Journal section: Clinical and Experimental Dentistry
Publication Types: Research

Modification of the working length after rotary instrumentation. A comparative study of four systems

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Received: 10/04/2008
Accepted: 21/01/2009

Martín-Micó M, Forner-Navarro L, Almenar-García A. Modification of the working length after rotary instrumentation. A comparative study of four systems. Med Oral Patol Oral Cir Bucal. 2009 Mar 1;14 (3):E153-7.
http://www.medicinaoral.com/medoralfree01/v14i3/medoralv14i3p153.pdf

Article Number: 5123658877 http://www.medicinaoral.com/
© Medicina Oral S. L. C.I.F. B 96689336 - pISSN 1698-4447 - eISSN: 1698-6946
eMail: medicina@medicinaoral.com
Indexed in:
-SCI EXPANDED
-JOURNAL CITATION REPORTS
-Index Medicus / MEDLINE / PubMed
-EMBASE, Excerpta Medica
-SCOPUS
-Indice Médico Español

Abstract

Objective: To determine variation in post-instrumentation working length and root area in the following rotary systems: ProTaper, RaCe, Mtwo and K3.
Study design: A sample of 40 resin blocks with double curvature (at 14 and 16 mm) and a 33º angle was used. Working length was verified with a digital measure using a number 10 K file. The specific sequence for each rotary system was followed. The canal was measured between each file, and the variation noted to determine which file showed the greatest variation within a same system and the different systems were compared. 1.5 X pre and post-instrumentation microscopic photographs were taken and measurements of the area were taken with an image analysis programme.
Results: The area was found to increase by the following amounts: ProTaper: 21.85 mm^2; Mtwo: 20.16 mm^2; K3: 17.24 mm^2 and RaCe: 16.09 mm^2 The differences in variation of the working length were: ProTaper: 0.81 mm; Mtwo: 1.07 mm; K3: 0.31 mm and RaCe: 0.81 mm
Conclusions: The values for the variation in working length are clinically not very significant. All the rotary systems analysed showed a tendency to straighten the canal and eliminate the apical curvature, and the ProTaper system was found to produce the greatest modification to the canal area and structure.

Key Words: *Crown-down, working length, rotary instruments.*

Introduction

During the last decade a wide variety of rotary instruments and techniques have been developed; differentiated by the sections, tip, cutting angle, taper, etc; but the main purpose of their design is to prepare the root system maintaining its original shape without the appearance of iatrogenic events such as transport, perforations and fractured instruments; however, although there are many studies in the literature none of them offer definitive scientific evidence on a system which achieves ideal preparation (1-3).

The working length is the distance between the coronal reference point and the point at which canal preparation and sealing must end; it determines the extent of the cleaning and shaping process (4). The traditional reference point is considered to be a point 1 mm shorter than the radiographic apex; however, the apical foramen can be 3 mm shorter. In general, a distance of 0.5 to 1 mm, or even 2 mm for some authors (5), from the end of the file to the apex surface is considered appropriate.

Accurate determination of root canal length is a key factor in successful endodontic therapy. An incorrect determination could lead to apical perforation, overfilling, post-operative pain, greater failure rate, incomplete instrumentation and deficient filling.

Crown-down instrumentation causes variations in canal morphology and area, which leads to a change between the preliminary measurement of the working length and that which is obtained after instrumentation, because of the variation in canal curvature (6).

This study aims to determine the action of rotary instruments by analysing: the variation in working length, area and post-instrumentation morphology in resin blocks produced by four rotary systems: K3, Mtwo, ProTaper and RaCe.

Materials and Methods

The sample was 40 resin blocks (Dentsply/Maillefer) measuring 10x19mm, with 0.02 taper and double curvature (at 14 and 16 mm) with a 33º angle at each curvature (7).

The rotary systems used were:

Mtwo (VDW): Ni-Ti rotary system with an "S" section and positive cutting angle. The sequence followed was: 04-10, 04-15, 04-20, 04-25 all at the working length (18 mm).

K3 (Sybron Endo): These files have 3 radial planes with positive cutting angles. The sequence followed was: 010-25 at 8mm, 08-25 at 10mm, 06-40 at 12mm, 04-40 at 14mm, 04-35 at 16mm, 04-30 at 18mm.

RaCe (FKG): This has twisted areas with straight non cutting areas and triangular section except for those with 0.02 taper which has a square section. The sequence followed was: 010-40 at 10mm, 08-35 at 12mm, 06-25 at 14mm, 04-25 at 16mm, 02-25 at 18mm.

ProTaper (Dentsply Maillefer): This system is characterised because there are different taper within the same file. The sequence followed was: S1 at 10mm, SX at 12mm, S1 at 14mm, S2 at 16mm, F1 at 18mm, F2 at 18mm, F3 at 18mm.

