

To Compare the Flexibility of Four Different Rotary Files – An *in vitro* study

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Abstract

Nickel-titanium rotary files were originally developed to allow for greater flexibility when instrumenting root canals. The increased flexibility of nickel-titanium instruments allowed operators to negotiate canal curvatures with greater ease. File design is continually changing. Manufacturers are trying to produce files that will work more efficiently and safely. Knowing the properties of files marketed is especially important in helping to choose an appropriate file system. Current ISO standards require force measurements at a static point along the file. The purpose of this study was to evaluate the flexibility of four different nickel-titanium files at three different points along the file.

Keywords: EndoSequence, ProFile, Vortex Blue.

INTRODUCTION

Dilaceration is the result of a developmental anomaly in which there has been an abrupt change in the axial inclination between the crown and the root of a tooth.^[1] Dilaceration can be seen in both the permanent and deciduous dentitions and is more commonly found in posterior teeth and in maxilla.^[2]

Periapical radiographs are the most appropriate way to diagnose the presence of root dilacerations. The controlled regularly tapered preparation of the curved canals is the ultimate challenge in endodontics.^[3,4] Careful and meticulous technique will yield a safe and sufficient enlargement of the curved canals.

Schilder stated that the most important phase of endodontic treatment is cleaning and shaping of the root canal system. Root canal instrumentation should clean the canal of pulpal tissue, microbes, and affected dentin, and shape the canal for irrigation and obturation.^[5,6] The purpose of instrumentation is to enlarge the apical third of the root canal system to allow for proper debridement, disinfection, and sealing of the canal space while maintaining the original root canal anatomy.^[7,8]

Complex canal anatomy causes instrumentation challenges, which may prevent adequate disinfection of the root canal system, or cause procedural errors such as instrument separation, transportation, perforation, or ledges to occur.

In 1985, Lim proposed the idea that a more flexible instrument would better negotiate the complex anatomy, helping to avoid procedural errors such as instrument separation, apical transportation, zipping, perforation, or ledges. Walia introduced nickel-titanium instruments in 1988, concluding that they were 3 times more flexible than traditional stainless steel instruments.^[9,10]

File design is continually changing. Manufacturers are trying to produce files that will work more efficiently and safely. Instruments with greater flexibility may cause fewer undesirable changes in the shape of curved canals. Knowing the properties of files marketed is especially important in helping to choose an appropriate file system.^[11]

In this study, the flexibility of different nickel-titanium rotary endodontic files (EndoSequence, ProFile, Vortex, and Vortex Blue) was measured. Current ISO standards (ISO 3630-1) measure the resistance to bending of root canal instruments by fixing the instrument 3 mm from its tip and bending it to a deflection of 45 degrees.^[12]

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This grasp length at 3 mm does not take into account curvatures along the length of the canal or the forces placed on various points along the instrument. The purpose of this study was to evaluate the flexibility of four different nickel-titanium rotary endodontic files at three different points, 3 mm, 5 mm, and 7 mm from the tip of the file.

MATERIALS AND METHODS

EndoSequence (Brasseler USA Dental, Savannah, GA), ProFile (Dentsply Tulsa Dental Specialties, Tulsa, OK), Vortex (Dentsply Tulsa Dental Specialties), and Vortex Blue (Dentsply Tulsa Dental Specialties) nickel-titanium rotary files were selected for this study. All files were 25 mm in length, ISO size 30, with a taper of 0.06.

The files were measured at 3 mm, 5 mm, or 7 mm from the tip using a digital caliper and marked with a rubber stopper. The files were also measured and marked 20 mm from the tip to represent the deflection point. The sample size was 10 for each file type at each length. Each file was secured between two metal plates on a load-sensing cell.

A universal testing machine (Instron, model 5500-R, Norwood, MA) was used to bend the files to a maximum deflection of 4.5 mm (Figures 1-7) at a rate of 2 mm/min at room temperature ($22^{\circ}\text{C} \pm 1^{\circ}\text{C}$). Data were collected electronically through Merlin Software (Instron, Norwood, MA) and transferred to Excel (Microsoft Corporation, Redmond, WA) for further analysis. Statistical analysis was completed with IBM SPSS statistical software (IBM Corp., Armonk, NY). A two-way analysis of variance and a *post hoc* Tukey test was used as indicated.

