Accuracy of endodontic millimeter rulers and calibrator hole, and evaluation of the regularity of the calibrator hole surface

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ABSTRACT

Objective: The aim was to evaluate the accuracy of the millimeter and calibration portion and evaluate the regularity of the calibrator orifice surfaces of the endodontic rulers. **Methods:** The millimeter portion of the Angelus, Maillefer, Maquira, Microdont and Prisma rulers was evaluated with an electronic digital caliper. The calibration holes of the Maillefer, Prisma and Angelus were measured with Profile Projector. The surface regularity of calibration holes was evaluated and classified in S1- without irregularities and S2- with irregularities. The accuracy analysis of the millimeter and calibration was performed with T-Test (p=0.05) and the frequencies of the surface types with Chi-square (p<0.05). **Results:** The Maillefer was the only rulers with accuracy in all lengths and holes. Prisma presented statistically more S2 type holes when compared with other endodontic rulers evaluated (p <0.05). There was no statistically significant difference between Angelus and Maillefer (p> 0.05). **Conclusion:** The Maillefer presented accuracy in the millimeter and calibration portion. Angelus endodontic rulers were not accurate at any rated length of the millimeter portion and it was not accurate in most calibration holes evaluated. Prisma endodontic ruler showed significantly more calibration holes with irregular surfaces than Angelus and Maillefer. We emphasize the need for quality control and specific standards for endodontic rulers manufacturing.

Keywords: Dimensional Measurement Accuracy. Endodontic. Body Surface Area.

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Introduction

The establishment of canal length and work length (WL) are extremely important since they directly influence the success of endodontic treatment.[1,2] Its importance is especially related to the biological aspects of the root canal apical third. This area, also called the apical critical zone,[2] comprises 3-4 mm of the root apex and has an intimate relation between the pulp cavity and the periodontal tissues, and may even be related to the maxillary sinus.[3]

Errors in obtaining the canal length may lead to over or under instrumentation and over or under obturation. Such errors result in non-instrumented areas, permanence of empty spaces after filling, and inflammatory response in the periapical tissues, prolonging or inhibiting their repair.[2,4]

In order to obtain the canal length, two methods are generally employed, the radiographic and the apical locator, which can be used separately or together.[5] Regardless of the technique of obtaining canal length, the use of an endodontic ruler (ER) is fundamental to perform the measurement of all the instruments used in the preparation of the root canal system and materials used in other stages of treatment such as lentulos, spacers, absorbent paper points and gutta-percha cones. Thus, it should be emphasized that ERs must be accurate. Different studies have evaluated the ERs accuracy.[6-8] Alencar et al.[6] evaluated Maillefer, Jon, Imagem and non-brandeders and found that the ERs evaluated were not accurate. The same was verified by Victorino et al.[7] with The Jon, Microdont, Angelus and Ice brands and Lins et al.[8] in relation to the Fava, Intermedium, Jon, Maquira, Maillefer, Microdont and Prisma brands.

Some ERs also have calibrator holes that correspond to the initial diameter of the ISO series endodontic files.[9] These ERs make it possible to adjust the initial diameter of the gutta-percha cone according to the diameter of the last file used in the WL, facilitating the selection of the main cone in the endodontic obturation stage. Cagol et al.[9] evaluated the calibration hole of the Angelus, Prisma and Maillefer brands, verifying that the three brands were not accurate.

From the studies that evaluated the millimeters of ERs,[6-8] only Lins et al.[8] evaluated Prisma and Maquira brands. Victorino et al.[7] evaluated only the length of 20 mm, whereas Alencar et al.[6] evaluated the length of 15 and 20 mm and Lins et al.[8] the length of 30 mm. The article that evaluated the calibration hole,[9] did not evaluate the diameter of all holes and their surface. However, if the calibrator holes surface are irregular, may interfere with the diameter of these holes. Thus, the aim of this study was to evaluate the precision of the millimeter and calibration portion and the surface of the calibration holes of the ERs.

Materials and Methods

A total of 50 ERs were evaluated, 10 ERs from 5 different brands (Table 1). Of these, 2 brands (Maquira and Microdont) have only the millimeter portion and 3 brands (Maillefer, Prisma and Angelus) also have the calibration portion.

The accuracy evaluation of the millimeter was performed in the 50 ERs through an electronic digital caliper UPM (UPM - Guogen/Japan) with a resolution of 0.01 mm. The nominal lengths corresponding to 1, 2, 5, 10, 15, 20, 25, 30 and 35 mm were measured. Only Maquira and Microdont ERs had nominal lengths greater than 30 mm (Table 1). After that, the mean and standard deviation of each length evaluated per group were obtained.

