blue a dynamic cyclic fatigue test at body temperature was performed for the other group. Files fractured by cyclic fatigue were randomly picked from all tested groups for Scanning Electron Microscopy i. Andthey concluded that the number of cycles to fracture (NCF) in the Race Evo group was significantly higher than the groups of One Curve and Tia Tornado Blue.
66. **Matoses F V(2023)** [96]Compared how the length of CM Gold Wire and CM Blue Wire NiTi alloy endodontic rotary files impacts their resistance to cyclic fatigue. These files were tested in static model of artificial canal at a 60 degree curvatureAnd he found that Rotary file length is inversely proportional to the cyclic fatigue resistance of the 25.06 CM Gold wire NiTi alloy at 31 mm, 25 mm, and 21 mm in length and of the 25.06 CM Blue wire NiTi alloy 17 mm length endodontic rotary files, with a greater length contributing to lower resistance to cyclic fatigue.

67. **Al-Amidi AH, Al-Gharrawi HA (2023)**[97] Compared the cyclic fatigue resistance of rotary files Twenty-four files each of EdgeFile X7, 2Shape, and F-One files were used in this study. The files were tested using a custom-made artificial canal. The number of cycles to fracture (NCF) was calculated. they found thatEdgeFile X7 was the most fatigue resistant. Autoclaving reduced the cyclic fatigue resistance of the tested files.

ListOfArmamentariumAndEquipmentsUsedInThisStudy:

1. Edge File(EFX7,Edgeendo ,NM,USA)
2. OneCurve(MicroMega, Besancon, France)
3. XPEndoshaper(FKGDentaire,La-Chaux-de-Fonds,Switzerland)
4. Trunatomy(DentsplySirona, Maillefer, Ballaigues,Switzerland)
5. Custommadecyclicfatiguedevicemadeof stainless steel
6. DentalOperatingMicroscope(Labomed,US A)
7. Lubricantoil(ZPremium,India)
8. DengenDentalMicroApplicatortip(Dengen Dental)
9. X-SMARTEndomotor(Dentsply,sirona,Switzerland)
10. DigitalvernierCaliper(Pinrui,Digital LCDCaliper,Shanghai,China)
11. Stopwatch(Apple,India)
12. Scanningelectronmicroscope(CARLZEISSMicroscopyLtdEVO-SEMMA15/18)
13. Isopropylalcohol(cleanpro ,USA)

Placeofthestudywhereitis conducted

This studywas conducted at Department of Conservative Dentistry and Endodontics,Babu BanarasiDasCollegeofDentalSciences,LucknowincollaborationwithIndianInstituteof technology ,Kanpur.

Study subjects

FourdifferentnovelrotaryNiTifile system.

StudySampleandsize

Studysampleandsize:60sampleswere takenwhichweredividedintofourdifferent groups each containing 15 samples.(n=15)

- **GroupA**-EdgeFileX7(EFX7,Edgeendo,NM,USA)
- **GroupB**-OneCurve(MicroMega,Besancon,France)
- **GroupC**-Trunatomy(DentsplySirona,Maillefer,Ballaigues,Switzerland)
- **GroupD**-XP-EndoShaper(FKGDentaireSA,LaChaux-de-Fonds, Switzerland)

.**Eligibilitycriteria:**

Inclusioncriteria-

Unutilizedendodonticrotaryfilesystemhavingdifferentmetallurgyandphysical characteristics

Exclusioncriteria-

Endodonticfileswithanysurfaceirregularitiesanddefects.

Samplecalculation

Sample size estimation forANOVAwas conducted using GPower software (version 3.0).A minimumtotalsamplesizeof59wasfoundtobesufficientforanalphaof0.05,powerof80 %,0.57aseffectsize(assessedfromasimilarstudy).Thusfinalsamplesizewasfurther roundedoff to 60 and was divided into 15 of each group.

Ftests-ANOVA:Fixedeffects,maineffectsandinteractions

Analysis: Apriori:Computerequiredsample size

Input:	Effectsizef	=0.57
αerrprob=		0.05
Power(1-βerrprob)		=0.80
Numeratordf		=10
Numberof groups		=4
Numberof covariates		=1
Output:	Noncentrality parameter λ	=19.1691000
Critical F	=	2.0111809
Denominatordf		=54
Totalsamplesize		=59
Actual power		=0.8020033

METHODOLOGY

1. Fabricationofthecustom-madesimulatedcanal model

Cyclic fatigue testing was carried out using a custom-made device made of stainless steel block mounted on wooden framework designed to enable a consistent simulation of an endodontic file confined within a curved canal. The model was constructed according to the recommendations of Pruett et al.with a 60 degree angle of curvature having a total length of 18mm of root canal with an inner diameter of 1.5mm & the angle of curvature located with a radius of 5mm from the tip of the file (as shown in figure 1). The upper part of the artificial canal was kept open. While testing it was covered with tempered glass to prevent the instruments from slipping out.

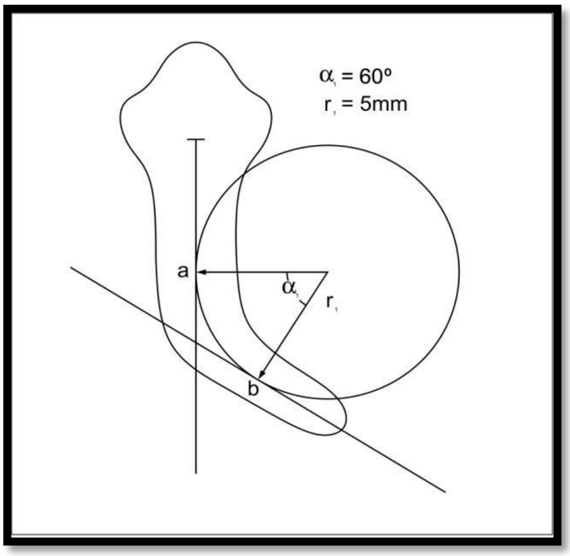


Fig1 –PreparationofArtificial Canal

2. Cyclicfatigue testing

NewTopofForm

packed filePacked files were open and examined under 20X magnification using a dental operating microscope to identify any microdefects, such as fracture lines. Files that were found to be microdefective were promptly discarded.The lubricant oil was applied by the applicator tip to the simulated canal until it was fully flooded with oil before each test. Furthermore, the rotary files were also coated with lubricant using the applicator tip before their application.These steps were incorporated in the experiment in order to reduce the frictionbetweenfileandsimulatedcanalwall.TheX-smartrotaryendodonticmotor

(Dentsply) with a contra angle (16:1 reduction) was positionedto the custom made device. The endodontic files were then used with endomotor at room temperature until files get fractured .All the rotary files were usedas per manufacturers recommended speed & torque incorporating a precise up and down movementas follows:

EdgefileX7fileat300rpm/2.5Ncm(tipsizeISO25with0.04taper) One curve

file at 300 rpm/2.5Ncm (tip size ISO 25 with 0.04 taper) Trunatomy file

at 500rpm/1.7Ncm. (tip size ISO 26 with 0.04 taper)

XPEndoshaper file at800rpm /1Ncm. (tip size ISO30 with0.04 taper)

Thetimetofracturewasrecordedinsecondsusingastop watch.Thetotalnumberofcycles to failure was calculated by multiplying the time to fracture in minutes by the number of rotations per minute.

NCF=TimetofractureinminutesXnumberofrotationsperminute NCF =

NUMBER OF CYCLES TO FRACTURE

3. Fracturedsegmentmeasurement

Foreachfile,thelengthofthefracturedsegment(FL)wasmeasuredusingaprecisiondigital caliper (Pinrui, Digital LCD Caliper, Shanghai, China) with a resolution of 0.01 mm.

4. Examinationofthefracturedfilesusingscanningelectronmicroscopy(SEM)

The separated files were kept in70% ethyl alcohol for 15 minutes before examination under SEM in order to remove any remnants of the lubricating oil & the debris entrapped inbetween the flutes or in the fracture surface during cyclic fatigue testing which was then allowed to dry. Two representative sample from each file system wasrandomly selected & photographed under SEM at magnification of400X and 1500X for the cross sectional views and 300X and 600X for the lateral views to verify the fracture mode. All the raw data was collected and statistical analysis was done