RESULTS

Stiffness is significantly different between the files. The stiffness of ProFile is greater than EndoSequence, which is greater than Vortex Blue. Vortex is significantly stiffer than Vortex Blue, but not significantly different from ProFile or EndoSequence. Force in general, the force for ProFile, EndoSequence, and Vortex are significantly greater than Vortex Blue at all deflection points (Table 1).

The force required to bend ProFile is significantly greater than EndoSequence at all deflection points. The force required to deflect ProFile 0.25 mm to 1 mm is significantly greater than Vortex, but at a deflection of 1.5 mm greater, there is no significant difference between the two. From 0.25 mm to 1.5 mm, there is no significant difference between the force required to deflect Vortex and EndoSequence, but at deflection lengths of 2.0 mm to 4.5 mm, Vortex is significantly greater (Table 2).

Bending moment similar to force, the bending moment for ProFile, EndoSequence, and Vortex are significantly greater than Vortex Blue at all deflection points. The bending moment for ProFile is also significantly greater than



Figure 1: Flexibility testing apparatus

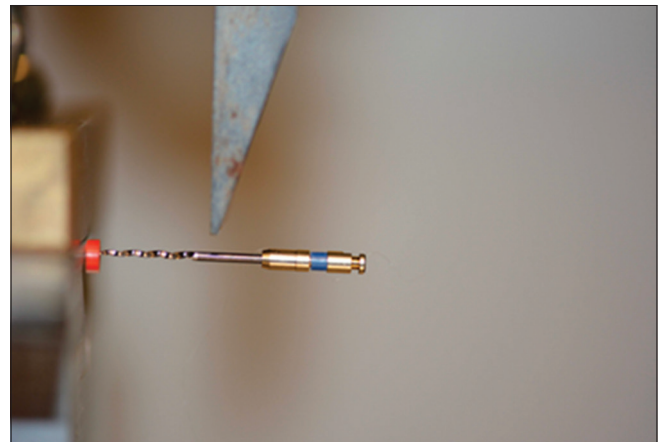


Figure 2: Mounted file

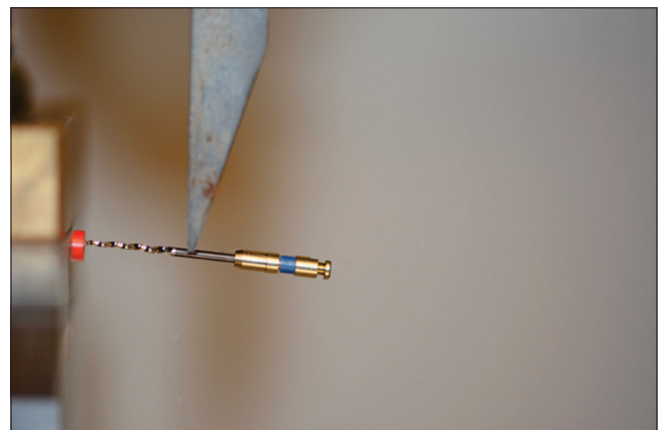


Figure 3: 1 mm deflection

EndoSequence at all deflection points. The bending moment for ProFile is significantly greater than Vortex at a deflection of 0.25–1.5 mm, but there is no difference at deflections of 2.0–4.5 mm. There is no difference in the bending moment for Vortex and EndoSequence at a deflection of 0.25–1.5 mm, but there is a significant difference at deflections of 2.0–