The calibration hole diameters of the Maillefer, Prisma and Angelus ERs ranging from 20, 25, 30, 35, 40, 45, 50, 55, 60, 70, 80, 90, 100, 110, 120, 130 and 140 according to the brand (Table 1). Measurements were made in all calibration holes with the Profile Projector (6C-2 - Nippon-Tokyo / Japan) with resolution of 0.001 mm. Before all tests the compatibility of the measurements of the digital caliper UPM and Profile Projector were tested.

The ERs were positioned on the table of the profile projector with the aid of utility wax to provide stability. The “Shadow” option of the equipment was chosen to perform the measure of the calibration hole through the shadow project on the screen.

We used 4 areas from the end of the hole, divided between points A (2 points) and points B (2 points). Points A are the most extreme points of the hole profile parallel to the long axis of the ER, while points B are the most extreme points of the perpendicular hole profile along the perpendicular axis of the ER.

The base line of the profile projector that is represent by the horizontal line projected on the screen was

Table 1. ER Brand and manufacturer.

Brand	Manufacturer	Material	Overall nominal length (mm)	Calibration Holes
Angelus Intermédium	Angelus Soluções Odontológicas, São Paulo, Brazil	Plastic	30	25 to 100
Maillefer	Dentsply, Ballaigues, Switzerland	Plastic	30	20 to 140
Maquira	Maquira, Paraná, Brazil	Aluminum	40	Absent
Microdont	Microusinagem de Precisão Ltda, São Paulo, Brazil	Aluminum	35	Absent
Prisma	Prisma Instrumentos Odontológicos, São Paulo, Brazil	Aluminum	30	25 to 140

positioned tangentially the points B, while the vertical line projected on the screen was positioned tangentially points A. The measures registered of each point A were subtracted, the same was done with points B. The diameter of the hole was obtained by the mean of points A and B. All measurements of the millimeter part and the calibrator hole were performed by a single operator pre-calibrated and repeated twice and then averaged.

Finally, the surface of all the calibration holes was evaluated through the shadow analysis projected on the profile projector. A procedure of sanitation of the samples was performed previously using running water and saponaceous, with friction movements performed with the aid of a brush. After washing the ERs underwent a drying process at room temperature. This procedure was designed to remove any external interference in the holes.

The surface regularity of the holes were classified into two types: S1- presented no type of irregularity (Fig 1A) or small irregularities without altering the shape of the hole (Fig 1B) and S2- presented irregularities with alteration of the shape of the hole (Fig 1C). First, an analysis of the frequency of the hole surface type between the brands was performed, regardless of the calibration hole size.

After, the calibration holes were subdivided according to the number of the hole into three subgroups: G1- 20 to 40 holes (nominal diameter of 0.20 mm to 0.40 mm), G2 - 45-80 holes (nominal diameter of 0.45 to 0.80 mm) and G3- 90 to 140 holes (nominal diameter of 0.90 to 1.40 mm). A second analysis was performed to verify the frequency of the hole surface type between the subgroups within the same ER brand.

Statistical analysis

The data were analyzed in the SPSS 20.00 program (IBM SPSS Statistics, Chicago, USA). The means and standard deviations of the millimeter portion and calibrator orifice were determined. The T-Test ($p=0.05$) was used to analyze the accuracy of the millimeter portion and calibration hole diameter within the same group. The frequencies of the calibration holes surface types were determined by directly comparing the ER brands independent of the subgroup, and comparing the subgroups (G1, G2 and G3) within each brand, using the Chi-Square Test ($p<0.05$).

Results

Table 2 shows the accuracy of the millimeter portion of the ERs evaluated. Maillefer ER was the only brand that presented precision in all evaluated lengths ($p>0.05$). Table 3 shows the accuracy of the calibration diameters hole of the ERs evaluated. The Maillefer ER was the only brand that showed precision in all the calibration holes ($p>0.05$).

Table 4 shows the frequency of the calibrator holes surface type. By directly comparing the ERs brands with each other, independently of the subgroup, it was verified that Prisma presented statistically more S2 type holes when compared with other ERs evaluated ($p <0.05$). There was no statistically significant difference between Angelus and Maillefer ($p> 0.05$). Within the same brand, the Prisma G1 subgroup presented a larger number of S2 surfaces than the G2 and G3 subgroups ($p <0.05$). There was no statistically significant difference between the Angelus and Maillefer subgroups ($p> 0.05$).