A digital ruler was used with 0.01mm/0.0005" resolution, ±0.02mm/0.001" (<100mm) precision and a repetition rate of 0.01mm/0.0005". The X-Smart micromotor (Dentsply Maillefer) was used for canal instrumentation. A torque of 1.4 Ncm and 300 rpm was used for all the techniques. There was profuse irrigation with hypochlorite between each file in all the techniques and an ethylene diamine tretraacetic acid and urea peroxide gel was used (Glyde File Prep Dentsply). The canal was measured between each file, and the variation noted to determine which file produced the greatest variation within a system and the different systems were compared. Pre and post-instrumentation photographs were taken at 1.5x with an OPMIpico version 8.0 microscope (Carl Zeiss).

The following measurements were made with the image analysis system Image J (Java): variation in the post-instrumentation area measuring total canal area and change in canal morphology taking measurements at apical level, 5 mm, 10 mm and 15 mm; for each of the instrumented blocks (Fig.1).

A descriptive analysis was made of the increase in the areas and the reduction in working length for each of the systems studied. Increases in areas and losses in working length were compared using the non parametric Kruskal-Wallis test.

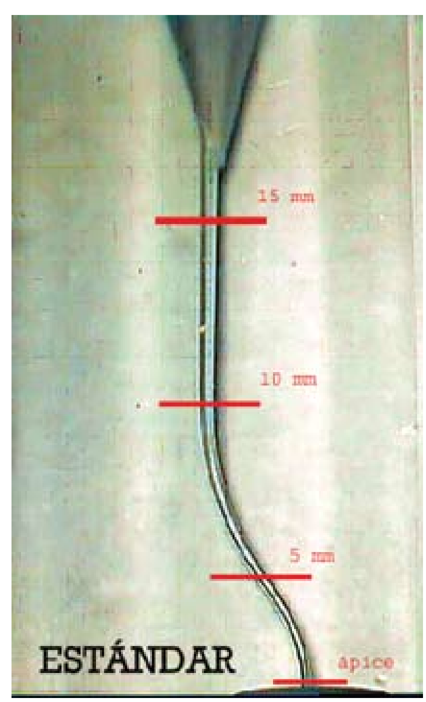

Fig. 1. The image analysis system Image J (Java).

Results

Variation in working length

RaCe: In the sample instrumented with RaCe files, the greatest change in working length was found to occur with the first 010 – 40 file, in the first 10 mm of the canal with an average of 0.29 mm, followed by the 04 – 25 instrument which reaches up to 16 mm of the canal and reduces the working length by an average of 0.15 mm. This was followed by files 08 – 35, 06 –25 and 02 –25 with 0.14 mm, 0.13 mm and 0.10 mm respectively. The RaCe system produces an average variation in working length of 0.81 mm.

Mtwo: The greatest change is obtained with file 25 with an average result of 0.34 mm followed by instruments 20, 15 and 10 with average values of 0.31 mm, 0.31 mm and 0.15 mm respectively. The average value for working length variation is 1.07 mm. This system produces the greatest variation during instrumentation of the simulated resin root canal.

ProTaper: The greatest change with ProTaper is produced with file F3 with an average value of 0.18 mm, followed by S2 which reached up to 16 mm and with a value of 0.16 mm and F2 with an average value of 0.15 mm; F1 (instrumented up to 18 mm) with 0.10 mm; S1 and Sx, instrumented up to 10 and 12 mm respectively, with 0.08 mm and S1 instrumented up to 14 mm with 0.07 mm. The ProTaper system produces an average variation in working length of 0.81 mm.

K3: In the sample instrumented with K3 files, it was observed that the greatest change in working length occurred with the first 010 – 25 file, in the first 10 mm of the canal with an average of 0.11 mm, followed by 04 – 40, 04 –35 and 04 –30 with 0.04 mm and finally 09 – 25 and 06 – 40 with 0.02 mm. The average variation in working length produced is 0.25 mm. This system produces the least variation in canal length.

Modification of the area

The average values obtained with the different systems were: RaCe: 16.09 mm^2; Mtwo: 20.16 mm2/ ProTaper: 21.85 mm^2; K3: 17.24 mm^2. The results show that RaCe produces the least modification in resin canal area followed by K3, Mtwo and ProTaper.

Comparison of the instrumented blocks with the non-instrumented block (with an area of 7.575) shows the following increases: RaCe: 8.53 mm^2; Mtwo: 12.58mm2/ ProTaper: 12.58 mm^2; K3: 9.67 mm^2.

Morphological variation

The results obtained after measuring the canal at the afore mentioned levels show that: at the apex, the least modification is obtained with the K3 system, at 5 mm from de apex the following series RaCe<K3<Mtwo<ProTaper, at 10 mm as in the previous case but with less difference between RaCe and K3 and at 15 mm RaCe and K3 obtain similar results as do Mtwo and ProTaper. The entire sample shows a tendency towards straightening the canal and eliminating the apical curvature.

