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Original Research Article

Cutting ability of nickel-titanium rotary systems ProTaper, Mtwo and K3

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Abstract:

Introduction: Nickel-titanium rotatory systems should remove dentin during the root canal preparation to promote the enlargement and tapered shape with continuously narrowing towards the apex. **Objective:** The aim of this study was to analyze the cutting ability of three NiTi rotatory systems (n = 12): ProTaper (group 1), Mtwo (group 2), and K3 (group 3). **Material and methods:** Thirty six maxillary molar teeth were weighted on an analytical balance before and after the rotatory preparation of the mesio-buccal root canal. Data was statistically analyzed by ANOVA and Tukey's test with a significance level of 5%. **Results:** The results revealed the following mass differences (g) before and after the root canal preparation: ProTaper (group 1 – 0.0159 ± 0.004), Mtwo (group 2 – 0.0125 ± 0.002), and K3 (group 3 – 0.007 ± 0.003). **Conclusion:** ProTaper showed the highest cutting ability among the three tested nickel-titanium rotatory systems followed by Mtwo and K3.

Introduction

Among the properties of NiTi Rotary system, their flexibility, cutting ability, resistance to fracture and elastic memory have been highlighted [3, 4, 11, 22, 17, 32, 34].

The cutting ability of endodontic instruments has been evaluated in wet bovine bone because of the instrument's cutting depth, with either linear filling movements [18, 15, 35], at traction movements with controlling of force, pressure, amplitude and number of movements [1, 39], or with ¼-turn clockwise rotation [10]. The cutting depth of the instrument has also been evaluated in polymethylmethacrylate blocks and artificial root canals made of epoxy resin [1, 16, 29, 24, 30] and Plexiglass plate [10]. The cutting ability was measured based on the removal of the Plexiglass mass weighed in analytical balance [10]. Schäfer and Lau [23] compared the cutting efficacy of NiTi instruments in curved canals of extracted teeth. Carvalho-Souza *et al*. [6] evaluated by using Gates Glidden rotary instruments and ProTaper, the thick of the remnant dentin in mandibular molars extracted and included in rein blocks, before and after their preparation.

Computed tomography has also been used to evaluate tridimensionally root canal preparation once it enables the observation of root canal shape, volume increasing and center and the cutting ability of the instrument [8, 24, 27, 33]. The efficacy of the cutting efficacy of NiTi instruments is analyzed by the cuts of the cervical, medium and apical thirds of natural or artificial teeth, measured before and after root canal preparation.

The aim of this study was to analyze the cutting ability of three NiTi rotary systems: ProTaper, Mtwo and K3.

Material and methods

To conduct this study, 36 maxillary molar human teeth coming from the tooth bank of the Araraquara School of Dentistry (São Paulo State University – short Unesp) were used. This study was approved by the Ethical Committee in Research. The teeth were stored in 0. 1% thymol solution for 30 days. Next, they were washed in tap water to eliminate this solution for 2 hours. Following, radiographic shots were taken through portable x-ray device (Heliodent, Siemens, São Paulo, SP, Brazil – 60 kV, 10 mA) to verify root canal internal anatomy and the curvature degree of the mesio-buccal root. Apical curvature was determined by using the method of Schneider [26], with the aid of the software Image J (www.rsb.info.nih.gov/ij). Inclusion criteria comprised teeth presenting apical curvature from 20º to 40º at mesial-distal direction. Caries lesions, metallic restorations and distal-buccal roots were removed. The surgical access of the teeth was accomplished through diamond burs #1012, #2082 (KG Sorensen, Cotia, São Paulo, SP, Brazil), mounted in handpiece at high speed and long carbide round bur (28 mm; size #2) (Dentsply-Maillefer, Petrópolis, RJ, Brazil), mounted in handpiece at low speed. Mesial-buccal canal was negotiated and the patency was verified through a K file size #10. The teeth were weighed in analytical balance (Bioprecisa, São Paulo, SP, Brazil) and embedded in condensation silicone impression material (Vigodent, Rio de Janeiro, RJ, Brazil), mounted in acrylic platform, adapted from the method of Southard *et al*. [29], to standardize the position of the teeth during root canal preparation. The teeth were divided into three groups of 12 teeth each with mesial-distal curvatures in mesial-buccal root from 20º to 29º (6 teeth) and from 30º to 40º (6 teeth).