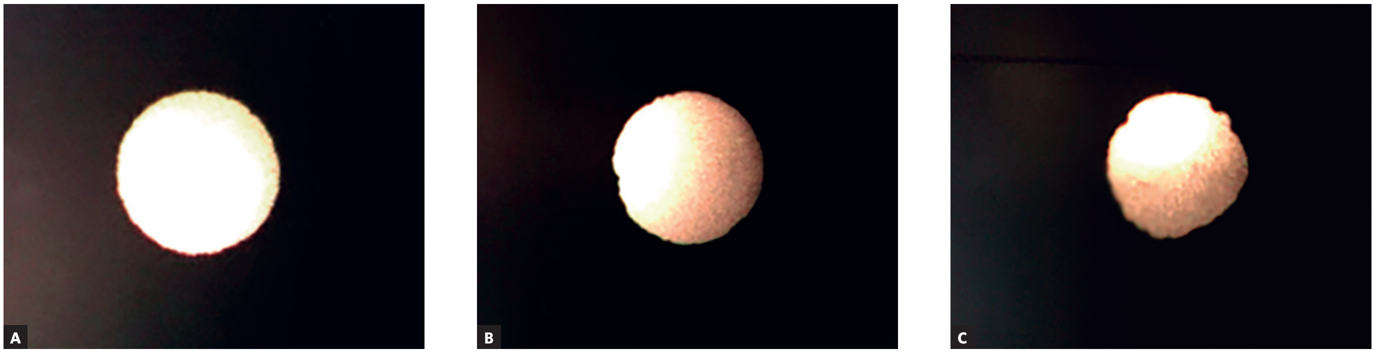

Figure 1. Surface classification of the calibrator holes; Surface without irregularity (**A**); surface with irregularities without changing the shape of the hole (**B**); surface with irregularities and alteration of the shape of the hole (**C**).

Table 2. Means, standard deviations and accuracy of the ERs millimeter portion (mm).

Nominal length	Angelus	Maillefer	Maquira	Microdont	Prisma
1	0.9±0.13	1.06±0.06*	1.03±0.12*	1.1±0.08	1.02±0.13*
2	1.95±0.15	2.07±0.12*	2.06±0.11*	2.1±0.07	1.99±0.14
5	4.98±0.11	5.06±0.10*	5.08±0.13	5.12±0.07	4.98±0.17
10	9.98±0.09	10.07±0.11*	10.07±0.10	10.16±0.09	9.96±0.15
15	14.98±0.08	15.12±0.09*	15.07±0.11	15.12±0.06	15.01±0.17
20	19.97±0.07	20.1±0.09*	20.09±0.11	20.15±0.09	19.98±0.15
25	24.94±0.09	25.13±0.06*	25.1±0.14	25.16±0.09	25±0.16
30	29.91±0.09	30.16±0.08*	30.08±0.11	30.17±0.07	29.97±0.17
35	NA	NA	35.1±0.11*	35.19±0.09*	NA

*: values with accuracy (p>0.05)
NA: absence of this length in the millimeter portion.

Table 3. Means, standard deviations and accuracy of the ERs calibration diameters hole (mm).

Nominal diameter	Angelus	Maillefer	Prisma
0.20	NA	0.189±0.021*	NA
0.25	0.23±0.019	0.234±0.038*	0.235±0.037*
0.30	0.272±0.046*	0.286±0.029*	0.298±0.015*
0.35	0.33±0.034*	0.343±0.026*	0.328±0.044*
0.40	0.377±0.015	0.391±0.018*	0.371±0.016
0.45	0.429±0.016	0.441±0.024*	0.431±0.055*
0.50	0.466±0.045	0.49±0.027*	0.493±0.022*
0.55	0.516±0.038	0.538±0.031*	0.56±0.047*
0.60	0.571±0.034	0.59±0.025*	0.595±0.053*
0.70	0.682±0.039*	0.687±0.025*	0.695±0.051*
0.80	0.775±0.025	0.786±0.028*	0.811±0.063*
0.90	0.881±0.025	0.896±0.023*	0.902±0.068*
1.0	0.997±0.014*	0.998±0.022*	0.998±0.060*
1.1	NA	1.094±0.016*	1.107±0.038*
1.2	NA	1.197±0.020*	1.229±0.035
1.3	NA	1.291±0.017*	1.319±0.048*
1.4	NA	1.389±0.018*	1.404±0.023*

*: values with accuracy (p>0.05).
NA: absence of calibration hole with this diameter.

Table 4. Frequency of the calibrator holes surface type.