fig2-Edge Filex7

Fig3-One Curve

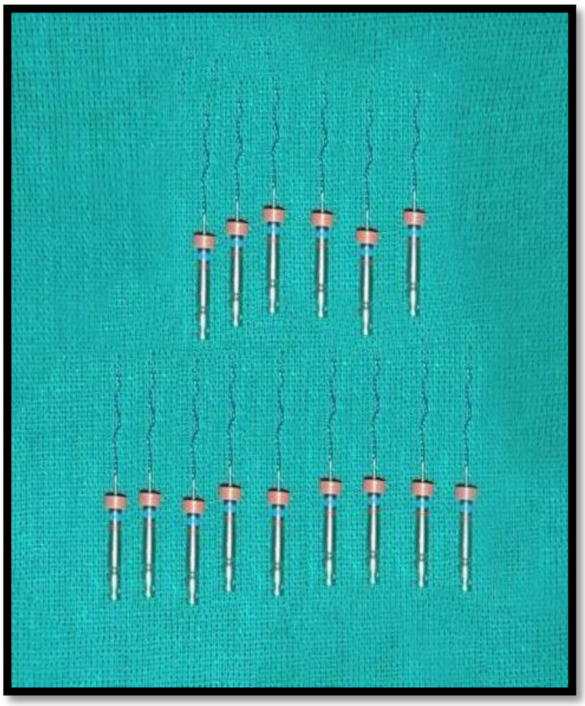


Fig4–Trunatomy

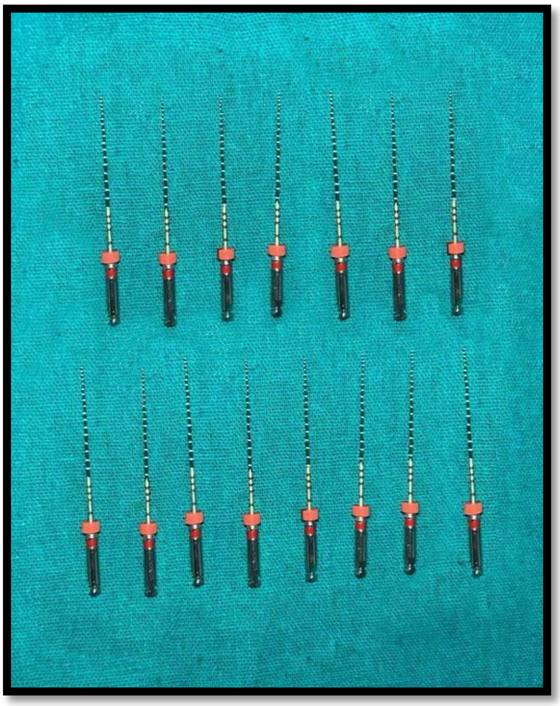


Fig5–XPEndoshaper

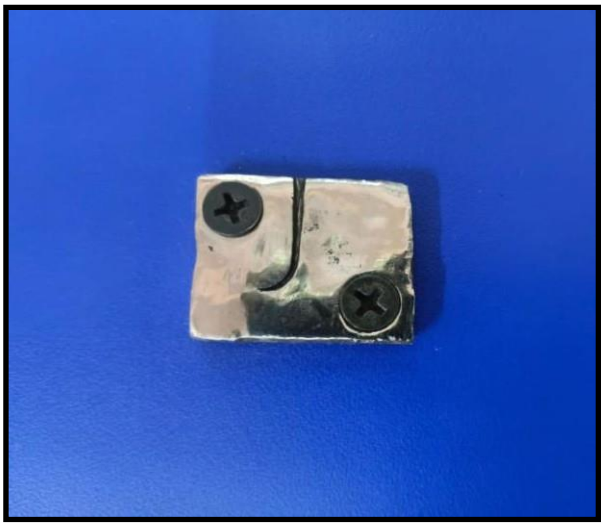


Fig6–CyclicFatigueTestingDevice

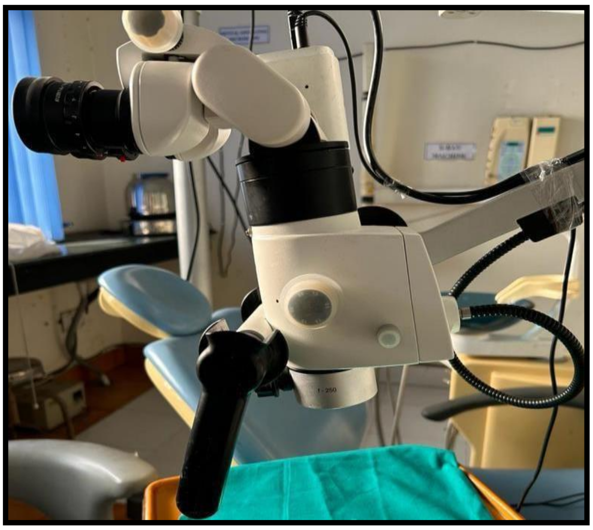


Fig7–DentalOperating Microscope

Fig8– X Smart Endomotor

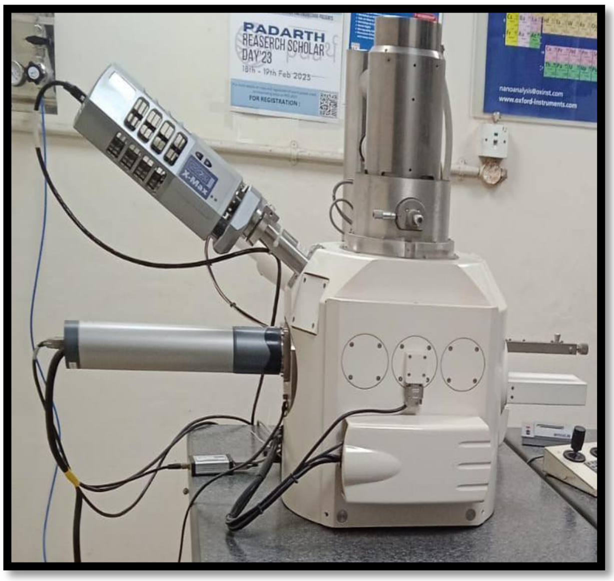


Fig9–ScanningElectronMicroscopeMachine

Fig10-StopWatch

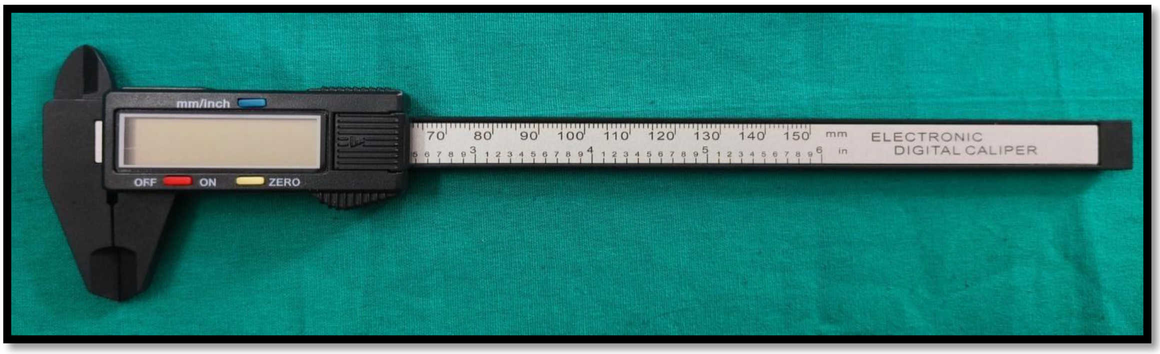


Fig11–DigitalVernierCalliper

Fig12–IsopropylAlcohol

Fig13–LubricantOil

Fig14–ApplicatorTip

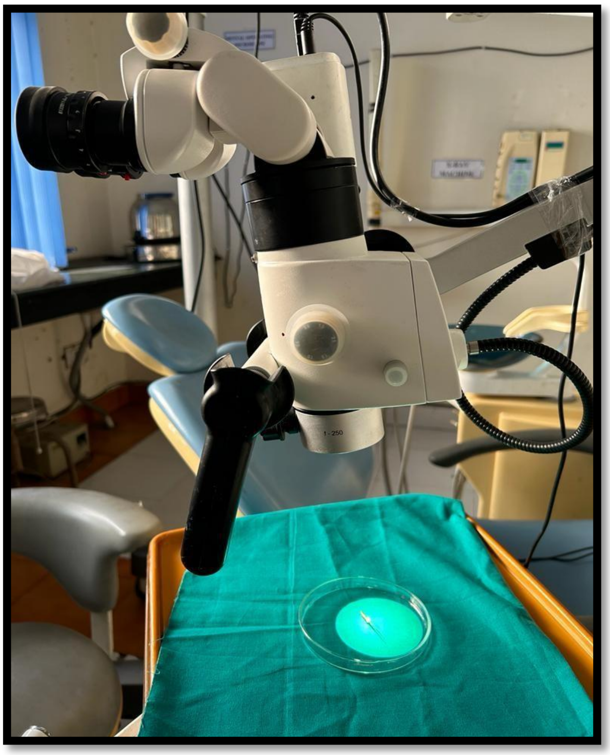


Fig15–MagnificationNitiFile

Fig16–WorkingLengthDetermination

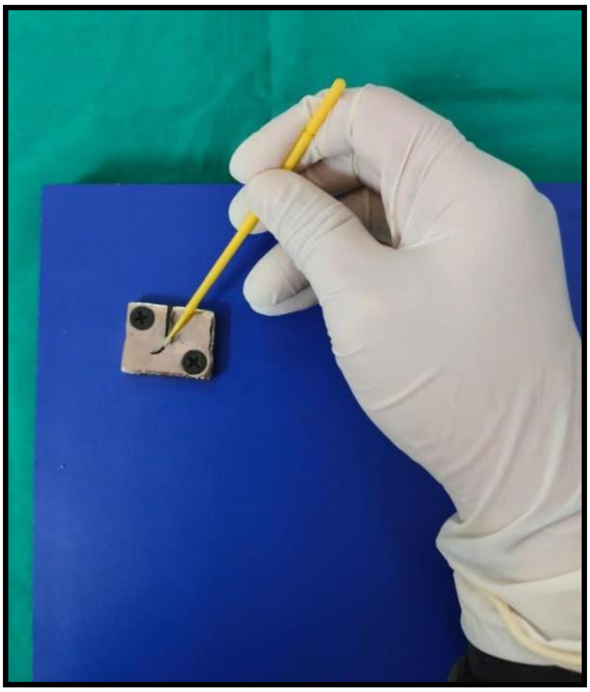


Fig17–ApplicationofLubricantOilonCanal

Fig18–ApplicationofLubricantOilonFile

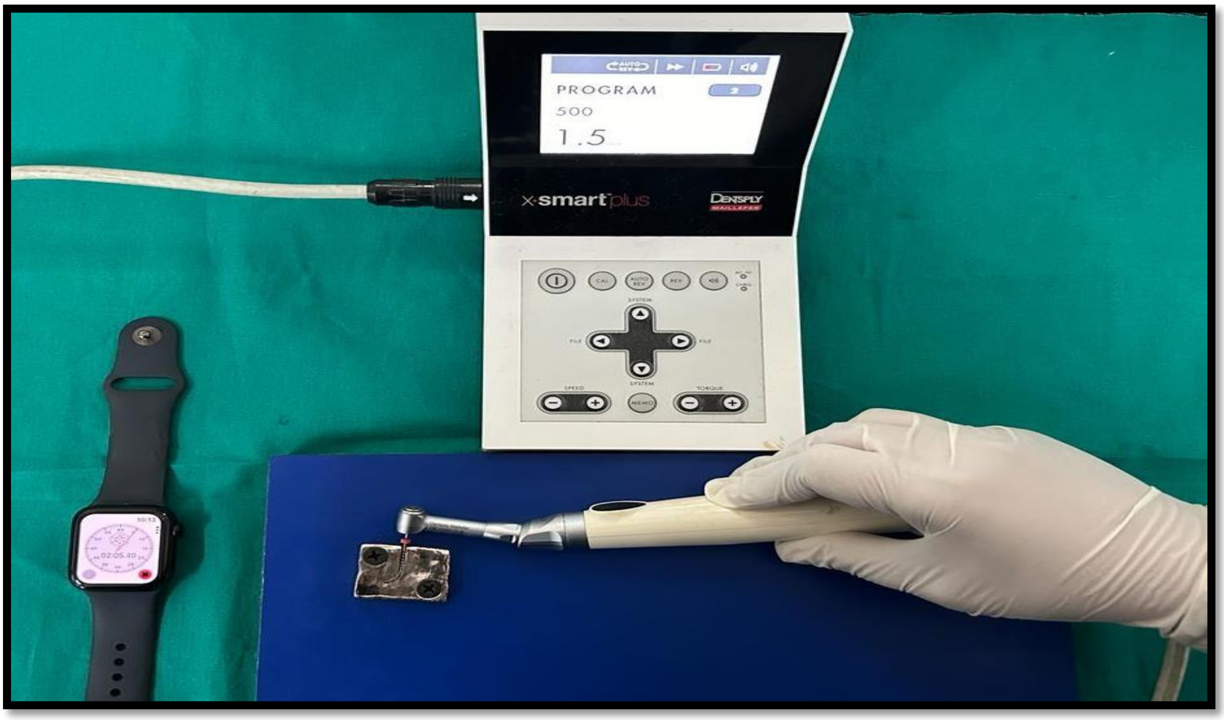


Fig19–CyclicTestingApparatus

Fig20–BrokenFragment

Fig21–MeasuredFLGroupA

Fig22–MeasuredFLGroupB

Fig23–MeasuredFLGroupC

Fig24–MeasuredFLGroupD

Fig25–MetalStub

EDGEFILEX7

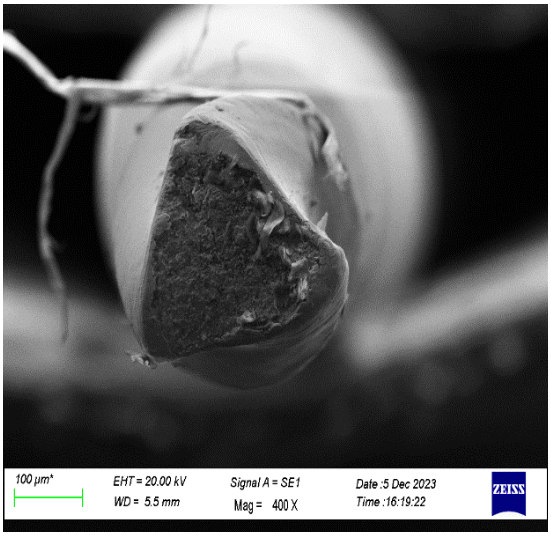


Fig26.1– Under 400X

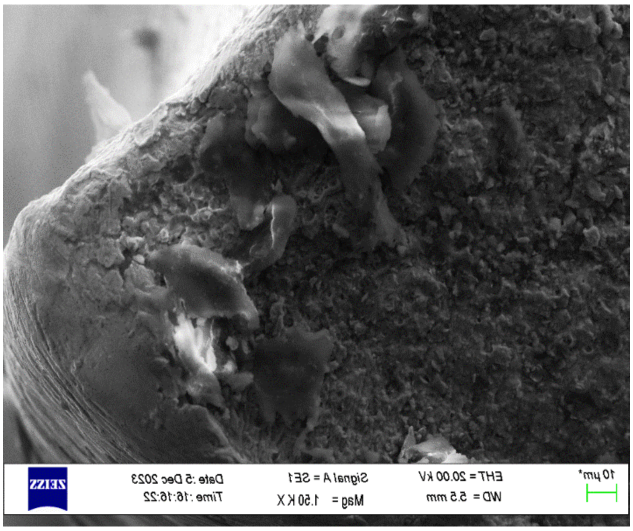


Fig26.2– Under 1500X

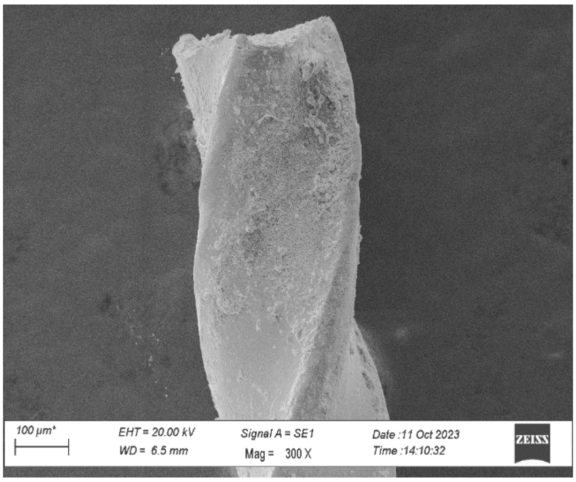


Fig26.3– Under 300X

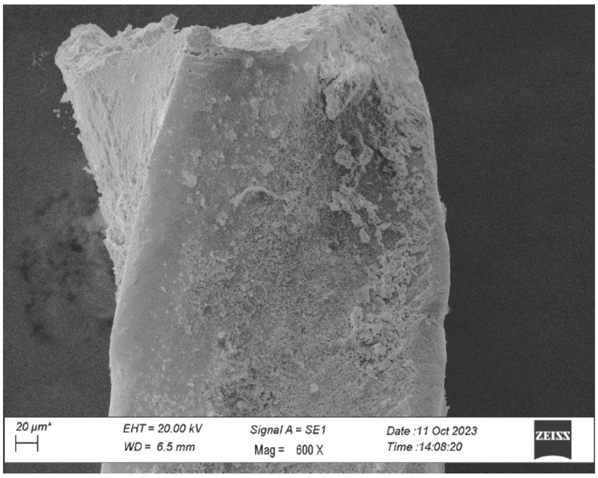


Fig26.4– Under 600X

ONECURVE

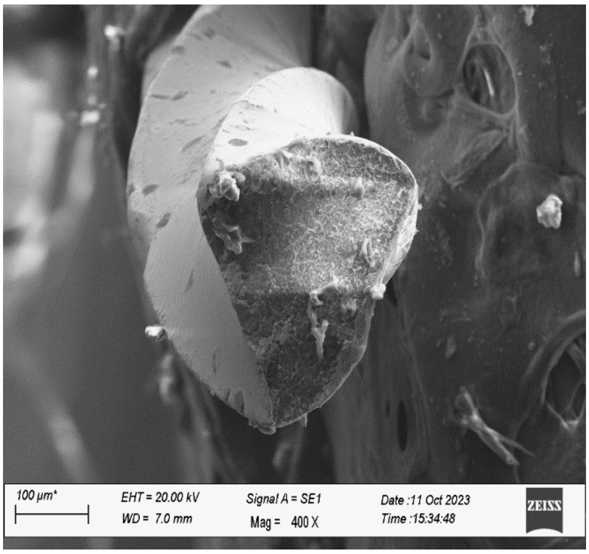


Fig27.1–Under400X

Fig27.2–Under1500X

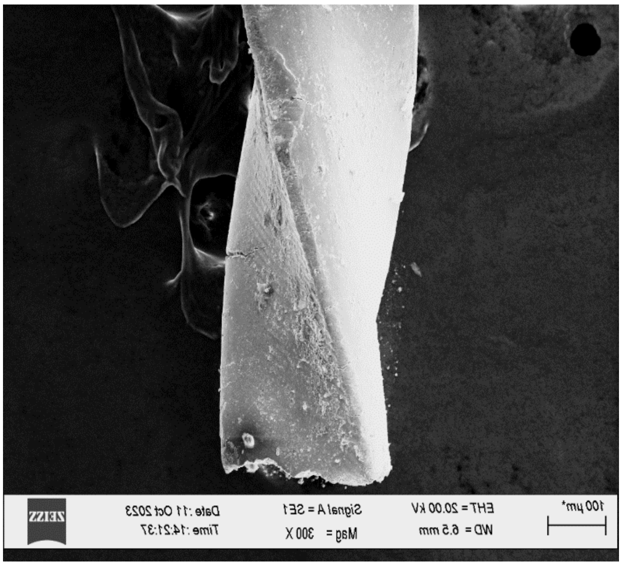


Fig27.3– Under 300X

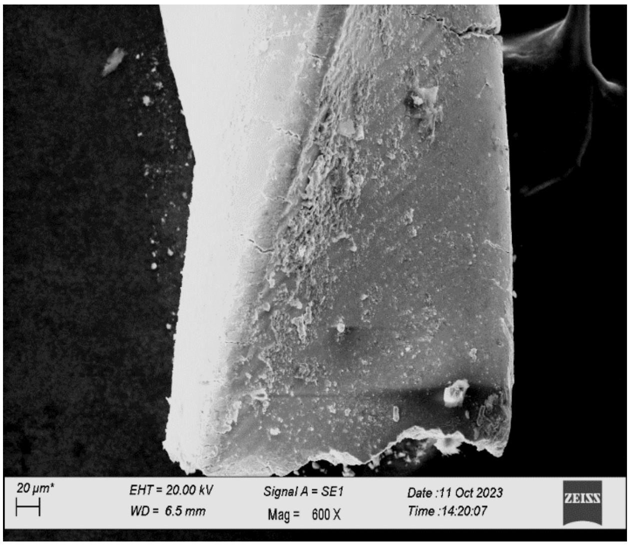


Fig27.4– Under 600X

TRUNATOMY

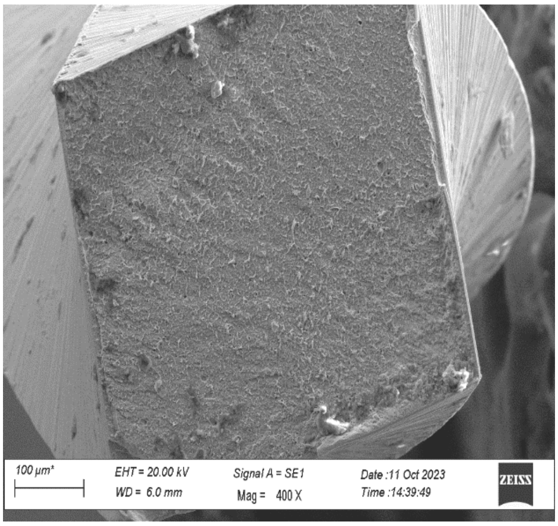


Fig28.1– Under 400X

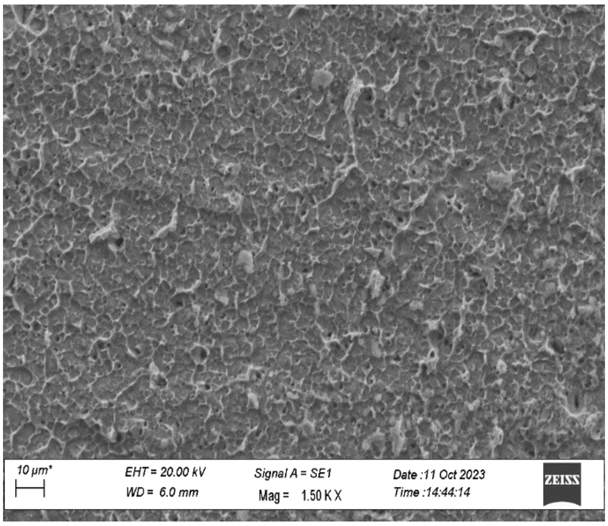


Fig28.2– Under 1500X

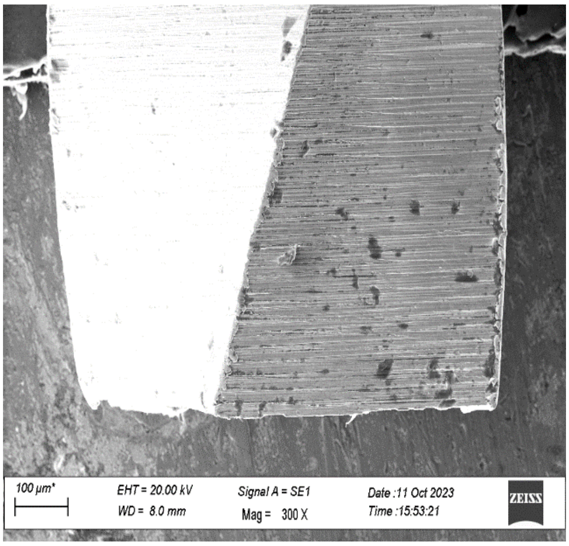


Fig28.3– Under 300X

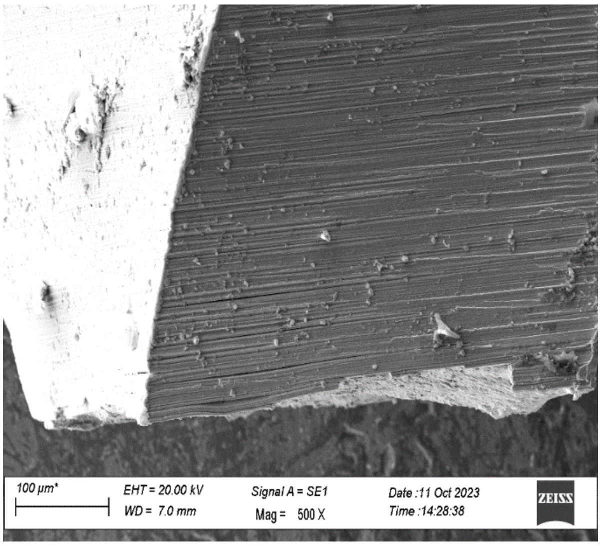


Fig28.4– Under 600X

XPENDOSHAPER

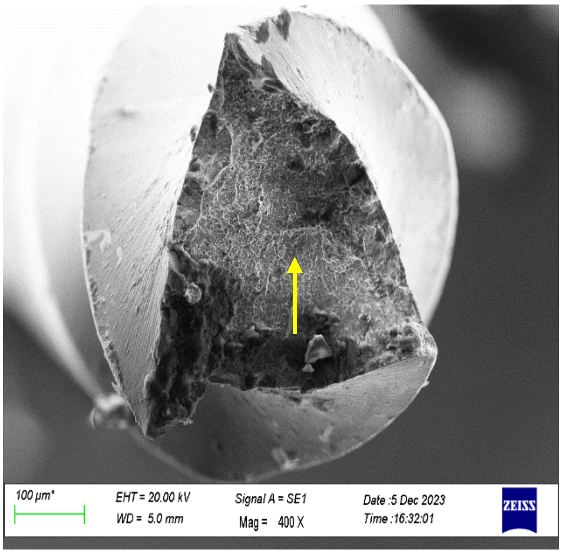


Fig29.1– Under 400X