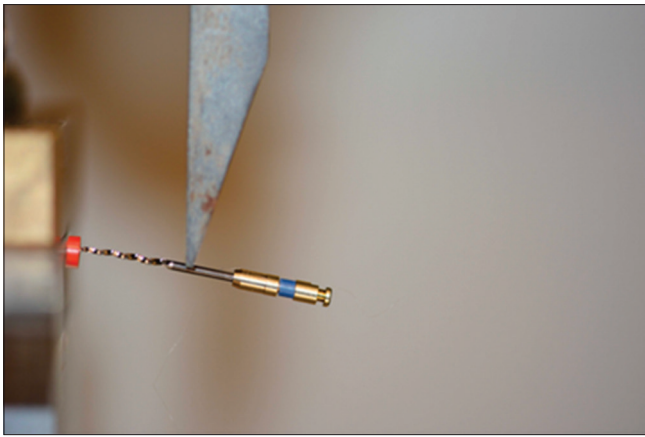


Figure 4: 2 mm deflection

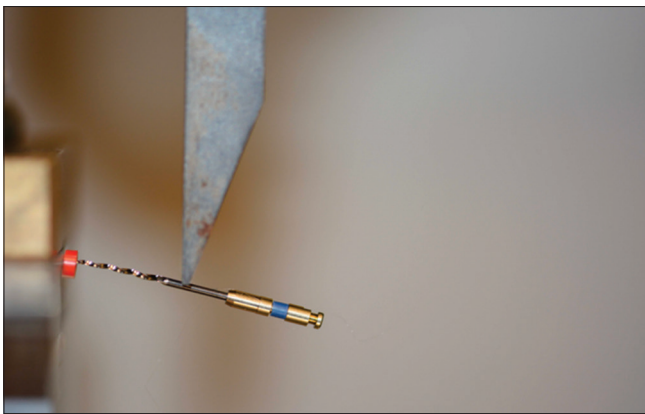


Figure 5: 3 mm deflection

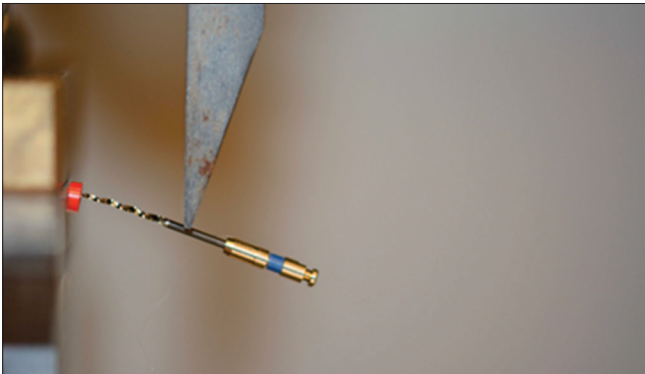


Figure 6: 4 mm deflection

4.5 mm. Length across all file systems, there is a significant difference between 3 mm, 5 mm, and 7 mm (7 mm > 5 mm > 3 mm).

DISCUSSION

Ideally, a nickel-titanium rotary endodontic file should be flexible and resistant to fracture to achieve the goal of non-surgical root canal therapy of prevention or resolution of apical periodontitis through proper cleaning, shaping, disinfection, and sealing of the root canal system.^[13]

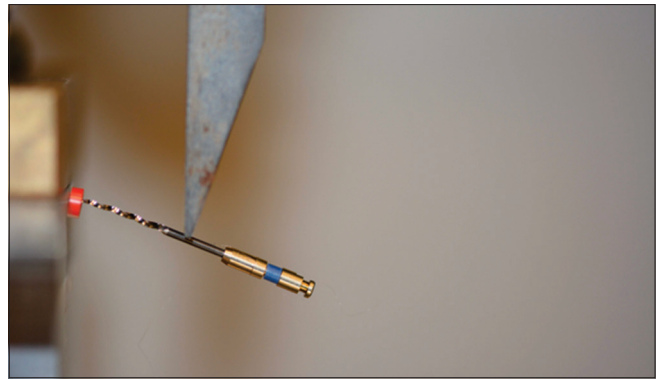


Figure 7: Maximum deflection (4.5 mm)

In this study, the flexibility of four different nickel-titanium rotary endodontic files was evaluated at different lengths along each file.^[14,15] The results of this study show that Vortex Blue files exhibit significantly greater flexibility than the other files studied, while ProFile was the stiffest file of the four files studied. ProFile instruments are made from conventional nickel-titanium, and have a U-file design in which the cutting edges are supported by radial lands.^[16]

EndoSequence files are made from conventional nickel-titanium, with alternating contact points along the instrument's cutting length. There are no radial lands, decreasing the thickness of metal and creating a more flexible file. Other important design characteristics are the noncutting tip, electropolishing, and variable pitch and helical angles.^[17]

Vortex files are similar in design to EndoSequence files, with a triangular cross section, no radial lands, variable pitch, and a non-cutting tip. One difference is that Vortex files are composed of M-Wire nickel-titanium. The enhanced characteristics of M-Wire files are made through a thermal mechanical treatment process. It has been reported that M-Wire technology allows more flexibility and resistance to cyclic fatigue.^[18]

