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Cyclic Fatigue Resistance of XP-Endo Shaper Compared With Different Nickel-Titanium Alloy Rotary Instruments: A Review

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Abstract

Introduction: *Endodontic instruments upon rotation are subjectedto both tensile and compressive stress incurved canals. This stress is localized at the pointof curvature.The purpose of this reviewwas to assess and compare theresistancetocyclicfatigueofXP-endoShaper(XPS;FKG Dentaire, La Chaux-de-Fonds, Switzerland) instruments with different nickel-titanium alloy instruments.*

Material and methods: *Electronic searches were performed in the Medline(PubMed), Scopus& Google Scholar databases using relevant keywords. Textbook searching was also applied. Following selection, articles were fully reviewed to ensure that they met inclusion/ exclusion criteria.*

Results:*Cyclic fatigue resistance of different nickel-titanium alloy instruments have been investigated, assessed and compared within the dental literature.*

Conclusion:*XP-endo shaper exhibited greater cyclic fatigue resistance compared with the other tested instruments.*

Keywords: *Cyclic fatigue resistance, XP-endo Shaper, nickel-titanium alloy rotary instruments.*

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I. Introduction

Fracture of nickel-titanium (NiTi) rotary instruments impairs the outcome of root canal treatment [1]. Cyclic fatigue and torsional failure are the fracture modes of NiTi rotary instruments [1]. Accordingly, enhancing resistance to fracture is essential in new NiTi rotary instruments manufacture and design [2]. Several attempts have been conducted in order to enhance the fracture resistance of NiTi instruments including thermal treatments, different cross-sectional design, surface treatment,and improvementsinmetallurgyofthe alloy [3–5].

Thermal treatment technology (e.g., M-Wire [Dentsply Tulsa Dental Specialties, Tulsa, OK, USA], controlled memory wire [CM; Coltene, Cuyahoga Falls, OH, USA], Blue Technology [Dentsply Tulsa Dental Specialties], and Rphase wire [SybronEndo, Orange, CA, USA]) have been utilized to modify the mechanical properties of NiTi alloys [6]. The purpose of thermomechanical technology is to enhance the fracture resistance and physical properties of NiTi alloys [3, 6–8]. TRUShape instruments (TRS; Dentsply Tulsa Dental Specialties) are manufactured from heat-treated NiTi alloy. Firstly, the flutes are ground into blanks and then the heat treatment is performed in order to shape the long axis of the instrument into distinctive bends [9]. The characteristic Sshape design of TRS instruments allows it to reach greater areas of the canal than the nominal instrument size [10, 11].It has been reported that TRS instruments preserved more dentinal structure while preparing the entire root canal [12].

Recently, XP-endo Shaper (XPS; FKG Dentaire, La Chaux-de-Fonds, Switzerland) instruments have been introduced. XPS is available in one size 30, 0.01 taper which is produced from NiTiMaxWire (Martensite-Austenite Electropolishing-Flex, FKG) alloy. MaxWire alloy enables the instruments to react to changes in temperature and take a predetermined shape inside the root canal at body temperature [13]. The MaxWire alloy allows the XPS to be in its martensitic phase at 20 °C; on the other hand, when placed inside the canal a tbody temperature, it transforms to the austenitic phase [13]. Another feature of XPS instrument is the Booster Tip in which the instrument has six cutting edges at the tip. According to the manufacturer, the Booster Tip allows the XPS instrument to start shaping after a glide path of at least ISO 15, and to steadily increase its working field to accomplish an ISO 30 with only one instrument [13].

The purpose of this study was to compare the cyclic fatigue resistance of the new XPS instruments with different NiTi alloy rotary instruments. The null hypothesis tested was that there was no significant difference in the cyclic fatigue resistance between the tested NiTi rotary instruments.