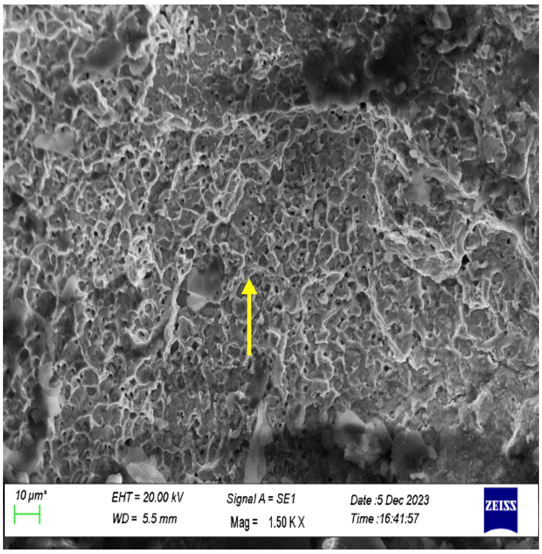


Fig29.2–Under1500X

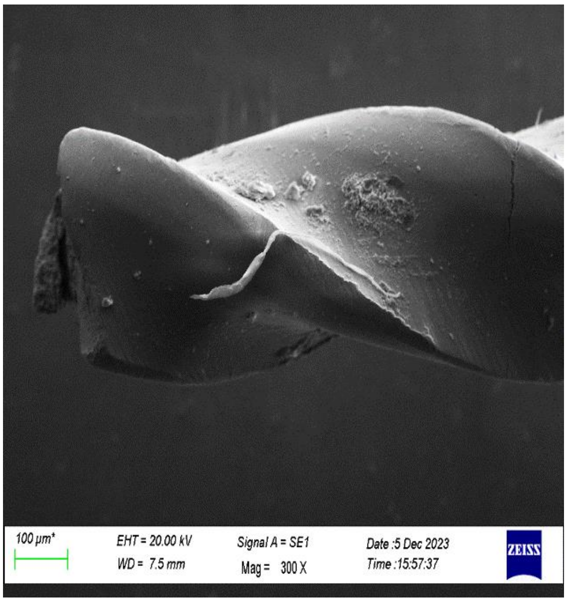


Fig29.3– Under 300X

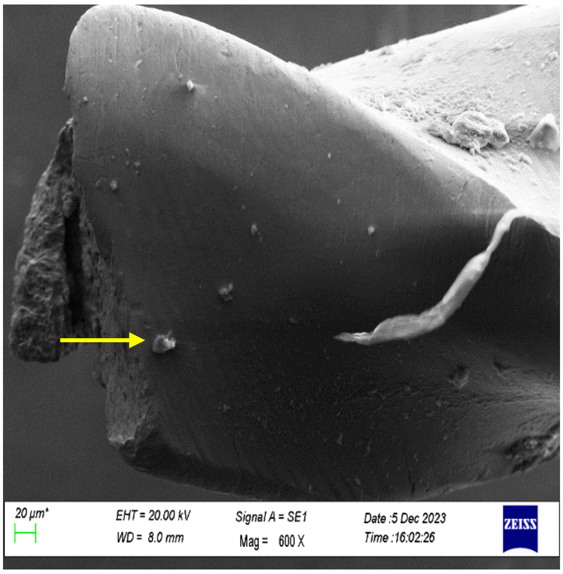


Fig29.4– Under 600X

Dataanalysis

Data was entered into Microsoft Excel spreadsheet and was checked for any discrepancies. Summarized data was presented using Tables and Graphs. The datawas analysed by SPSS (21.0 version). Shapiro Wilk test was used to check which all variableswerefollowingnormaldistribution. Datawasnormallydistributedtherefore, bivariate analyses were performed using the one way ANOVA test. Level ofstatistical significance was set at p-value less than 0.05

Table 1, Shows the distribution of NCF values that was tested among the NiTi files (Edge file X7,One curve ,Trunatomy, Xp endoshaper) used in this study.

Table 2, Shows the distribution of FL values in mm that was tested among the NiTi files of different systems (Edge file X7,One curve ,Trunatomy, Xp endoshaper)

Table 3 and Graph 1, Shows comparison of the number of cycles to failure (NCF) at 5mm from the artificial canal tip and 60 degree angle canal curvature amongEdge file X7,One curve ,Trunatomy, Xp endoshapergroups . The mean and S.D values of NCFGROUPA,GroupB,GROUPC,GROUPDwere1276.750(375.6),1169.833 (318.2094), 1049.583 (255.3915), and 1218.167 (176.6264) respectively. There was a statistically no significant difference between fourgroups at 60 degree canal curvature (p value >0.05).

Table 4 and Graph 3, Shows comparison of the fractured fragment FF values in mm that was tested among the NiTi files of different systems . The meanand S.D values ofNCF ofGROUPA,GroupB,GROUPC,GROUPDwere2.3775(0.41451),2.5167 (0.52886), 3.4167 (0.99620), and 2.7500 (0.75378) respectively. There was a statistically significant difference between all three groups at 60 degree canal curvature (p value >0.05).