In the three groups, working length was established with a K file size #10 until root canal patency, confirmed through periapical radiographs The NiTi rotary systems evaluated in this study were: group 1: ProTaper – Universal (Dentsply-Maillefer, Ballaigues, Switzerland); group 2: Mtwo (VDW, Bayerwaldstr-München, Germany); and group 3: K3 (Sybron-Endo, Orange, CA, USA). In all teeth, before the preparation, at every instrument change and at the preparation ending, root canal were irrigated with 1% sodium hypochlorite with the aid of a 3 ml plastic syringe and 30 Gauge needle and Endo-Eze tip (Ultradent, Salt Lake City, USA), up to 2 mm shorter of the apical foramen. At the ending of the preparation, a capillary tip plastic needle (Ultradent, Salt Lake City, USA) with 0.014 inch caliper, coupled to a metallic cannula and to the suction unit (Dabi Atlante, Ribeirão Preto, SP, Brazil) of the dental chair with pump suction, was introduced up to the apical third for the aspiration of possible dentin debris and residual irrigant. Apical preparation diameter and the velocity, torque and time elapsed for preparation for each root canal were standardized, respectively in 0.30 mm, 250 rpm, 1.6 Ncm and 30 seconds. For root canal preparation, the X-Smart motor (Dentsply-Maillefer, Ballaigues, Switzerland) was employed. ProTaper instrument sizes S1, S2, F1, F2, F3; Mtwo instrument sizes 10/04, 15/05, 20/06, 25/06 30/05; and K3 instrument sizes 25/08, 15/04, 20/04, 25/06, 30/04 were used. In ProTaper and Mtwo systems, all instruments were introduced up to the apical foramen (patency) as working length. In K3 system, the instrument size 25/08 was used to access the cervical third and the other instruments were used up to the apical foramen. The instruments were inserted with linear back-and-forth movements without apical pressure up to reach the apical foramen. When the instrument found some resistance, the self-reverse mechanism of the device was automatically driven. In this case, new back-and-forth movements were initiated up to reach the apical foramen. Each instrument was used four times. All groups were prepared by the same examiner. After root canal preparation and irrigation, all canals were dried with 0.30 mm paper points. Next, the teeth were removed from the silicone block and again weighed on the analytical balance. The aim was to analyze the cutting ability of the instruments through the mass loss (grams) after root canal preparation. Data was evaluated by one-way ANOVA and Tukey test for multiple comparisons with level of significance of 0.05.

Results

The results of the cutting ability of each instrument through the mass assessment before and after root canal preparation (initial mass minus final mass) as well as the comparison among them are seen in table I. The results indicated mass difference before and after preparation of each system. During canal preparations, only one fracture occurred: Mtwo system size #20 during its fourth use.

Table I – Mass (g) of the teeth, before and after preparation, and the mass difference among the three rotary systems

Mass	Group	Mean ± sd	CI 95%	p value
Before	ProTaper	1.714 ± 0.308	(1.518;1.910)	0.199
	Mtwo	1.854 ± 0.0302	(1.662;2.046)	
	K3	1.950 ± 0.336	(1.736;2.164)	
After	ProTaper	1.698 ± 0.306	(1.503;1.892)	0.176
	Mtwo	1.842 ± 0.301	(1.651;2.034)	
	K3	1.943 ± 0.335	(1.729;2.156)	
Mass difference (before-after)	ProTaper	0.0159 ± 0.004	(0.131;0.187)	< 0.001
	Mtwo	0.0125 ± 0.002	(0.011;0.014)	
	K3	0.007 ± 0.003	(0.005;0.009)	

Discussion

For Schäfer and Vlassis (2004) [25], artificial root canals embedded in epoxy resin blocks neither reflect the behavior of root canal of the human tooth nor the dentin structure nor its removal. Nevertheless, in human tooth, because of the great variety of the internal and external anatomy, the age of the patient when losing the tooth, presence of restorations and caries lesions, it is very difficult to standardize the study's groups. However, this is one advantage of epoxy resin artificial root canal, in which it is possible to standardize the diameter, length and curvatures. Sonntag *et al*. (2007) [28], in a same study, associated extracted human teeth and epoxy-resin root canals. The results of epoxy-resin canals were higher than those with human teeth, just because of the possibility in standardizing the canals regarding to the curvature, length and diameter.

In this present study, the cutting ability of ProTaper, Mtwo and K3 rotary instruments were analyzed through the mass loss of the tooth during root canal preparation. The parameter employed was the analytical balance, weighing the tooth before and after the preparation. Velocity, torque and time of the instruments were standardized. Root canal preparations were executed by the same examiner; force and pressure were not calibrated. To avoid greater variation in rotary instrument insertion, the linear movement was standardized for the three groups. This movement was appropriate because all instruments reached the patency of root canal without difficulty. Other methods, such as cutting depth and canal volume increase, have also been employed to analyze the cutting ability of the instruments [24, 28, 33]. Although human tooth simulates the clinic situation regarding to the material, it may have variations in the calcification and hardness of the substrate, because of the age and substrate site; this same pattern also occurred in bovine tooth. Notwithstanding, methods employing materials different from human teeth does not mimic the clinical condition.