CYCLIC FATIGUE RESISTANCE

The fracture of instruments used in continuous rotary motion has been attributed to torsional stress or cyclic fatigue (Yared 2004, Parashos& Messer 2006). Cyclic fatigue occurs when the instrument does not bind in the canal but rotates freely in a curvature whilst being subjected to repeated cycles of tension and compression, which disintegrates its structure and consequently leads to fracture (Peters 2004, Parashos& Messer 2006, Gambarini et al. 2008). Cyclic fatigue primarily occurs in acutely curved canals with short radii of curvature (Pruett et al. 1997), where the instrument experiences increased tension/compression during rotation at the point of greatest curvature.

Dederich&Zakariasen (1986) considered this the leading cause of NiTi instrument failure, with metal fatigue and subsequent breakage being potential problems associated with the use of 360^0 rotary instruments in curved canals. Mechanical stress of NiTi files is mainly reported to occur because of the root canal curvature and dentine hardness (Mesgouez et al.2003), but it is also related to cyclic fatigue and to the torque of the motor during root canal preparation (Pruett et al. 1997, Yared et al.2000).

The phenomenon of repeated cyclic metal fatigue caused by canal curvatures may be the most crucial factor in instrument separation [31]. When NiTi rotary instruments are loaded in a cyclic mode, complete fracture may occur after sufficient cycles with load variations. The magnitude of

individual load excursion may be so small that one single application does not show any visible damage at all. In fact, the damage done involves cumulative microstructural changes that eventually lead to the fracture of the instrument. It has been suggested that cyclic fatigue has accounted for **50% to 90%** of mechanical failures [32].

II. Material And Methods

Electronic searches were performed in theMedlinePubmed, Scopus& Google Scholar databases using the keywords:Cyclic fatigue resistance, XP-endo Shaper, nickel-titanium alloy rotary instruments. Textbook searching was also applied for relevant information. Articles were first selected according to titles and abstracts, and they were then fully reviewed to ensure that they met the inclusion/exclusion criteria.

Inclusion criteria

Studies with all designs that used differentnickel-titanium alloy rotary instruments and or techniques included. The study should refer toCyclic fatigue resistance of XP-endo Shaper significance. Searches were limited to papers written in English and published between 2015 and 2018.

Exclusion criteria

All studies that failed to meet the inclusion criteria. If a study did not refer to the cyclic fatigue resistance or explain its relation withXP-endo shaper, it was discarded. Studies that discussed a cyclic fatigue resistance of other nickel titanium rotary instrument without includingXP-endo shaperwere also rejected.

III. Results

Cyclic fatigue resistance of XP-endo Shaper (XPS; FKG Dentaire, La Chaux-de-Fonds, Switzerland) compared of different nickel-titanium alloy rotary instruments had been investigated, assessed and compared within the dental literature.

Different nickel-titanium alloy rotary instruments are as follows:

1) TRUShape (TRS; Dentsply Tulsa Dental Specialties, Tulsa, OK, USA)
2) K3XF Instruments
3) ProTaper Gold Nickel-titanium Instruments
4) HyFlex CM (HCM; Coltene, Cuyahoga Falls, OH, USA),
5) Vortex Blue (VB; Dentsply Tulsa Dental Specialties),
6) iRace (iR; FKG Dentaire) nickel-titanium rotary instruments
7) FlexMaster nickel-titanium rotary instruments

1)Silva EJ et al. Compared Cyclic and torsional fatigue resistance of XP-endo Shaper and TRUShape instruments. Journal of endodontics. **2018 Jan** Concludedthatthe XP-endo Shaper instruments showed a higher cyclic fatigue resistance and angle of rotation to fracture but lower torque to failure than TRUShape instruments[33].

2)Elnaghy A, Elsaka S. Cyclic fatigue resistance of XP-endo Shaper compared with different nickel-titanium alloy instruments. Clinical oral investigations. **2018 Apr**Concludedthat the XPS instruments exhibited greater cyclic fatigue resistance compared with the TRUShape, HyFlexCM (HCM; Coltene, Cuyahoga Falls, OH, USA), Vortex Blue (VB; Dentsply Tulsa Dental Specialties), and iRace (iR; FKG Dentaire) nickel-titanium rotary instruments at body temperature [34].