There was no significant difference between RB & WOG and HEDM & OC with respect to the length of the fractured file fragments 60° curvature (P > 0.05).

TABLE1 THE NUMBER OF CYCLES TO FAILURE (NCF)OF THE DIFFERENTNITIFILESYSTEMSTESTEDINTHEPRESENTSTUDYAT CANALCURVATURE 60 DEGREE

GROUPA	**GROUPB**	**GROUPC**	**GROUPD**
1133	1635	1015	1036
1100	1503	745	1034
1300	1605	1150	1043
1500	524	1200	1500
1111	1266	1000	1005
1115	1244	1040	1500
1089	1047	650	1200
1076	903	1000	1200
1123	930	1030	1200
1234	1230	1065	1200
1134	1074	1700	1300
2406	1121	1000	1400
1241	1028	854	1120
2201	989	1010	1231
1304	1125	945	1256

TABLE2:THELENGTHOFTHEFRACTUREDFRAGMENT(FL)(MM)OF THE TESTED NITI FILES AT CANAL CURVATURE ANGLE 60 DEGREE

GROUPA	GROUPB	GROUPC	GROUPD
2.10 mm	3.10 mm	3.10 mm	3.10 mm
3.11 mm	3.10 mm	3.27 mm	3.11 mm
3.10 mm	2.11mm	4.10 mm	3.10 mm
3.02 mm	2.12 mm	3.10 mm	3.02 mm
2.10 mm	2.13 mm	4.11 mm	2.10 mm
3.03 mm	2.14 mm	2.10 mm	3.03 mm
3.09 mm	2.11mm	3.10 mm	3.09 mm
2.01 mm	2.12 mm	3.23 mm	2.01 mm
2.11mm	2.03mm	3.52 mm	2.14 mm
2.12 mm	3.10 mm	3.59 mm	2.11mm
2.13 mm	3.10 mm	3.32 mm	1.11mm
2.14 mm	2.14 mm	3.12 mm	3.10 mm
2.11 mm	2.11mm	4.10 mm	3.11 mm
2.02 mm	3.10 mm	3.111 mm	1.23 mm
2.03 mm	3.10 mm	2.10 mm	2.34 mm

Table3COMPARISONOFTHENUMBEROFCYCLESTOFAILURE(NCF) OF THE DIFFERENT NITI SYSTEMS TESTED IN THE PRESENT STUDY AT CANAL CURVATURE 60 DEGREE

Group	Mean	Std. Deviation	Std. Error	95% Confidence IntervalforMean		Minimum	Maximum
				Lower Bound	Upper Bound		
GROUP A	1276.750	375.6839	108.4506	1038.052	1515.448	1076.0	2406.0
GROUP B	1169.833	318.2094	91.8592	967.653	1372.014	524.0	1635.0
GROUP C	1049.583	255.3915	73.7252	887.315	1211.851	650.0	1700.0
GROUPD	1218.167	176.6264	50.9876	1105.944	1330.390	1005.0	1500.0
P value							0.280

Graph1:COMPARISONOFFOURGROUPSWITHRESPECTTOTHE NUMBER OF CYCLES TO FAILURE (NCF) AT CANAL CURVATURE60

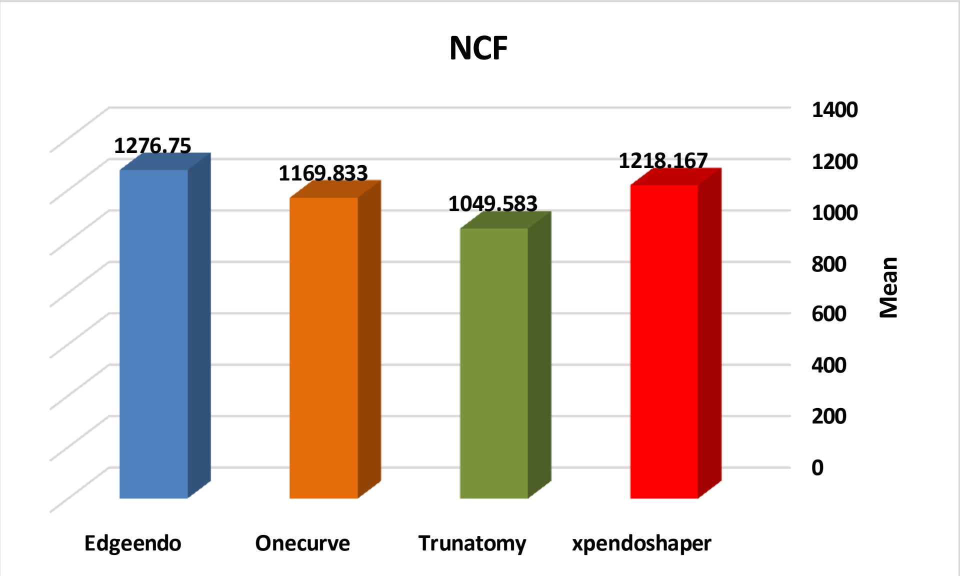


Table4:Post hocforNCFintergroup comparisonbetween NiTifilesystem

Group	Group	Mean Difference (A-D)	Pvalue	95% ConfidenceInterval	
				Lower Bound	Upper Bound
A	B	106.9167	.805	-210.324	424.158
	C	227.1667	.238	-90.074	544.408
	D	58.5833	.960	-258.658	375.824
B	A	-106.9167	.805	-424.158	210.324
	C	120.2500	.743	-196.991	437.491
	D	-48.3333	.977	-365.574	268.908
C	A	-227.1667	.238	-544.408	90.074
	B	-120.2500	.743	-437.491	196.991
	D	-168.5833	.495	-485.824	148.658
D	A	-58.5833	.960	-375.824	258.658
	B	48.3333	.977	-268.908	365.574
	C	168.5833	.495	-148.658	485.824

Table 5: COMPARISON OF THE LENGTH OF THE FRACTURED FRAGMENT(FL)(MM)OFTHETESTEDNITIFILESATCANAL CURVATURE ANGLE 60O

Group	Mean	Std. Deviation	Std.Error	95% Confidence IntervalforMean		Minimum	Maximum
				Lower Bound	Upper Bound		
GROUP A	2.3775	.41451	.11966	2.1141	2.6409	2.00	3.17
GROUP B	2.5167	.52886	.15267	2.1806	2.8527	2.00	3.60
GROUP C	3.4167	.99620	.28758	2.7837	4.0496	2.00	5.00
GROUP D	2.7500	.75378	.21760	2.2711	3.2289	2.00	4.00
Pvalue					0.089		

GRAPH2COMPARISONOFFOURGROUPSWITHRESPECTTOTHE NUMBER OF CYCLES TO FAILURE (NCF) AT CANAL CURVATURE60

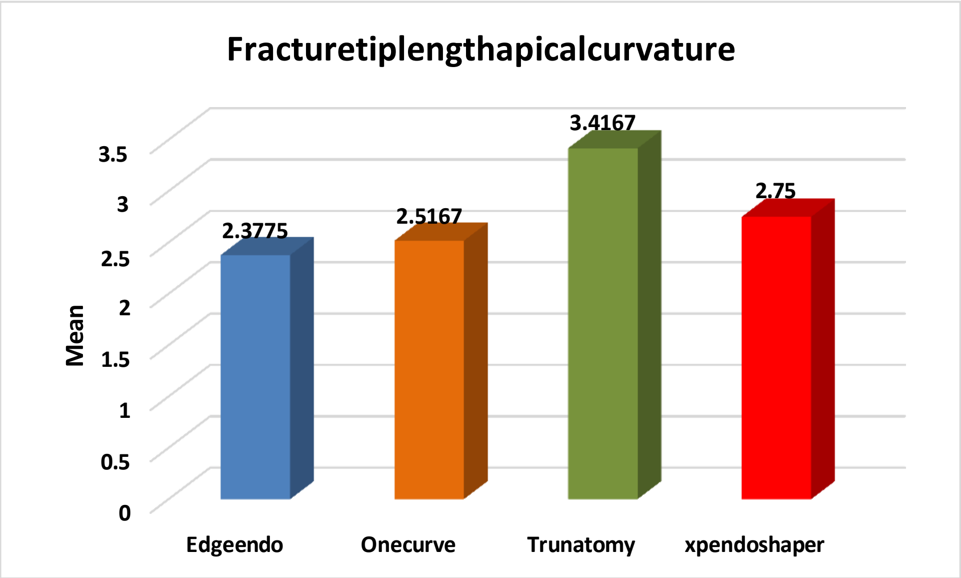


TABLE6Posthocforfracturetiplengthapicalcurvatureintergroup comparison of niti file system

(I) Group	(J) Group	Mean Difference(I-J)	Std. Error	P value	95%Confidence Interval	
					Lower Bound	Upper Bound
1	2	-.13917	.28955	.963	-.9123	.6339
	3	-1.03917*	.28955	.064	-1.8123	-.2661
	4	-.37250	.28955	.576	-1.1456	.4006
2	1	.13917	.28955	.963	-.6339	.9123
	3	-.90000*	.28955	.057	-1.6731	-.1269
	4	-.23333	.28955	.851	-1.0064	.5398
3	1	1.03917*	.28955	.064	.2661	1.8123
	2	.90000*	.28955	.057	.1269	1.6731
	4	.66667	.28955	.113	-.1064	1.4398
4	1	.37250	.28955	.576	-.4006	1.1456
	2	.23333	.28955	.851	-.5398	1.0064
	3	-.66667	.28955	.113	-1.4398	.1064

*.The mean differenceissignificantatthe0.05 level.

Various specialized instruments and materials have been innovatedFOR the biomechanical preparation.[98] These instruments, recognized for their rigidity, exceptional strength, and efficient cuttingefficiency, were frequently employed inthe past to shape curved root canals. This usage often led to the formation of challenges such as elbows, zips, transportation issues, ledges, and perforations.[99]

.To overcome these drawbacks , Walia et al. introduced nitinol, a nickel-titaniumalloy(NiTi), in 1988. Instrumentsfabricated with NiTi havegreaterflexibility, super elasticity, increased safety , allowing for well-centered canal preparation in less time and with less transportation.[11,100]Even with their ease of use and clinical efficiency, these instruments can cause complications such as instrument separation.Instrument separation is one of the major concern associated with NiTi file system.[101]

The separation of the instruments is a frustrating situation for the clinician because it can prevent full length instrumentation and root canal obturation. As a result, tooth healing may have a poor prognosis.[102]Spili et al. proposed that the presence of a preoperative periapical lesion is more important than the presence of a fractured instrument for healing rate, but Grossman found that the healing rate for a fractured instrument is lower than that of a preoperative periapical lesion and he reported that fracture instrument in a canal decreases the prognosis of tooth.[14,103]

Fracture of NiTi files used in continuous rotary motion has been attributed by two mechanisms:cyclic fatigueandtorsional stress.Torsionalfatiguesoccur whenthetip or another part of the instrument becomes locked and separates in the canal during continuous rotation; this type of fracture occurs when the torque exceeds the elastic limit of the metal.[17] The number of cycles that an instrument can support is referred to as cyclic fatigue. [104] Cyclic fatigue occurs unexpectedly and without any sign of previous permanent deformation when instruments are subjected to rotation inside a curved canal under an excessive number of tension-compression cycles.[105]Becauseof flexural stress and cyclic fatigue, canal curvature is thought to be a major riskfactor for instrument failure.According to one study, the incidence of NiTi rotary instrument fracture is only 5%, with cyclic fatigue accounting for 70% and torsional fatigue accounting for 30%.[104] According to Parshos et al.stated that, cyclic fatigue failure is the most common type of instrument fracture, whereas Satapan et al. claim that torsional stress is slightly more common.[16,106]

Increasing fatigue resistance is thought to be the primary goal for ensuring safety during endodontic therapy.[107]Numerous variables influence the fatigue resistanceof NiTi rotary files, including rotational speed, metal surface treatments, multiple autoclaving, root canal radius and angle of curvature, number of uses of the files, motor torque, dentist experience, and metallurgical characterization of the NiTi alloys.[108]

To prevent these fractures of NiTi files,manufacturers are continuosly attemptingto develop , manufacturing processes,different alloys, various heat treatments, (Max-wire,C-wire ,F wire) and protocols to minimise the occurrence of instrument fracture**.**[109]

Currently,thereisnospecificationorinternationalstandardfortestingthecyclic fatigue resistance of endodontic rotary instruments. As a result, a variety of devicesandmethodswereusedtoinvestigatetheinvitroflexuralcyclicfatiguefracture resistance of NiTi rotary endodontic instruments. The rotating instrument was either confinedinaglassormetaltube,agroovedblock-and-rodassembly,orasloped metal block in nearly all studies reported in the endodontic literature.[110,111,112] Although using natural human teeth to evaluate the flexural cyclic fatigue resistanceofendodonticinstrumentswouldbetheidealmethodbecausetheycanaccurately simulateclinicalconditions,onelimitationofsuchtestsisthatatoothcanonlybe usedoncebecausetheshapeoftherootcanal changes duringinstrumentation, making it impossible to standardise the experimental conditions.[111]Therefore, in the present study, a custom-made stainless steel canal model was used to ensure a fixed radius of curvature, a fixed angle of curvature, and a fixed center of maximum curvature.[110]

The design of the simulated canal used in the study followed the method described by Pruett et al.[110] This method describes theroot canal curvature based onthe angle ofcurvatureand theradius ofcurvature. The radius ofcurvature represents howabruptly or severely a specific angle of curvature occurs as the canal deviates from a straightline. The smaller the radius of curvature, the more abrupt the canal deviation, and the stress on the instrument is inversely related to the radius of canal curvature .