ER	Subgrup	Surface Type (%)		Total n (%)	p
		S1	S2		
Angelus	G1	35 (87.5)	5 (12.5)	**40 (100)**	0.659
	G2	54 (90)	6 (10)	**60 (100)**	
	G3	19 (95)	1 (5)	**20 (100)**	
	Total	108 (90)	12 (10)	**120(100)**	
Maillefer	G1	46 (92)	4 (8)	**50 (100)**	0.125
	G2	59 (98.3)	1 (1.7)	**60 (100)**	
	G3	59 (98.3)	1 (1.7)	**60 (100)**	
	Total	166 (96.5)	6 (3.5)	**170(100)**	
Prisma	G1	21(52.5)	19 (47.5)	**40(100)**	0.037
	G2	44 (73.3)	16 (26.7)	**60 (100)**	
	G3	45 (75)	15 (25)	**60 (100)**	
		110 (68.8)	50 (31.3)	**150 (100)**	

Discussion

The ER is indispensable during the chemical-mechanical preparation and obturation of the root canal system. However, it is necessary that the ERs be precise, avoiding errors of interpretation and measurement.[6]

For the ERs measurement a digital caliper was used, which has a graduated ruler that allows an approximation to read the dimensions of an object with greater accuracy. This methodology is in agreement with previous studies,[7,8] with the exception of the study carried out by Alencar et al.,[6] who used a profile projector.

The results of the present study showed that Maillefer ER was the only one that presented precision in all the measured millimeter part. Angelus was not accurate in any length evaluated, Prisma presented accuracy only in the nominal leght of 1 mm, Microdont in the nominal length of 35 mm and Maquira in the 1, 2 and 35 mm lengths. It was also found that Angelus contained lower than nominal lengths, while Maquira and Microdont greater lengths. Similar results were obtained by Lins et al.[8] who reported that Maillefer presented accuracy, whereas Maquira was less precise. Victorino et al.[7] and Alencar et al.[6] observed that Angelus and Maquira ERs were not accurate.

During endodontic filling the root canal must be filled three-dimensionally.[10] In order to achieve a good sealing of the root canal and to prevent overfilling, a correct gutta-percha cone adaptation to the WL must be performed.[11-13] Previous studies[14,15] have shown that gutta-percha cones of different brands showed no correspondence between nominal diameters and tapers. The same was verified in relation to the ERs calibration hole diameter.[9] The profile projector was the method used in the present study to evaluate the calibration hole diameter. However, Cagol et al.[9] used digital photography.

All the calibration holes of the Maillefer, Prisma and Angelus ERs were evaluated. The Angelus had calibration holes of 25 to 100, Maillefer of 20 to 140 and Prisma of 25 to 140, corresponding to nominal diameters of 0.25 to 1 mm, 0.20 to 1.40 mm and 0.25 to 1.40 mm; respectively. In this way, it is possible to verify the lack of standardization between brands. Contrary to our study that assessed all calibrator holes, Cagol et al.[9] have evaluated only the 35, 50, and 140 calibration holes. According to them, the choice of the holes evaluated was done by the frequency of use, with the exception of the hole 140.

Through the analysis of the diameter hole it was possible to observe that the Maillefer presented precision in all the holes, followed by Prisma and Angelus.

The Angelus presented lower values than the nominal one and Prisma varied according to the calibration hole evaluated. Differently, Cagol et al.[9] observed that Maillefer, Angelus and Prisma were not accurate. According to ISO 6877[16] guidance the tip diameter of conventional standard gutta percha cones may have a tolerance of 0.05 mm up to cones #25 and 0.07 mm up to cones #140. Extrapolating this tolerance limit of the cones also for the calibration holes, all marks remained within this standard of tolerance.

Imperfections in the ER calibration hole may difficult the gutta-percha cone adjust to the ER proposed diameter and consequently the anchorage during the selection of the master cone. Thus, we evaluated the surface of the calibration holes in the profile projector. Up to this moment no studies have been found to make such an assessment. We classify surfaces according to the presence or absence of shape change. The results showed that Prisma presented significantly more holes with shape change than Angelus and Maillefer. It was also verified that the calibration holes of nominal lower diameters of the Prisma group showed significantly greater frequency of shape changes. Thus, there was a tendency for imperfections in the smaller calibration holes. Such an occurrence was not observed in Angelus and Maillefer ERs.

All measurements were made only by a single operator, which was previously calibrated, in order to reduce errors and measurement variations. The ERs used had not undergone any sterilization cycle. A study[9] demonstrated that Angelus, Maillefer and Prisma ERs after 4 cycles of sterilization underwent changes in their diameters due to abrupt changes in temperature during the sterilization process, leading to the expansion of metal and the changes in the plastic polymers, which are normally more sensitive to large changes in temperature, consequently leading to the reduction of the holes.

Conclusion

We conclude that Maillefer ER may be considered accurate, both in the millimeter and in the calibration portion. Prisma ER showed significantly more calibration holes with irregular surfaces than Angelus and Maillefer, especially in holes with nominal diameters of 0.25 to 0.40 mm. We emphasize the need for quality control and specific standards for ERs manufacturing.

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