Vortex Blue files are similar in design to Vortex files, but undergo a proprietary processing technique to decrease spring back to its original shape and are marketed for use in curved canals. In this study, the stiffness of Vortex files was not significantly different from ProFile or EndoSequence. In fact, at deflections of >2.0 mm, the force and bending moment of Vortex were greater than that of EndoSequence.^[19,20]

This can be supported by a study by Lopes *et al.* in which Vortex showed worse than expected flexibility and fatigue resistance. Also noted was a significant difference in grasp length, with force being the greatest at 7 mm, followed by 5 mm, with 3 mm exhibiting the least amount of force. The data show a much greater increase in force and bending moment when grasp length is increased from 5 mm to 7 mm as compared with the change from 3 mm to 5 mm.

This may be due to the greater bulk of material present at 7 mm, especially with ProFile's U-shape design compared with the triangular cross sections of EndoSequence and Vortex.

Table 1: Force exhibited by the files at various deflections

File	Grasp Length (mm)	Stiffness (g/mm)	Force (g) @ 0.25 mm	Force (g) @ 0.50 mm	Force (g) @ 0.75 mm	Force (g) @ 1.0 mm	Force (g) @ 1.5 mm	Force (g) @ 2.0 mm	Force (g) @ 2.5 mm	Force (g) @ 3.0 mm	Force (g) @ 3.5 mm	Force (g) @ 4.0 mm	Force (g) @ 4.5 mm
Endo- Sequence	3	6.39±1.47	3.15±0.35	5.14±0.69	5.11±1.06	8.89±1.39	10.16±2.06	13.12±2.64	17.76±3.23	19.91±3.56	19.58±3.83	20.38±4.13	22.80±4.10
Endo- Sequence	5	12.92±3.24	3.91±0.90	7.42±1.79	10.32±2.66	13.79±3.41	20.66±4.47	23.71±5.43	28.35±6.11	33.74±6.71	36.18±6.77	35.69±6.65	37.02±6.41
Endo- Sequence	7	41.74±6.09	11.36±1.45	22.66±3.14	35.63±4.79	45.10±6.12	62.18±8.28	75.91±10.37	85.66±11.42	88.75±11.77	91.99±12.27	96.93±12.39	97.93±12.63
ProFile	3	9.87±0.89	1.72±0.33	6.15±0.56	6.47±0.75	8.64±1.00	12.63±1.38	18.23±1.80	21.51±2.11	22.37±2.32	26.61±2.57	26.68±2.63	30.24±2.88
ProFile	5	18.31±1.94	6.66±0.60	9.83±1.07	16.88±1.48	21.54±1.99	30.05±2.94	37.68±3.70	42.65±4.29	50.33±4.74	54.67±5.31	57.24±5.64	56.69±5.70
ProFile	7	45.86±3.38	13.35±1.39	26.02±2.31	38.31±3.04	49.12±3.80	69.00±5.23	86.02±5.77	100.78±6.23	108.79±8.08	114.43±8.75	116.61±10.12	119.49±9.90
Vortex	3	8.11±0.99	1.00±0.26	4.87±0.46	4.76±0.70	6.45±0.94	10.01±1.26	13.28±1.54	18.49±1.82	19.37±2.08	22.32±2.90	25.61±3.15	27.42±2.96
Vortex	5	15.03±1.71	4.30±0.59	8.16±1.00	12.03±1.43	15.67±1.76	22.50±2.50	29.02±3.26	34.83±4.06	39.96±4.50	44.58±6.09	47.31±7.22	49.68±8.28
Vortex	7	44.54±4.44	12.83±1.22	24.00±2.32	35.46±3.42	46.39±4.40	68.17±5.29	87.65±6.00	103.63±6.87	113.74±7.49	120.50±6.98	124.40±11.21	130.08±12.76
Vortex- Blue	3	2.80±0.82	1.04±0.18	1.78±0.34	2.47±0.52	3.18±0.76	4.62±1.11	6.18±1.48	7.87±1.85	9.58±2.18	11.31±2.47	12.75±2.77	13.78±3.09
Vortex- Blue	5	5.58±2.02	2.05±0.97	3.62±1.36	5.04±1.78	6.46±2.30	9.50±3.21	12.79±4.00					
Vortex- Blue	7	22.40±11.34	6.67±1.74	11.68±4.12	17.17±6.95	22.91±9.61	35.21±14.28	47.06±16.61	57.28±16.21	64.88±14.68	70.27±13.86	73.70±14.29	76.65±14.38