The cyclic fatigue life span of endodontic instruments exhibits a reduction with an increase in the angle of curvature, a decrease in the radius of curvature, higher rotational speed, and larger instrument diameter. Consequently, the metal mass of the instrumentat the pointof maximumstressemerges asacrucial contributingfactor.[113]

All of the previously listed variables i.e rotational speed ,root canal radius , angle of curvature, torque , metallurgical properties were fixed and standardised in the current study,withtheexceptionofthemanufacturinganddesignprocessfortheinstruments. As has been done in previous studies, the simulated canal had an apical curvature of 60°, a radius of 5 mm, and a point of maximum curvature located 5 mm from the canal's apex to replicate the apical curvature that can be found clinically, where the maximumstresseson theinstrument areconcentrated. Theresults ofPruett et al , who stated that curvature less than 30° and at a radius of 5 mm produced low stress levels, are also reflected in these values.[114-116]Therefore, the current study used a 60° angle of curvature and a 5 mm radius of curvature in an attempt to simulate a more acute curvature. This allowed for comparisons with other studies and the simulation of abrupt apical curvature patterns that are clinically observed.

In a current study all instruments had previously been inspected using a dental operating microscope with a magnification of 20X to conduct a morphologic analysis and look for any signs of visible deformation. All defective instruments would have been discarded**.**

In the current study to withstand friction wear, a custom-made simulated canal model was fabricated from hardened stainless steel.And a stainless-steel metal block with a radius of curvature of 5mm and a diameter of 1.5mm 18.Ounsi et al [27] used astainless steel model that was custom-designed to mimic a 2-mm-wide artificial canal space.If instruments of the same dimensions follow different trajectories in the test apparatus, it may be difficult to establish a direct comparison between instruments of different brands, and the results obtained may be unreliable and inconsistent.

In the current study A glass screen was placed over the artificial canal to keep the instruments from sliding out, make the fragmented instrument easier to remove, and prevent the loss of the broken pieces.

In this present study throughout the procedurelubricant oil was used to allow the instrument to rotate freely in the canal without friction and resistance during thecyclic fatigue test (Pedulla et al.2013)

In a recent study The separated files were immersed in 70% ethyl alcohol for 15 minutes before SEM examination to remove any remnants of the lubricating oil and debris entrapped between the flutes or on the fracture surface during flexural cyclic fatigue testing, and then allowed to dry.[117]

SEM studies are widely recognised as the most accurate method for assessing fractured sites. Understanding the fatigue behaviour of NiTi alloys requires the analysis of fracture surfaces using SEM images. Distinctive features on these surfaces must be examined to determine fracture patterns. The SEM analysis of fractured file surfaces revealed a ductile fracture pattern with microscopic dimples. Further magnification revealed fatigue lines, offering insights into the early stages of crack progression.[118]

In the present study cyclic fatigue resistance of four novel rotary NiTi file system Edge file X7 ,Xp endoshaper, One curve, Trunatomy were comparatively evaluated. According to the findings of present studyEdge file X7 demonstratedheighest cyclic fatigueresistancefollowedbyXpendoshaper,OnecurveandTrunatomyasshownin graph 1.

Edge file X7 file system showed high resistance to cyclic fatigue in this study 1276.750, table no. 2 due to its annealed heat-treated fire wire technique which increases the flexibility of this instrument. Pongione G etal.[119] stated that endodontic rotary files having an increased flexibilityperceived to be more resistant to cyclic fatiguewhichmayhavecauseincreasecyclicfatigueresistanceofEdgefileX7inthis study. The effect of cross-sectional design and core massof rotary instruments on cyclic fatigue resistance has already been demonstrated, with a smaller metal volume (core mass) appearing to be associated with greater resistance to cyclic fatigue.[81,120,121] As Edgefile x7 file system which has parabolic cross-sectionhas minimal core volume then the cross sections of all the other tested files therefore it might have been cause of its maximum resistance to cyclic fatiguethan all the other tested files.

Mohammed AM etal.[122]In their study demonstrated that Edge file X7have high cyclic fatigue resistance which is in accordance with our study. Similarly, Al-Amidi AH etal.[97] Examined the cyclic fatigue resistance ofEdge file X7, 2shape and F-one endodontic instruments and observed Edge file X7 has highest resistance to cyclic fatigue which supports the finding of this study.

However,Abu Naeem FM etal.[123]Compared the cyclicfatigueresistance ofEdgefile X7with Edge one, wave one gold and wave one Rotary files and observed that edge fileX7hasthelowestcyclicfatigueresistanceamongthetestedfiles.This discrepancy in the findings from this study can be attributed to the difference in methodology of the study and file systems tested in their research.

Xp endoshaper showed significantresistance to cyclic fatigue1218.167according to table no. 2XPS is produced from Max Wire NiTi alloy.[81]According to its manufacturers,this technique demonstrated high flexibility and fatigue resistancewhen it shape root canal up to30.04 dimensions at body temperature. Max-Wire instruments remain relatively straight at room temperature as they are predominantly martensitic, they undergo austenitic changes to a predetermined curved shape when exposed to higher temperatures.[7] As eggeleret al [124] demonstrated the effect of the rotational speed is related to heat generation which move the instrument in to martensite to austenite phase.xp endoshaper has speed of 800 rpm which may have cause the phase transformation and change in taper from 0.1 to 0.4 of file system leading to higher resistance to cyclic fatigue.

Keskin C etal [125] in their study observed that xp endoshaperhave high cyclicfatigue resistance as . Similarly ,Silva L N [48] examined the cyclic fatigue resistance of Xp endoshaper and trushape NiTi instruments andthey observed thatXp endoshaper has goodresistance to cyclic fatigue which supports the findings of our study.

In thisstudy ,Xp endoshaper showed higher fatigue resistance as compared to one curve 48.3333TableNO. 3 .This can be explained based on the taper of these file systems as file diameter of ni ti file system is inversely proportional to cyclic fatigue resistance.[86]Xpendoshaperhasinitialtaperof0.1whereasonecurvehas0.4taper .manufacturers of xp endoshaper claims that the instruments' swaggering motionleads to a taper expansion up to 30/.04. This initial small ISO diameter and narrow taper make XPS instrument more resistant to cyclic fatigue.[81]

On comparison of XPendoshaper with trunatomy.xp endoshaper demonstrated better resistance to cyclic fatigue 168.5833table no.3 which was non significant .As our result are consistent with those of previous studies showing that niti files with smaller cross sectional areas presented superior resistance to cyclic fatigue.[81,120,121] Xp endoshaper with triangular cross section have more resistant to cyclic fatigue then trunatomy files which have off centered parallelogram cross section . Further, XP-endoShaperhasauniquedesign,withacurvedshape,boostertip,andsixcutting edges. The contact time between the surface of the instrument and the artificial root canal during rotation was less with XP-endo Shaper than with other instruments.[7] This may have lowered the stress developing due to repetitive bending during the cyclic fatigue resistance test in this study.

According to table no. 2, one curve demonstrated moderate cyclic fatigue resistanceof 1169.833. This file is fabricatedfrom a C-Wire by using a proprietary heat treatment with a controlled memory property that improved the cyclic fatigue resistance of this instrument.[119] In addition to this ,performance of one curve rotary file in this study can also be explained based on their cross section which is triplehelix at the tip of the instrument and s cross section at the handle. As the volumeof themetalmassatthemaximumcurvaturepointcontributestothefatigueresistanceof the File (GrandeNM 2006) [92]

Elnaghy,M A [76]compared the Cyclic fatigue Resistance of One Curve, with2Shape, ProFile Vortex, Vortex Blue, and RaCeand observed that one curve has moderate cyclicfatigueresistance.similarly, GhahramaniY etal [126] comparedCyclic fatigue resistance of one curve with AF F-One and Hyflex EDM and found that one curve has moderate cyclic fatigue resistance

However, AltufayliMD [127]compared the cyclic fatigue resistance of one curve with F one and reciproc blueand they found that one curve has least cyclic fatigue resistance than other tested niti file system. This aversed finding can be due to discrepancy in research methodology.

In this study the one curve instrumentis more resistantto cyclic fatigue on comparison with trunatomy 120.2500 Table no. 3 which was non significant. Loupes H etal [37] stated that rotational speed of rotary file is also a factor that influence the cyclicfatigueresistancetheyconcludedthatincreaseinrotationalspeedsignificantly reduced the number of cycles to fracture. According to Tobushi et al [128], in a cyclic fatigue assay under constant stress range, the temperature increases proportionally to the rotational speed, resulting in a lower number of cycles to fatigue failure.In the present study, TN files were operated at higher speeds and lower torques than one curvefiles (500 vs. 300 RPM and 1.5 vs. 2.5 N-cm, respectively); these parameters were selected according to the manufacturers' recommendations. This might be the cause of higher value of fatigue resistance of one curvein relation to trunatomy.

Gouédard C [92] compared in his study the cyclic fatigue resistance ofone curve with hyflex CM , skytaper f6 and protaper next and they found that these file system has significant resistance as compared to protaper next .SimilarlyElnaghyM [92]showed one curveinstruments displayed superior cyclic fatigue resistance than Profile vortex and Raceinstruments.

Howeveryeimajk[129]comparedcyclicfatigueresistanceofonecurve,hyflexEDM, waveone gold and reciproc blue nickel-titanium rotary files and they observedone curve has least cyclic fatigue resistance among all the tested files This discrepancy in thefindings can beattributedto thestudy's methodologyand thefilesystems tested in their research.

In this study, cyclic fatigue resistance of trunatomy rotary niti file system was evaluated and it was observed that it has least resistance to cyclic fatigue among allthe tested files. As Gündoğar M, demonstrated that offcentered parallelogram has large surface area. Therefore, it can be stated that trunatomy has off centered parallelogram cross section which has maximumsurface area amongall the tested file system.zhang ,cheung etal [130]has reported that the cross section design rather than smallersizeandtaperhasgreaterinfluenceonaninstrumentunderaloadtherefore ,this might be the cause of least resistance of trunatomy files to cyclic fatigue in this research.

Gündoğar M etal [84] comparatively evaluated the cyclic fatigue resistance of four niti file system that were VDW rotate,2 shape ,trunatomy, hyflex CM and observed that trunatomy has least resistance to cyclic fatigue which supports the findings of this study. However, Reddy NB etal [118] compared the cyclic fatigue resistance of trunatomy with ProTaper, HyFlex EDM and Reciproc blue andfound trunatomy has high cyclic fatigue resistance among all the tested niti file system.similarlyRiyahi MA etal [134]compared the trunatomy with**t**wisted Filesand ProTaper Next and showed trunatomy has highest resistance to cyclic fatigue.This averse finding can be attributed to the variation in mechanical and physical properties ofrotary files tested and difference in methodology and of the research.

Some previous studies found a significant difference between the mean length of the fractured fragments. Differences in the designs and alloys of the instruments may cause the location of the maximum stress points to vary). As the file became more resistanttocyclicfatigue,areaswithsmallercross-sectionsmayhavebecomemore resistant, whereas regions with larger cross-sections may have been more prone to cyclic fracture.

According to El Feky HM fragment length isinverselyproportional to the cyclic fatigue resistance. In this studyon comparison of Edge file X7 with Xp endoshaper and One curvehas smaller fragment length as compared to trunatomy

It can be concludedfrom this study edge filex7 has maximum resistance to cyclic fatigue and trunatomy file has the lowest cyclic fatigue resistance among the tested niti file system there was no statistically significant difference in the cyclic fatigue resistanceof all the tested endodontic rotary niti file system.i.e Edge file X7 ,one curve , xp endoshaper,trumatomy .

Within the constraints of this research it can be concluded that the cross-sectional design of rotary files significantly impacts their resistance to cyclic fatigue. In this study, Edge File X7 which has parabolic cross section have minimum core volume exhibited the highest cyclic fatigue resistance, followed by XP EndoShaper and One Curve, while TruNatomy demonstrated the lowest resistance. it can be also stated that length of the fractured fragment is also associated with cyclic fatigue resistance and inversely proportional to it . As trunatomy file system in this study exhibited the largest fractured segment and demonstrated minimal cyclic fatigue resistance.