The results show that a significantly higher increase in area is obtained with Mtwo and ProTaper in relation to RaCe and K3, while Mtwo increases the working area in the standardised blocks significantly less than ProTaper (Table 1).

With regard to the decrease in working length, the K3 system produces a significantly lower reduction than the other systems studied (Table 2).

Table 1. Area increase.

Systems	N	Mean	Standard D.	Confidence interval	
Mtwo (a)	9	12.5833	.64074	12.0908	13.0759
Protaper (a,b)	9	14.2800	.86462	13.6154	14.9446
RaCe (a,b)	10	8.5340	1.94170	7.1450	9.9230
K3 (a,b)	8	9.6663	.31888	9.3997	9.9328
Total	36	11.2344	2.59868	10.3552	12.1137

a, b: Groups with statistically significant differences in area increase.

Table 2. Reduction in working length.

Systems	N	Mean	Standard D.	Confidence interval	
Mtwo	9	1.0656	.40596	.7535	1.3776
Protaper	9	.8122	.18233	.6721	.9524
RaCe	10	.8090	.13763	.7105	.9075
K3 *	8	.2513	.08026	.1842	.3183
Total	36	.7500	.36862	.6253	.8747

*Group which shows statistically significant differences in the decrease of working length in relation to the others.

Discussion

The change in working length after each file use has not previously been studied.

Schäfer et al. used simulated resin canals (28º-35º) in their study of the K3 system and reported that the change in working length was not statistically significant showing values of 0.28 and 0.35 mm respectively for each canal, coinciding with the average value of 0.31 mm obtained in this present study (8).

Schäfer et al. compared the ProTaper and RaCe systems observing a greater loss of length with Protaper at 35º curvatures with a result of 0.38 mm. For curvatures of 28º a result of 0.26 mm was obtained; and with RaCe for a 28º curvature the result was 0.16 mm and for a 35º curvature, 0.20 mm. These results do not coincide with the values obtained in this present study because a different procedure was followed, using extracted teeth (9). Veltri et al., used 20 mesial canals with curvatures between 23º and 54º obtaining a variation in working length for ProTaper of -0.25 ± 0.23 mm (11). Iqbal et al., compared Profile with ProTaper, and obtained a value of 0.41±0.28 mm for canals instrumented with ProTaper (12) which is lower than the value reported here. And finally, Paqué et al, compared RaCe and ProTaper instrumentation instrumenting the mesial root (with curvatures between 20º and 40º) of 50 mandibular molars, obtaining a loss in working length of 1-2 mm (13).

With regard to the variation in canal modification, the literature review showed the following studies coinciding with the rotary systems used. Schäfer et al., determined that the K3 rotary system prepares curved canals quickly with minimum transportation to towards the external area of the curve (8). Yun et al., determined that ProTaper produces the greatest change in curvature and presents the greatest deformation as the diameter increase coefficient is higher than that of other systems, in addition to the resistance offered by resin. The authors determined that the use of ProTaper must be controlled in narrow curved canals (18). Schäfer et al., compared RaCe with ProTaper and established that RaCe maintained the original curvature perceptibly better than ProTaper, which coincides with the results obtained in this present study (9,10). Veltri et al., in a study on ProTaper saw that the preparations made by ProTaper focused on the canal, with a minimum tendency to transport the curvatures; their results may be due to the high flexibility of the Ni-Ti alloy (11). Peters et al. carried out a microtomographic study of ProTaper with teeth and they observed that, in general, apical transportation takes place which is independent from the canal's preoperative anatomy but a correct preparation is produced in curved, narrow canals (14-17). Recently, Jodway and Hülsmann made a comparative study of K3 and NiTi-TEE, and reached the conclusion that both systems maintain the original curvature of the canal (19).

The use of simulated resin canals provides standardisation in terms of degrees and curvature, in three dimensions. This model guarantees reproducibility and standardisation of the experimental models but the results cannot be transferred due to the difference between resin and dentine. A force of 34-40 kg/mm2 is required to work dentine which is double the 20-22 kg/mm2 required to work resin; furthermore, it is more difficult to remove the resin debris from the blocks (1).

All the articles reviewed coincide in determining that the variation in length obtained is not significant as the values obtained are within the range accepted for canal instrumentation of 0.5 to 1 mm in relation to the apex (2,5-7,9,18).

Conclusions

After instrumentation of the resin blocks with the above mentioned rotary systems and following the proposed methodology, the following conclusions were reached: all the rotary systems studied show a tendency to straighten the canal and eliminate the apical curvature, with ProTaper producing the greatest variation. The values obtained for the variation in working length do not have any great clinical impact.

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