3)**Keskin C, Inan U, Guler DH, Kalyoncuoğlu E.**Compared Cyclic Fatigue Resistance of XP-Endo Shaper, K3XF, and ProTaper Gold Nickel-titanium Instruments. Journal of endodontics. **2018 Jul** Concluded that XP-endo Shaper instruments exhibited greater cyclic fatigue resistance compared with K3XF, and ProTaper Gold Nickel-titanium Instruments at the intracanal temperature[35].

4) **Adiguzel M, Isken I, Pamukcu II.** Comparison of cyclic fatigue resistance of XP-endo Shaper, HyFlex CM, FlexMaster and Race instruments. Journal of dental research, dental clinics, dental prospects. **2018**Concluded that the XP-endo Shaper instruments were found to be more resistant to cyclic fatigue than the #30/.04 Ni-Ti rotary instruments immersed in water at simulated body temperature [36].

IV. Discussion

NiTi rotary instruments have a high risk of fracture during root canal instrumentation in curved root canals [2, 20]. Consequently, testing the fracture resistance is essential for newly developed NiTi rotary instruments to give reliable recommendation for endodontists [2]. In the present study, the cyclic fatigue resistance of newly developed XPS which is manufactured from MaxWire alloy was comparedwithdifferent NiTi alloy systems.

The cyclic fatigue resistance of NiTi instruments is influenced by various factors, including the properties of raw materials, cross-sectional design and manufacturing method [22, 23].

In the present study, XPS instruments revealed the highest NCF among the tested instruments. This finding could be attributed to the metallurgy of XPS as it is manufactured from Max Wire alloy. It is claimed by the manufacturer that MaxWire alloy provides XPS instruments with high flexibility, super elasticity and more resistance to fatigue [13]. The shape memory of XPS enables it to take a predefined shape inside the canal [13]. It has been demonstrated that the newer developed alloys are assumed to have higher transformation temperatures compared with conventional austenitic NiTi rotary instruments [15, 24] and may perhaps transform at body temperature [15, 25].

It has been reported that the NiTi alloy that contained more martensitic had a higher fatigue resistance than austenitic instruments [26, 27]. In addition, XPS had the smallest taper size (0.01 taper) with a smaller core diameter compared with other instruments that might improve its resistance to cyclic fatigue.

HCM, VB, and TRS instruments revealed higher resistance to cyclic fatigue compared with iR instruments. This is could be due to the metallurgical differences between the instruments. HCM, VB, and TRS instruments are manufactured from heat-treated alloys, whereas iR instruments are manufactured from conventional NiTi alloy. It was reported that HCM instruments had a higher cyclic fatigue resistance compared with instruments manufactured from conventional NiTi alloy [15, 28, 29].

The conversion of HCM from martensitic to austenitic is not entirely finished at body temperature. This mean that HCM at body temperature will be in a mixed martensitic and austenitic structure[15].NiTi alloy that had more martensitic is more flexible and consequently more fatigue resistance [15, 30].

The instruments fractured nearly 5 mm from the tip of theinstrument,revealed narrowareaofultimateflexure[18, 35]. Fractured instruments revealed ductile fracture that was due to accumulation of metal fatigue[36]. XPS instrumentshowedasmallercorediametercomparedwithother instruments.Ithasbeenclaimedbythemanufacturer that the small core diameter of XPS instruments enhances debris removal and impedes it from being condensed into canal irregularities [13].

Enhancement of manufacturing process of NiTi rotary instruments could theoretically be significant [26]. NiTi instruments with increased flexibility and resistance of fatigue allows the preparation of curved root canal with minimal risk of instrument fracture inside the canal [26]. Different manufacturing methods of the instruments noticeably influence their fatigue resistance [6].

V. Conclusion

Under the limitations of the present study, XP-endo Shaper instruments were found to be more resistant to cyclic fatigue than the different nickel-titanium alloy rotary instruments tested in dental literature.

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Conflicts of interest
There are no conflicts of interest.

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