1. HülsmannM,PetersOA,DummerPMH.Mechanicalpreparationofrootcanals: shaping goals, techniques and means. Endodontic Topics. 2005;10(1):30-76.
2. Siqueira JF, Jr. Aetiology of root canal treatment failure: whywell-treated teeth can fail. Int Endod J. 2001;34(1):1-10.
3. Schilder H. Cleaning and shaping the root canal. Dent Clin North Am.1974;18(2):269-296.
4. Weine FS, Kelly RF, Lio PJ. The effect of preparation procedures on original canal shape and on apical foramen shape. J Endod. 1975;1(8):255-262.
5. .Connert T, Weiger R, Krastl G. Present status and future directions – Guided endodontics. Int Endod J. 2022 Oct;55 Suppl 4(Suppl 4):995-1002. doi10.1111/iej.13687. Epub 2022 Feb 4. PMID: 35075661; PMCID: PMC9790195.
6. Tabassum S, Zafar K, Umer F. Nickel-Titanium Rotary File Systems: What's New? Eur Endod J. 2019 Oct 18;4(3):111-117. doi: 10.14744/eej.2019.80664. PMID: 32161896; PMCID: PMC7006588.
7. Crump MC, Natkin E. Relationship of broken root canal instruments to endodontic case prognosis: a clinical investigation. J Am Dent Assoc 1970;80:1341–7. .
8. Al-Fouzan KS. Incidence of rotary ProFile instrument fracture and the potential for bypassing in vivo. Int Endod J 2003;36:864 –7.
9. Walia H, Brantley WA, Gerstein H. An initial investigation of the bending and torsional properties of Nitinol root canal files. J Endod 1988;14:346–51.
10. Sch€afer E, Schulz-Bongert U, Tulus G. Comparison of hand stainless steel and nickel titanium rotaryinstrumentation: a clinical study. J Endod 2004;30:432–4.
11. Gluskin A, Brown D, Buchanan L. A reconstructed computerized tomographic comparison of NiTi rotary GT™ files versus traditional instruments in canals shaped by novice operators. Int Endod J 2001;34:476–84.
12. Zhou H, Peng B, Zheng YF. An overview of the mechanical properties of nickel–titanium endodontic instruments. *Endod Topics.* 2013;29(1):42–54.
13. Spili P, Parashos P, MesserH. Theimpact ofinstrument fracture on outcomeof endodontic treatment. J Endod 2005; 31:845-850

14. Separatedinstruments-a mind-setbetweenhardandrock-areview.DeepikaG, Mitthra S, Anuradha B, Karthick A.*J Evolution Med Dent Sci.*2017;6:6077–6080.

15. .Sattapan B, Nervo GJ, Palamara JE, Messer HH. Defects in rotary nickel-titanium files after clinical use. J Endod. 2000 Mar;26(3):161-5. doi: 10.1097/00004770-200003000-00008. PMID: 11199711.

16. Plotino G, Grande Nm, Cordaro M, Testarelli L, Gambarini G.A Review of Cyclic Fatigue Testing of Nickel-Titanium Rotary Instruments.J Endod. 2009

17. Peters OA, Schönenberger K, Laib A. Effects of four Ni-Ti preparation techniques on root canal geometryassessed bymicro computed tomography. Int Endod J.2001;34(3):221-230.

18. Barbakow F, Lutz F.The'Lightspeed'preparationtechniqueevaluatedbySwiss clinicians after attending continuing education courses. Int Endod J. 1997;30(1):46 50.

19. Kaval ME, Capar ID, Ertas H. Evaluation of the cyclic fatigue and torsional resistance of novel nickel-titanium rotary files with various alloy properties. J Endod 2016;42(12):1840–1843. DOI: 10.1016/j.joen.2016.07.015

20. Cheung GS, Peng B, Bian Z, Shen Y, Darvell BW. Defects in ProTaper S1 instruments after clinical use: fractographic examination. Int Endod J. 2005

21. DauskardtRH,DuerigTW,RitchieRO.Effectofinsituphasetransformationon fatigue-crack propagation in Ti-Nishape memory alloy.In: Proceedings of Materials ResearchSociety International Meeting on Advanced Materials.Vol. 9.Pittsburgh,PA:MaterialsResearchSociety;1989.p.243-9

22. Hülsmann M, Donnermeyer D, Schafer E. A critical appraisal of studies on cyclic fatigue resistance of engine-driven endodontic instruments. Int Endod J. 2019;2:1427-45

23. Li UM, Lee BS, Shih CT, et al. Cyclic fatigue of endodontic nickel-titanium rotary instruments: static and dynamic tests. J Endod. 2002;28:448-51

24. .Keleş A, Eymirli A, Uyanık O, Nagas E. Influence of static and dynamic cyclic fatigue tests on the lifespan of four reciprocating systems at different temperatures. Int Endod J. 2019;52:880-86

25. Shen Y, Cheung GSP. Methods and models to study nickel-titanium instruments. Endodontic Topics. 2013;29:18-41

26. Pedullà E, Lo Savio F, Boninelli S, Plotino G, Grande NM, La Rosa G, et al. Torsional and Cyclic Fatigue Resistance of a New Nickel-Titanium Instrument Manufactured by Electrical Discharge Machining. *J Endod*. 2016;42(1):156–9.

27. OneCurvedirectionsforuse.Availablat:http://micromega.com/wpcontent/uploads/ 2018/03/Brochure-One-Curve-EN-1.pdf.AccessedApril21,2018

28. Edge file x7 Available at https://edgeendo.com/wp-content/uploads/2015/08/DFU-EdgeFile-x7.pdf

29. F360Brochure418689-pdf.pdf(kometdental.com

30. END-TruNatomy-Brochure.pdf(dentsplysirona.com)

31. Cheung GS, Darvell BW. Fatigue testing of a NiTi rotary instrument. Part 2: fractographic analysis. IntEndod J 2007;40:619-625.

32. Grande NM, Plotino G, Pecci R, Bedini R, Malagnino VA, Somma F. Cyclic fatigue resistance and three-dimensional analysis of instruments from two nickel-titanium rotary systems. Int Endod J. 2006 Oct;39(10):755-63.

33. Plotino G, Grande NM, Sorci E, Malagnino VA, Somma F. Influence of a brushing working motion on the fatigue life of NiTi rotary instruments. Int Endod J. 2007 Jan;40(1):45-51.

34. Ounsi HF, Salameh Z, Al-Shalan T, Ferrari M, Grandini S, Pashley DH, TayFR. Effect of clinical use on the cyclic fatigue resistance of ProTaper nickel-titanium rotary instruments. J Endod. 2007 Jun;33(6):737-41.

35. KramkowskiTR,BahcallJ.Aninvitrocomparisonoftorsionalstressandcyclic fatigue resistance of ProFile GT and ProFile GT Series X rotarynickel-titanium files. J Endod. 2009 Mar;35(3):404-7.

36. Kim HC, Kim HJ, Lee CJ, Kim BM, Park JK, Versluis A. Mechanical response of nickel-titanium instruments with different cross-sectional designs during shaping of simulated curved canals. Int Endod J. 2009 Jul;42(7):593-602.

37. Lopes HP, Ferreira AA, Elias CN, Moreira EJ, de Oliveira JC, Siqueira JF Jr. Influence of rotational speed on the cyclic fatigue of rotary nickel-titanium endodontic instruments. J Endod. 2009 Jul;35(7):1013-6.

38. Lopes HP, Chiesa WM, Correia NR, de Souza Navegante NC, Elias CN, Moreira EJ, Chiesa BE. Influence of curvature location along an artificial canal on cyclic fatigue of a rotary nickel-titanium endodontic instrument. Oral Surg Oral Med Oral Pathol Oral RadiolEndod. 2011 Jun;111(6):792-6.

39. Gao Y, Gutmann JL, Wilkinson K, Maxwell R, Ammon D. Evaluation of the impact of raw materials on the fatigue and mechanical properties of ProFile Vortex rotary instruments. J Endod. 2012 Mar;38(3):398-401.

40. Plotino G, Grande NM, Testarelli L, Gambarini G. Cyclic fatigue of Reciproc and WaveOne reciprocating instruments. Int Endod J. 2012 Jul;45(7):614-8.

41. Kim HC, Kwak SW, Cheung GS, Ko DH, Chung SM, Lee W. Cyclic fatigueand torsional resistance of two new nickel-titanium instruments used in reciprocation motion: Reciproc versus WaveOne. J Endod. 2012 Apr;38(4):541- 4.

42. Arias A, Perez-Higueras JJ, de la Macorra JC. Differences in cyclic fatigue resistance at apical and coronal levels of Reciproc and WaveOne new files. J Endod. 2012 Sep;38(9):1244-8.

43. Gavini G, Caldeira CL, Akisue E, Candeiro GT, Kawakami DA. Resistance to flexural fatigue of Reciproc R25 files under continuous rotation and reciprocating movement. J Endod. 2012 May;38(5):684-7.

44. Kim HC, Kwak SW, Cheung GS, Ko DH, Chung SM, Lee W. Cyclic fatigueand torsional resistance of two new nickel-titanium instruments used in reciprocation motion: Reciproc versus WaveOne. J Endod. 2012 Apr;38(4):541- 4.

45. Pedullà E, Grande NM, Plotino G, Gambarini G, Rapisarda E. Influence of continuous or reciprocating motion on cyclic fatigue resistance of 4 different nickel-titanium rotary instruments. J Endod. 2013 Feb;39(2):258-61.

46. Khurana P, Khurana KK. Effect of curvature angle and rotational speed on fracture of various Ni-Ti rotary files used in extracted molars. J Rest Dent2013; 1(2); 49-54.

47. Lopes HP, Chiesa WM, Correia NB, Navegante NC, Elias CN, Moreira EJ, etal. Influence of the geometry of curved artificial canals on the fracture of rotary nickel-titanium instruments subjected to cyclic fatigue tests. J Endod 2013;39(5):704-7.

48. Al-Hadlaq SM. Evaluation of cyclic flexural fatigue resistance of 25/0.04 and 25/0.06 twisted file rotary nickel-titanium endodontic instruments. Aust Endod J.2013Aug;39(2):62-5.

49. Kiefner P, Ban M, De-Deus G. Is the reciprocating movement per se able to improve the cyclic fatigue resistance of instruments? Int Endod J. 2014 May;47(5):430-6.

50. Dagna A, Poggio C, Beltrami R, Colombo M, Chiesa M, Bianchi S. Cyclic fatigue resistance of OneShape, Reciproc, and WaveOne: An in vitro comparative study. J Conserv Dent. 2014 May;17(3):250-4.

51. Pérez-Higueras JJ, Arias A, de la Macorra JC, Peters OA. Differences in cyclic fatigue resistance between ProTaper Next and ProTaper Universal instrumentsat different levels. J Endod. 2014 Sep;40(9):1477-81.

52. Elnaghy AM. Cyclic fatigue resistance of ProTaper Next nickel-titanium rotary files. Int Endod J. 2014 Nov;47(11):1034-9.

53. Reddy Y P, S K, Subbarao CV. Cyclic fatigue testing of three different rotary nickel titanium endodontic instruments in simulated curved canals - an in vitro sem analysis. J Clin Diagn Res. 2014 Feb;8(2):211-3.

54. Capar ID, Ertas H, Arslan H. Comparison of cyclic fatigue resistance of novel nickel-titanium rotary instruments. Aust Endod J. 2015 Apr;41(1):24-8.

55. Capar ID, Kaval ME, Ertas H, Sen BH. Comparison of the cyclic fatigue resistance of 5 different rotary pathfinding instruments made of conventional nickel-titanium wire, M-wire, and controlled memory wire. J Endod. 2015 Apr;41(4):535-8

56. Sekar V, Kumar R, Nandini S, Ballal S, Velmurugan N. Assessment of the role of cross section on fatigue resistance of rotary files when used in reciprocation. Eur J Dent. 2016 Oct-Dec;10(4):541-545

57. Neelakantan P, Reddy P, Gutmann JL. Cyclic fatigue of two different singlefileswithvaryingkinematicsinasimulated double-curvedcanal.J InvestigClin Dent. 2016 Aug;7(3):272-7.

58. de Almeida-Gomes F, de Matos HR, Nunes RF, Arrais AM, Ferreira-Maniglia C, de Morais Vitoriano M, Gurgel-Filho ED. Cyclic fatigue resistance of different continuous rotation and reciprocating endodontic systems. Indian J Dent Res. 2016 May-Jun;27(3):278-82.

59. Varghese NO, Pillai R, Sujathen UN, Sainudeen S, Antony A, Paul S. Resistance to torsional failure and cyclic fatigue resistance of ProTaper Next, WaveOne, and Mtwo files in continuous and reciprocating motion: An in vitro study. J Conserv Dent. 2016 May-Jun;19(3):225-30.

60. Taha Özyürek DDS PhD, Koray Yılmaz DDS, Gülşah Uslu DDS. Comparison of cyclic fatigue resistance of old and new generation one shape NiTi instruments. Int J Appl Dent Sci 2016;2(4):04-07.

61. Topçuoğlu HS, Düzgün S, Aktı A, Topçuoğlu G. Laboratory comparison of cyclic fatigue resistance of WaveOne Gold, Reciproc and WaveOne files in canals with a double curvature. Int Endod J. 2017 Jul;50(7):713-717.

62. Uslu G, Özyürek T, Yılmaz K, Gündoğar M. Cyclic fatigue resistance of R-Pilot, HyFlex EDM and PathFile nickel-titanium glide path files in artificial canals with double (S-shaped) curvature. Int Endod J. 2018 May;51(5):584-589.

63. Yılmaz K, Uslu G, Özyürek T.*In vitro*comparison of the cyclic fatigue resistance of HyFlex EDM, One G, and ProGlider nickel titanium glide path instruments in single and double curvature canals. Restor Dent Endod. 2017 Nov;42(4):282-289.

64. Yılmaz K,Özyürek T.Cyclic fatiguelifeofTango-Endo,WaveOne GOLD,and ReciprocNiTi instruments. Restor Dent Endod. 2017 May;42(2):134-139.

65. Gündoğar M, Özyürek T. Cyclic Fatigue Resistance of OneShape, HyFlex EDM, WaveOne Gold, and Reciproc Blue Nickel-titanium Instruments. JEndod. 2017 Jul;43(7):1192-1196.