In the three groups analyzed, there was only one instrument fracture, in group 2, (size #20; Mtwo). This tooth showed a curvature of 36.7º in mesial-buccal root, close to the maximum curvature included in this study (40º). The instrument fracture occurred in its fourth use, at apical third and within working length, with fragment of about 2 mm. By using torque below 1.6 N when the instrument found a resistance, the self-reverse device was automatically driven, which may contribute to avoid the fracture of a greater number of instruments. Sonntag *et al.* [28] recorded a fracture of ProTaper and Mtwo instruments, but none with K3, when these three systems were used in the preparation of mandibular human molars. The instrument fracture may be associated to several factors, such as torque, fatigue, curvature radius and degree, instrument diameter, geometry, number of uses, preparation velocity and torque [20]. Yared and Kulkarni [38] tested the torque at 1.3 Ncm, 1.1 Ncm and 0.75 Ncm of five motor devices (Tulsa Dentsply) for NiTi rotary instruments. They concluded that the actual torque was higher than that recorded by the device's display. Also, these authors affirmed that some fractures in Profile instruments occurred because of the torque discrepancy.

The geometry of the cross-cut section, the cutting angle of the blade, the instrument tip, and the tapering have been reported by several authors as determining factors in the cutting ability and resistance to flexion and torsion [3, 4, 12, 14]. This study's instruments differed among each other regarding their geometric shape of the cross-cut section. The ProTaper instrument presents a convex triangular section with three cutting blades, while Mtwo presents a rectangular S-shape section with double cutting angle, and K3 shows a section with two radial planes and one cutting blade, totaling three asymmetrical surfaces. Berutti *et al.* [4] affirmed that Profile presents greater flexibility than ProTaper instrument because of its 30% smaller area. However, after force application, ProTaper demonstrated the best tension distribution when compared with Profile. Uyanik *et al.* [33] also concluded that ProTaper removed the greatest amount of dentin than HeroShaper, but without significant difference when compared to RaCe system. Kim *et al.* [13] studied the mechanic reactions of NiTi Profile, Hero Shaper, Mtwo and NRT instruments. The results showed that rectangular cross-section sections, as Mtwo and NRT, created more tension during the preparation simulation with 1 and 2 Ncm, velocity of 240 rpm, and they may find more residual tension and plastic deformation than triangular cross-section instruments.

Shen and Haapasalo [27] used the volume loss through computed tomography before and after preparation. These authors reported that is very difficult to evaluate the mass loss of NiTi instruments because of the low power of their cuttings. Accordingly, in this present study, the mass difference, before and after preparation, found in each system was very small. A statistically significant difference was found among ProTaper, Mtwo and K3. Plotino *et al.* [21] did also not noted statistically significant difference in the amount of dentin removed at the coronal third of the root between ProTaper and Mtwo. One possible explication for the greater amount of dentin removed by the instrument may be attributed by the difference of taper regarding to Mtwo and K3.

Wu *et al.* [36] verified that in 25% of the cases, the instrument are not supposed to touch all root canal walls during preparation. Wu *et al.* [37] recorded that the single mesial-buccal canal diameter of the maxillary molar at 1 mm shorter of the apex is 0.43 mm; at 5 mm shorter of the apex is 0.96 mm in buccal-palatal direction and 0.22 mm and 0.29 mm in mesial and distal direction, respectively. The findings of these authors may explain the small mass loss of the teeth after the use of the three rotary systems in our study, when compared with studies on bovine bone, dentin discs and epoxy-resin canals.

Shen and Haapasalo [27] emphasized that root canal lubrication with the irrigant during preparation make easy the contact between the cutting blade of the instrument and the dentin, decreasing friction. Some studies [5, 7, 9, 19] have shown that NaOCl attacks the organic matrix of the dentin and reduces the microhardness of radicular dentin, making the preparation easier. Shen and Haapasalo [27] found less compression force and more cutting efficacy in these following NiTi rotary systems: Hero Shaper, FlexMaster, K3, Libertor, Alpha and Profile on bovine femur after irrigation with NaOCl compared to a dried canal. Among them, FlexMaster and K3 removed greater volume of bovine bone both in wet and dried canal. The treatment surface of the NiTi instrument (bhorio ion implantation; thermal nitridation process; deposition of titanium nitride by physical vapor; cryogenic, argon and nitrogen treatment) may increase the cutting efficiency of NiTi instrument [2, 9, 24, 40]. Shen and Haapasalo [27] well emphasized that the dentin cutting is an essential step during endodontic treatment. It enormously contributes to the removal of infected dentin and promotes a proper tapering to the prepared canal.

Conclusion

Considering the limitations of this study, it can be concluded that the cutting capacity of nickel-titanium rotary systems was descending for the systems: ProTaper, Mtwo, and K3.

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