Table 2: Bending moment exhibited by the files at various deflections

FILE	Grasp Length (mm)	Bending Moment (g*mm) @ 0.25mm	Bending Moment (g*mm) @ 0.50mm	Bending Moment (g*mm) @ 0.75mm	Bending Moment (g*mm) @ 1.0mm	Bending Moment (g*mm) @ 1.5mm	Bending Moment (g*mm) @ 2.0mm	Bending Moment (g*mm) @ 2.5mm	Bending Moment (g*mm) @ 3.0mm	Bending Moment (g*mm) @ 3.5mm	Bending Moment (g*mm) @ 4.0mm	Bending Moment (g*mm) @ 4.5mm
Endo-Sequence	3	37.63±5.89	69.43±11.69	102.92±18.08	135.09±23.57	188.76±35.08	239.10±44.85	285.92±54.92	322.45±60.54	350.91±65.12	364.49±70.25	369.59±69.66
Endo-Sequence	5	60.34±13.52	112.80±26.82	163.53±39.89	209.48±51.13	293.90±66.99	369.58±81.52	441.26±91.63	492.16±100.72	528.77±101.62	551.33±99.72	569.37±96.12
Endo-Sequence	7	161.73±18.81	308.64±40.88	460.21±62.32	563.30±79.52	794.34±107.68	975.85±134.84	1090.55±148.47	1066.81±152.95	1200.93±159.48	1250.07±161.11	1254.09±164.16
ProFile	3	48.23±5.56	88.48±9.46	128.94±12.80	160.96±16.93	230.68±23.53	300.88±30.66	360.69±35.94	410.29±39.47	420.34±43.71	460.53±44.77	499.02±48.99
ProFile	5	84.91±9.00	162.39±16.02	238.14±22.25	308.06±29.84	435.79±44.11	550.24±55.56	654.81±64.28	739.89±71.04	805.01±79.70	843.59±84.62	865.36±85.47
ProFile	7	173.61±18.04	338.27±30.00	498.04±39.49	638.52±49.46	896.99±68.02	1118.29±74.97	1310.09±81.00	1414.28±105.10	1487.65±113.76	1515.98±131.61	1553.32±128.75
Vortex	3	34.06±4.40	65.84±7.85	97.87±11.94	126.71±15.95	187.15±21.42	242.70±26.11	297.25±30.92	346.36±35.42	396.47±49.37	418.31±53.62	449.19±50.27
Vortex	5	65.46±8.84	123.47±14.96	181.41±21.44	234.12±26.45	338.49±37.56	436.34±48.83	524.42±60.96	596.37±67.45	664.74±91.29	730.63±108.23	735.16±124.25
Vortex	7	156.85±15.86	322.01±30.18	451.00±44.48	613.04±57.15	856.23±68.82	1169.48±77.94	1387.23±89.33	1448.57±97.34	1536.52±90.71	1637.19±145.68	1672.08±165.93
Vortex-Blue	3	18.70±3.05	29.18±5.70	42.95±8.79	53.08±12.91	79.47±18.84	95.14±25.22	123.76±31.38	152.82±37.09	182.31±42.07	206.77±47.08	244.34±52.52
Vortex-Blue	5	30.73±14.58	54.29±20.37	75.65±26.68	96.96±34.50	142.46±48.21	191.87±60.05					
Vortex-Blue	7	88.71±22.57	153.78±53.58	225.15±90.36	310.78±124.87	447.76±185.68	600.78±215.93	733.68±210.70	833.38±190.83	900.57±180.21	903.08±185.81	986.48±186.90

Greater flexibility may allow the file to better follow the natural curvatures of the canals with less unwanted forces that could result in apical transportation or ledging of the canals.^[21]

From this study, Vortex Blue files were found to be the most flexible and may be better able to negotiate curved canals. Care should also be taken in canals that curve more coronally, as more force is required to bend the files at a higher grasp length.

CONCLUSION

Study conclude that Vortex Blue files were found to be the most flexible and may be better able to negotiate curved canals. Care should also be taken in canals that curve more coronally, as more force is required to bend the files at a higher grasp length.

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