66. Nagarjuna P, Mangat P, Dayal C, Tomer AK, Chauhan P, Rana S, Goud V. In vitro Evaluation of Cyclic Fatigue Resistance of Reciprocating and Rotary Singlefile System. Int J Prev Clin Dent Res 2017;4(1):19-22.

67. Goo HJ, Kwak SW, Ha JH, Pedullà E, Kim HC. Mechanical Properties of Various Heat-treated Nickel-titanium Rotary Instruments. J Endod. 2017 Nov;43(11):1872-1877.

68. TopçuoğluHS,DemirbugaS,DüzgünS,TopçuoğluG.Cyclicfatigueresistance of new reciprocating files (Reciproc Blue, WaveOne Gold, and SmartTrack) in two different curved canals. J Investig Clin Dent. 2018 Aug;9(3):e12344.

69. Rubio J, Zarzosa JI, Pallarés A. A Comparative Study of Cyclic Fatigue of 10 Different Types of Endodontic Instruments: an in Vitro Study. Acta Stomatol Croat. 2019 Mar;53(1):28-36.

70. Shalan, Linz & Al-Huwaizi, Hussain & Mohammad, Saif Alislam. Evaluation ofCyclicFatigueResistanceofWaveOneGoldGliderandSomeRotary

NiTiPreflaring Files.nternational Journal of Medical Research & Health Sciences. 2018, 7(10): 58-61.

71. Serafin M, De Biasi M, Franco V, Angerame D. In vitro comparison of cyclic fatigueresistanceoftworotarysingle-fileendodonticsystems:OneCurveversus OneShape. Odontology. 2019 Apr;107(2):196-201.

72. Palma PJ, Messias A, Cerqueira AR, Tavares LD, Caramelo F, Roseiro L, Santos JM. Cyclic fatigue resistance of three rotary file systems in a dynamic model after immersion in sodium hypochlorite. Odontology. 2019 Jul;107(3):324-332.

73. Özyürek T, Gündoğar M, Uslu G, Yılmaz K, Staffoli S, Nm G, Plotino G, Polimeni A. Cyclic fatigue resistances of Hyflex EDM, WaveOne gold,Reciproc blue and 2shape NiTi rotary files in different artificial canals. Odontology. 2018 Oct;106(4):408-413.

74. Azim AA, Tarrosh M, Azim KA, Piasecki L. Comparison between Single-file Rotary Systems: Part 2-The Effect of Length of the Instrument Subjected to Cyclic Loading on Cyclic Fatigue Resistance. J Endod. 2018 Dec;44(12):1837-1842.

75. Adiguzel M, Isken I, Pamukcu II. Comparison of cyclic fatigue resistance ofXP-endo Shaper, HyFlex CM, FlexMaster and Race instruments. J Dent Res Dent Clin Dent Prospects. 2018 Summer;12(3):208-212.

76. ElnaghyAM,ElsakaSE.CyclicFatigueResistanceofOneCurve, 2Shape,ProFile Vortex, Vortex Blue, and RaCeNickel-Titanium Rotary Instruments in Single and Double Curvature Canals. J Endod. 2018 Nov;44(11):1725-1730.

77. Topçuoğlu HS, Topçuoğlu G, Kafdağ Ö, Arslan H. Cyclic fatigue resistance of new reciprocating glide path files in 45- and 60-degree curved canals. Int Endod J. 2018 Sep;51(9):1053-1058.

78. Silva EJNL, Vieira VTL, Belladonna FG, Zuolo AS, Antunes HDS, Cavalcante DM,EliasCN,De-DeusG.CyclicandTorsionalFatigueResistanceofXP-endo Shaper and TRUShape Instruments. J Endod. 2018 Jan;44(1):168-172.

79. Serafin M, De Biasi M, Franco V, Angerame D. In vitro comparison of cyclic fatigueresistanceoftworotarysingle-fileendodonticsystems:OneCurveversus OneShape. Odontology. 2019 Apr;107(2):196-201.

80. Rubio J, Zarzosa JI, Pallarés A. A Comparative Study of Cyclic Fatigue of 10 Different Types of Endodontic Instruments: an in Vitro Study. Acta Stomatol Croat. 2019 Mar;53(1):28-36.

81. Di Nardo D, Gambarini G, Seracchiani M, Mazzoni A, Zanza A, Giudice AD,et al. Influence of different cross-section on cyclic fatigue resistance of two nickel–titanium rotary instruments with same heat treatment: An in vitro study. Saudi Endod J 2020;10:221-5.

82. Pedullà E, La Rosa GRM, Virgillito C, Rapisarda E, Kim HC, Generali L. Cyclic Fatigue Resistance of Nickel-titanium Rotary Instruments according to the Angle of File Access and Radius of Root Canal. J Endod. 2020 Mar;46(3):431-436.

83. Ruiz-Sánchez C, Faus-Llácer V, Faus-Matoses I, Zubizarreta-Macho Á, Sauro S, Faus-Matoses V. The Influence of NiTi Alloy on the Cyclic Fatigue Resistance of Endodontic Files. J Clin Med. 2020 Nov 21;9(11):3755.

84. Gündoğar M, Uslu G, Özyürek T, Plotino G. Comparison of the cyclic fatigue resistance of VDW.ROTATE, TruNatomy, 2Shape, and HyFlex CM nickel-titanium rotary files at body temperature. Restor Dent Endod. 2020 Jun 22;45(3):e37.

85. Sharroufna R, Mashyakhy M. The Effect of Multiple Autoclave Sterilization on the Cyclic Fatigue of Three Heat-Treated Nickel-Titanium Rotary Files: EdgeFile X7, Vortex Blue, and TRUShape. Biomed Res Int. 2020 Dec 14;2020:8826069.

86. Faus-Llácer V, Hamoud-Kharrat N, Marhuenda Ramos MT, Faus-Matoses I, Zubizarreta-Macho Á, Ruiz Sánchez C, Faus-Matoses V. Influence of the Geometrical Cross-SectionDesignontheDynamicCyclic FatigueResistanceof NiTi Endodontic Rotary Files-An In Vitro Study. J Clin Med. 2021 Oct 14;10(20):4713.

87. Koçak S, Şahin FF, Özdemir O, Koçak MM, Sağlam BC. A comparative investigation between ProTaper Next, Hyflex CM, 2Shape, and TF-Adaptivefile systems concerning cyclic fatigue resistance. J Dent Res Dent Clin Dent Prospects. 2021 Summer;15(3):172-177.

88. Vieira TM, Cardoso RM, Alves NCC, Emanuel Acioly Conrado de Menezes S, BatistaSM,SilvaSA,VelozoC,deAlbuquerqueDS,MonteiroGQM.Cyclic

Fatigue Resistance of Blue Heat-Treated Instruments at Different Temperatures. Int J Biomater. 2021 Jul 30;2021:5584766.

89. Faus-Llácer V, Kharrat NH, Ruiz-Sánchez C, Faus-Matoses I, Zubizarreta-Macho Á, Faus-Matoses V. The Effect of Taper and Apical Diameter on the Cyclic Fatigue Resistance of Rotary Endodontic Files Using an Experimental Electronic Device. *Applied Sciences*. 2021; 11(2):863

90. Pedullà E, Kharouf N, Caruso S, La Rosa GRM, Jmal H, Haikel Y, Mancino D. Torsional, Static, and Dynamic Cyclic Fatigue Resistance of Reciprocating and Continuous Rotating Nickel-Titanium Instruments. J Endod. 2022 Nov;48(11):1421-1427.

91. Al-ObaidaMI, AlzuwayerAA, AlanaziSS,BalhaddadAA. InVitroAnalysisof the Fatigue Resistance of Four Single File Canal Preparation Instruments. Materials (Basel). 2022 Jan 17;15(2):688.

92. Gouédard C, Pino L, Arbab-Chirani R, Arbab-Chirani S, Chevalier V. Comparisonofthecyclic fatigueresistanceofOneCurve, F6Skytaper,Protaper Next, and Hyflex CM endodontic files. Restor Dent Endod. 2022 Mar 4;47(2):e16.

93. ZanzaA,RussoP,RedaR,DiMatteoP,DonfrancescoO,AusielloP,Testarelli L. Mechanical and Metallurgical Evaluation of 3 Different Nickel-Titanium Rotary Instruments: An In Vitro and In Laboratory Study. Bioengineering (Basel). 2022 May 20;9(5):221.

94. Abunaeem,F.,nageh,M.,Morsy,D.CyclicFatigueResistanceOfEdgeFileX7, Edge One, WaveOne Gold And WaveOne Rotary Files Using Artificial Canals With Different Angles And Radii Of Curvature. *Egyptian Dental Journal*, 2022; 68(4): 3971-3979.

95. Ramadan F, AbuMostafa A, Alharith D. Evaluation of cyclic fatigue and bending test for different Nickle-Titanium files. PLoS One. 2023 Aug 25;18(8):e0290744.

96. Faus-Matoses V, Faus-Llácer V, Ruiz-Sánchez C, Prats Gallego S, Zubizarreta-MachoÁ, Solano-MendozaB, Biedma BM, Faus-Matoses I. TheCyclic Fatigue Resistance of Different Lengths of CM Gold Wire and CM Blue Wire NiTi Alloy Endodontic Rotary Files: An In Vitro Study. *Applied Sciences*. 2023; 13(7):4612.

97. Al-Amidi AH, Al-Gharrawi HA. Effect of autoclave sterilization on the cyclic fatigue resistance of EdgeFile X7, 2Shape, and F-one nickel-titaniumendodontic instruments. J Conserv Dent. 2023 Jan-Feb;26(1):26-30.

98. Ruddle CJ. Current concepts for preparing the root canal system. Dent Today. 2001 Feb;20(2):76-83.

99. R.Bellizzi,WilliamP. Cruse, AHistoric Review ofEndodontics JOE-1980.

100. Pruett JP, Clement DJ, Carnes DL Jr. Cyclic fatigue testing of nickel-titanium endodontic instruments. J Endod. 1997 Feb;23(2):77-85.

101. Martín B, Zelada G, Varela P, Bahillo JG, Magán F, Ahn S, Rodríguez C. Factors influencing the fracture of nickel-titanium rotary instruments. Int Endod J.2003 Apr;36(4):262-6.

102. Maryam El Chares And KleonikiLyroudiaSeparated Instrument inEndodontics: Frequency, Treatment and Prognosis Balk j dent med, Volume 22: Issue 3 29 Oct 2018

103. Grossman LI. Guidelines for the prevention of fracture of root canalinstruments. Oral Surg Oral Med Oral Pathol. 1969 Nov;28(5):746-52.

104. Berutti E, Paolino DS, Chiandussi G, Alovisi M, Cantatore G, Castellucci A, Pasqualini D. Root canal anatomy preservation of WaveOne reciprocating files with or without glide path. J Endod. 2012 Jan;38(1):101-4.

105. Varela-Patiño P, Ibañez-Párraga A, Rivas-Mundiña B, Cantatore G, Otero XL, Martin-Biedma B. Alternating versus continuous rotation: a comparative study of the effect on instrument life. J Endod. 2010 Jan;36(1):157-9.

106. Parashos P, Gordon I, Messer Hh Factors Influencing Defects of Rotary Nickel-Titanium Endodontic Instruments After Clinical Use.JEndod. 2004 Oct;30(10):722-5.

107. Taschieri S, Necchi S, Rosano G, Del Fabbro M, Weinstein R, Machtou P. Avantages et limites des instruments en nickel-titane pour la préparationcanalaireendodontique. Revue de la littératurerécente [Advantages and limits of nickel-titanium instruments for root canal preparation. A review of the current literature]. Schweiz MonatsschrZahnmed. 2005;115(11):1000-5.

108. Chaves Craveiro De Melo M, Guiomar De Azevedo Bahia M, Lopes Buono Vt. Fatigue Resistance of Engine-Driven Rotary Nickel-Titanium Endodontic Instruments.JEndod. 2002 Nov;28(11):765-9.

109. Peters OA, Gluskin AK, Weiss RA, Han JT. An in vitro assessment of the physical properties of novel Hyflex nickel-titanium rotary instruments. Int Endod J. 2012 Nov;45(11):1027-34.

110. Pruett JP, Clement DJ, Carnes DL Jr. Cyclic fatigue testing of nickel-titanium endodontic instruments. J Endod. 1997 Feb;23(2):77-85.

111. Yared GM, Bou Dagher FE, Machtou P. Cyclic fatigue of Profile rotary instruments after simulated clinical use. Int Endod J. 1999 Mar;32(2):115-9.

112. Plotino G, Grande NM, Cordaro M, Testarelli L, Gambarini G. A review of cyclic fatigue testing of nickel-titanium rotary instruments. J Endod2009;35:1469-1476

113. Turpin YL, Chagneau F, Vulcain JM. Impact of two theoretical cross-sectionson torsional and bending stresses of nickel-titanium root canal instrument models. J Endod. 2000 Jul;26(7):414-7.

114. AlShwaimi E. Cyclic fatigue resistance of a novel rotary file manufacturedusing controlled memory Ni-Ti technology compared to a file made from M- wire file. Int Endod J. 2018 Jan;51(1):112-117.

115. Chang SW, Shim KS, Kim YC, Jee KK, Zhu Q, Perinpanayagam H, Kum KY. Cyclic fatigue resistance, torsional resistance, and metallurgical characteristicsof V taper 2 and V taper 2H rotary NiTi files. Scanning. 2016 Nov;38(6):564- 570.

116. Pedullà E, Plotino G, Grande NM, Pappalardo A, Rapisarda E. Cyclic fatigue resistance of four nickel-titanium rotary instruments: a comparative study. Ann Stomatol (Roma). 2012 Apr;3(2):59-63.

117. Short RD, Dorn SO, Kuttler S. The crystallization of sodium hypochlorite on gutta-percha cones after the rapid-sterilization technique: an SEM study. J Endod. 2003 Oct;29(10):670-3.

118. Reddy BN, Murugesan S, Basheer SN, Kumar R, Kumar V, Selvaraj S. Comparison of Cyclic Fatigue Resistance of Novel TruNatomy Files with Conventional Endodontic Files: An *In Vitro* SEM Study. J Contemp Dent Pract. 2021 Nov 1;22(11):1243-1249.

119. Pongione G, Pompa G, Milana V, Di Carlo S, Giansiracusa A, Nicolini E, De Angelis F. Flexibility and resistance to cyclic fatigue of endodontic instruments made with different nickel-titanium alloys: a comparative test. Ann Stomatol (Roma). 2012 Jul;3(3-4):119-22.

120. Grande NM, Plotino G, Pecci R, Bedini R, Malagnino VA, Somma F. Cyclic fatigue resistance and three-dimensional analysis of instruments from two nickel-titanium rotary systems. Int Endod J. 2006 Oct;39(10):755-63.

121. Pedullà E, Plotino G, Scibilia M, Grande NM, De Santis D, Pardo A, Testarelli L, Gambarini G. Cyclic fatigue comparison among endodontic instruments with similar cross section and different surface coating. Minerva Stomatol. 2019 Apr;68(2):67-73.

122. Mohammed MA ,Alchalabi AS Cyclic Fatigue resistance of Edge File X7 Endodontic System;AN INVITRO STUDYJournal of Survey in Fisheries Sciences 10(3S) 3419-3431

123. Abunaeem,F.,nageh,M.,Morsy,D.CyclicFatigueResistanceOfEdgeFileX7, Edge One, WaveOne Gold And WaveOne Rotary Files Using Artificial Canals With Different Angles And Radii Of Curvature. *Egyptian Dental Journal*, 2022; 68(4): 3971-3979. doi: 10.21608/edj.2022.146738.2168

124. Eggeler G, Hornbogen E, Yawny A, et al. Structural and functional fatigue of NiTishape memory alloys. Mat Scien Eng 2004;378:24–33. 21.

125. KeskinC,InanU,GulerDH,KalyoncuoğluE.CyclicFatigueResistanceofXP- Endo Shaper, K3XF, and ProTaper Gold Nickel-titanium Instruments. J Endod. 2018 Jul;44(7):1164-1167.

126. Ghahramani Y, Sedigh-Shams M, Atbaei M, Asar S. Cyclic fatigue resistance: comparison of AF F-One and One Curve rotary instruments with Hyflex EDM OneFile in root canal therapy. AANBT [Internet]. 5Apr.2022 [cited 24Jan.2024];3(1):14-7.

127. Altufayli MD, Salem B, Katbeh I, Georges P, Moualla RK. Evaluation of cyclic fatigue resistance of four heat-treated nickel-titanium single file systems in canals with single curvature - An in-vitro study. Medical Science, 2021,25(115), 2275-2280

128. Tobushi H, Shimeno Y, Hachisuka T, et al. Inflfluence of strain rate on superelastic properties of TiNi shape memory alloy. Mechanics Mater 1998;30:141–50.

129. Yılmaz, Koray&Özyürek, Taha &Uslu, Gülşah. (2019). Comparision of Cyclic Fatigue Resistance of One Curve, Hyflex EDM, WaveOne Gold and Reciproc Blue Nickel-Titanium Rotary Files at Intra-canal Temperature. Cumhuriyet Dental Journal. 22. 42-47..

130. Zhang EW, Cheung GSP, Zheng YF. 2010. Influence of cross-sectional design anddimension on mechanical behavior of nickel-titanium instruments under torsion and bending: a numerical analysis. Journal of Endodontics 36:1394–1398

131. Pedullà E, Plotino G, Grande NM, Scibilia M, Pappalardo A, Malagnino VA, Rapisarda E. Influence of rotational speed on the cyclic fatigue of Mtwo instruments. Int Endod J. 2014 Jun;47(6):514-9

132. Pérez-Higueras JJ, Arias A, de la Macorra JC. Cyclic fatigue resistance of K3, K3XF, and twisted file nickel-titanium files under continuous rotation or reciprocating motion. J Endod. 2013 Dec;39(12):1585-8.

133. Martín B, Zelada G, Varela P, Bahillo JG, Magán F, Ahn S, Rodríguez C. Factors influencing the fracture of nickel-titanium rotary instruments. Int Endod J.2003 Apr;36(4):262-6

134. Riyahi AM, Bashiri A, Alshahrani K, Alshahrani S, Alamri HM, Al-Sudani D. Cyclic Fatigue Comparison of TruNatomy, Twisted File, and ProTaper Next Rotary Systems. Int J Dent. 2020 Feb 26;2020:3190938.

ANNEXURE-I

BABU BANARASI DAS UNIVERSITY
BBD COLLEGE OF DENTAL SCIENCES, LUCKNOW

BBD UNIVERSITY

BBDCODS/IEC/09/2022 Dated: 16th September, 2022

Communication of the Decision of the Xth Institutional Ethics Sub-Committee Meeting

IEC Code: 04

Title of the Project: Comparative Evaluation Of Cyclic Fatigue Resistance Of Four Different Novel Rotary File Systems: An In- Vitro Study.

Principal Investigator: Dr Shalu Shukla **Department:** Conservative Dentistry and Endodontics

Name and Address of the Institution: BBD College of Dental Sciences Lucknow.

Type of Submission: New, MDS Project Protocol

Dear Dr Shalu Shukla,

The Institutional Ethics Sub-Committee meeting comprising following members was held on 15th September, 2022.

1.	Dr. Lakshmi Bala Member Secretary	Prof. and Head, Department of Biochemistry
2.	Dr. Praveen Singh Samant Member	Prof. & Head, Department of Conservative Dentistry & Endodontics
3.	Dr. Jiji George Member	Prof. & Head, Department of Oral Pathology & Microbilogy
4.	Dr. Amrit Tandan Member	Professor, Department of Prosthodontics and Crown & Bridge
5.	Dr. Rana Pratap Maurya Member	Reader, Department of Orthodontics & Dentofacial Orthopaedics

The submitted documents of the current MDS Project Protocol is exempted for review in the meeting.

Decision: The MDS Protocol is exempted for review by the Institutional Ethics Sub-Committee.

Forwarded by:

Prof. Dr. Puneet Ahuja
Principal 16/9
BBD College of Dental Sciences
BBD University, Lucknow

PRINCIPAL
Babu Banarasi Das College of Dental Sciences
(Babu Banarasi Das University)
BBD City, Faizabad Road, Lucknow-226028

Lakshmi Bala 16/09/22

Dr. Lakshmi Bala
Member-Secretary
Institutional Ethics Sub-Committee (IEC)
BBD College of Dental Sciences
BBD University, Lucknow

Member-Secretary
Institutional Ethic Committee
BBD College of Dental Sciences
BBD University
Faizabad Road, Lucknow-226028

ANNEXURE-II

BABU BANARASI DAS UNIVERSITY

BBD COLLEGE OF DENTAL SCIENCES, LUCKNOW

BBD UNIVERSITY

INSTITUTIONAL RESEARCH COMMITTEE APPROVAL

The project titled **"Comparative Evaluation Of Cyclic Fatigue Resistance Of Four Different Novel Rotary File System: An In- Vitro Study"** submitted by **Dr Shalu Shukla** Postgraduate student in the **Department of Conservative Dentistry and Endodontics** for the Thesis Dissertation as part of MDS Curriculum for the academic year 2021-2024 with the accompanying proforma was reviewed by the Institutional Research Committee in its meeting held on **14th September, 2022** at BBDCODS.

The Committee has granted approval on the scientific content of the project. The proposal may now be reviewed by the Institutional Ethics Committee for granting ethical approval.

Prof. Dr. Puneet Ahuja
Chairperson

Dr. Mona Sharma
Co-Chairperson

ANNEXURE-III

(Letter Head of the sponsor)

(Date)

To
Dean of Research & Development
Indian Institute of Technology Kanpur

Dear Sir

Sub: (Title of the project) **COMPARATIVE EVALUATION OF CYCLIC FATIGUE RESISTANCE OF FOUR DIFFERENT NOVEL ROTARY FILE SYSTEMS : AN IN- VITRO STUDY**
Project Investigator(s) (PIs) from IIT Kanpur **Dr. Kantesh Balani**

With reference to the above, we agree to the following are terms and conditions of IIT Kanpur:

1. Any and all deliverables, information, materials, reports, results, services, intellectual property, other property or rights, prototype ("Outcomes") developed, granted or provided by IIT Kanpur to the Funding Agency are on an as-is-where-is basis.

2. The Outcomes provide views/ thought/ opinion of the PI(s) as subject expert and not that of IIT Kanpur. The Funding Agency accepts full responsibility for its use.

3. IIT Kanpur and the PI(s) do not make any warranties of any kind, either express or implied, as to any matter including, but not limited to, warranty of fitness for particular purpose, or merchantability, exclusivity or results obtained from use. IIT Kanpur and the PI(s) shall not be liable for any loss or damage including third party damage that may arise out of usage of the Outcomes.

4. IIT Kanpur and the PI(s) will not be liable to the Funding Agency or any third party for any decision made or action taken in reliance on the Outcomes or for any consequential, special or similar damages, even if advised of the possibility of such damages.

5. The Outcomes are not to be considered as certification. The Outcomes are merely for research and scientific studies purposes and are not a legal validation of the sample or material.

6. IITK and the PI(s) will neither be liable to appear for any enquiry or clarification nor ensure to maintain any records.

Thanking you,

Yours Sincerely

(Authorized Signatures of the Sponsor and Seal)
Name: Dr. SANDEEP DUBEY
Designation: READER
Contact Number: 5977333235

ANNEXURE-IV

Application for SEM Usage and User Charge Payment Approval

Scanning Electron Microscopy Facility, MSE, IIT Kanpur

1. User Information

Name: Dr Shalu Shukla & Roll No: 01	E-mail: shalushukla3729@gmail.com
No. of Samples: 10	Mobile No.: 8958243729
Department: Academic Institutions	Institute: IIT Kanpur

2. Characterization requested (User should make separate requests if different instruments are to be used)

Instrument to be used	Carl Zeiss EVO 50
Do you want to use Gold coating facility	no

3. Sample Information

Sample Type	Magnetic
Date when the samples would be ready for the requested measurements	11-10-2023
Preferred time-slot forenoon or afternoon	2

User/Student Signature: Shalu

Date & Time: 6/10/23 (10:00Am)

(Signature of the PI/Supervisor/HOD)

Name: Dr SANDEEP DUBEY

4. Payment information

I agree to pay Rs. ________ (in words ________________________) from account no. 500 ________________ to the laboratory development account no. IITK/MET/2020235

Signature of the PI/Supervisor and Date:

Name & Seal:

5. User Payment Details

MSE	(Number of Slots) × Rs. 200
NON-MSE	(Number of Slots) × Rs. 300
NON-IITK Users:	(Number of Slots) × Rs. 500
Industrial and R&D Lab Users	(Number of Slots) × Rs. 2500
Gold Coating	Non MSE Users (Number of runs) × Rs. 400/run Non IITK Academic Users (Number of runs) × Rs. 500/run Industrial and R&D Lab Users (Number of runs) × Rs. 500/run
Convener, SEM Facility	
	Signature of Convener
Time of Making Request	Tue Oct 03 2023 17:56:53 GMT+0530 (India Standard Time)

(Above the time slot print in invoice is like 1, 2 here the 1 = 10:00am to 12:00pm and 2 = 01:30pm to 03:30pm)
(Above the time slot print in invoice is like 3 here the 3 = 03:30pm to 05:30pm)

ANNEXURE-V

DrillBit

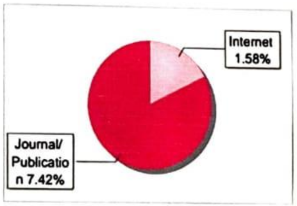
The Report is Generated by DrillBit Plagiarism Detection Software

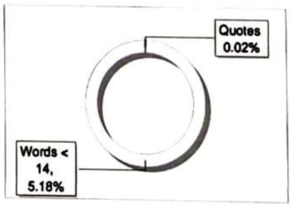
Submission Information

Author Name	SHALU SHUKLA
Title	COMP ARATIVE EVALUATION OF CYCLIC FATIGUE RESISTANCE OF FOUR DIFFERENT NOVEL ROTARY FILE SYSTEMS : AN IN- VITRO STUDY.
Paper/Submission ID	1416002
Submitted by	amarpal.singh056@bbdu.ac.in
Submission Date	2024-02-09 12:44:50
Total Pages	30
Document type	Dissertation

Result Information

Similarity **9 %**





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Database Selection

Language	English
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Internet or Web	Yes
Institution Repository	Yes

Sandeep Dubey