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Tip and taper compatibility of accessory gutta-percha points with rotary and reciprocating instruments

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Conflict of Interest
No potential conflict of interest relevant to this article was reported.

Author Contributions
Conceptualization: Streck JNZ, Arcaro S, Ceretta RA, Bortoluzzi EA, Garcia L, Almeida J, Kopper PMP, Bernardi AV. Data curation: Streck JNZ, Arcaro S, Bernardi AV. Formal analysis: Bortoluzzi EA, Garcia L, Almeida

ABSTRACT

Objectives: This study was conducted to evaluate and compare the tip and taper compatibility of accessory gutta-percha points (AGPs) with various rotary and reciprocating instruments.
Materials and Methods: Using a profile analyzer, tip and taper measurements were taken of 10 AGPs of each of the 14 models available from Odous de Deus and the 4 models available from Dentsply-Maillefer. Diameter measurements were taken at 1-mm intervals, from 3 mm from the tip (D3) to 16 mm.
Results: Based on the mean values obtained, 3-dimensional (3D) models of the AGPs were drawn in Autodesk Fusion 360 and superimposed on 3D models of each instrument selected (Mtwo, Reciproc, RaCe, K3, and ProDesign Logic) to determine the compatibility between the instrument and the AGP. Data corresponding to the tips and tapers of the various AGPs, as well as the tip and taper differences between the AGPs and the instruments, were analyzed using descriptive statistics. The tapers of the AGPs were subject to the American National Standards Institute/American Dental Association No. 57 standard. The Odous de Deus extra-long medium and extra-long extra-medium AGPs were shown to be compatible with Mtwo, K3, and ProDesign Logic instruments with taper 0.06 and tip sizes 25 and 30, while the Dentsply fine and fine medium cones were compatible with Mtwo, RaCe, and K3 instruments with conicity of 0.04 and tip sizes 35 and 40.
Conclusions: Both the Odous de Deus and Dentsply commercial brands included 2 AGP models with tip (D3) and taper compatibility with Mtwo, RaCe, K3, and/or Prodesign Logic instruments.

Keywords: Dental equipment; Dimensional measurement accuracy; Endodontics; Endodontic obturation; Gutta-percha

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INTRODUCTION

The outcomes of several studies have shown that effective root canal obturation contributes to the success of endodontic treatment, as well as retreatment [1,2]. Three-dimensional (3D) obturation is the final step in a complex chain of therapeutic procedures involving root canal cleaning, disinfecting, and shaping [3,4]. Gutta-percha has been successfully used as a core filling material for the endodontic space in conjunction with different root canal sealers [4]. Nevertheless, despite advances in endodontics, the hermetic sealing of root canals after biomechanical preparation cannot be achieved [2]. The main challenge inherent to proper root obturation is the complex anatomy and varied morphology of the root canals [5]. Minimizing void and gap formation during root canal obturation is clinically relevant, as sealer shrinkage (even at low levels) may create enough space for bacteria and endotoxins to proliferate [6,7], hindering periapical tissue healing [7,8]. Therefore, successful endodontic treatment depends heavily on the filling materials and obturation techniques used [2,4].

Unlike conventional hand files, rotary and reciprocating instruments are available with several tapers [9]. To reduce the clinical time and properly fill the endodontic space, specific gutta-percha points have also been developed based on the tip and taper of each type of mechanized system [9]. However, in endodontic practice, the mechanized instrumentation protocol may be chosen based on the hybridization of several systems [10,11]. Given this strategy, an interesting option for professionals is to have on hand several types of gutta-percha points for convenient use as master cones. Due to their variable tapers, non-standardized or accessory gutta-percha points (AGPs) are indicated for a variety of root canal preparations involving manual or mechanized instrumentation [12]. Although typically used as accessory cones, AGPs may be used as master cones in various root canal shaping techniques, since the tip may be adjusted with a gauge ruler [13].

According to specification No. 57 of the American National Standards Institute/American Dental Association (ANSI/ADA) [12], an AGP should have a consistent taper variation up to a diameter of 16 mm (D16); however, a divergence of ± 0.005 mm is allowed. Once the tip and taper measurements of an instrument from a mechanized system and the taper of the AGP are known, the tip can be standardized and used as a master cone, ensuring compatibility and adaptation to the root canal preparation. Thus, the purpose of the present study was to evaluate and compare the tip and taper compatibility of AGPs from Odous de Deus and Dentsply-Maillefer with the Mtwo, Reciproc, RaCe, K3, and Prodesign Logic instruments. The hypothesis tested was that the AGP points from both manufacturers would present tip and taper compatibility with all instruments assessed.

MATERIALS AND METHODS

AGPs

The AGPs were randomly selected while in their original packaging. In total, 10 points of each of the 14 models available from the manufacturer Odous de Deus (Belo Horizonte, MG, Brazil) were selected: medium fine (MF), fine (F), fine medium (FM), medium (M), extra-medium (MX), extra-large medium (MLX), medium large (ML), large (L), extra-large (XL), extra-long fine rotary FR (FR [EL]), extra-long fine medium (FM [EL]), extra-long extra-medium (MX [EL]), extra-long medium (M [EL]), and extra-long medium large (ML [EL]).

In addition, 10 points of each of the 4 models available from the manufacturer Dentsply-Maillefer (Ballaigues, Switzerland) were selected: MF, F, FM, and M.

Rotary and reciprocating instruments

To measure AGP compatibility, the following instruments were applied: Mtwo (VDW GmbH, Munich, Germany) – sizes 25/0.06, 25/0.08, 30/0.05, 30/0.06, 35/0.04, 35/0.06, 40/0.04, 40/0.06, and 50/0.04; Reciproc (VDW GmbH) – sizes 25/0.08, 40/0.06, and 50/0.05; RaCe (FKG Dentaire, La Chaux-de-Fonds, Switzerland) – sizes 30/0.04, 35/0.04, 35/0.06, 40/0.04, and 50/0.04; K3 (Sybron/Kerr, Orange, CA, USA) – sizes 25/0.04, 25/0.06, 25/0.08, 30/0.04, 30/0.06, 35/0.04, 35/0.06, 40/0.04, 40/0.06, 45/0.04, 45/0.06, 50/0.04, and 50/0.06; and ProDesign Logic (Easy, Belo Horizonte, MG, Brazil) – sizes 25/0.06, 25/0.08, 30/0.05, 35/0.05, and 40/0.05.

Point diameter measurement

Before measurement, the AGPs were kept refrigerated (16°C ± 2°C) to avoid deformation (shrinkage and/or expansion) of the specimens. All AGPs were measured with a vertical profile projector analyzer (PJ-A3000; Mitutoyo Europe GmbH, Neuss, Germany), with an accuracy of 0.001 mm (resolution, 1° or 0.01°; range, ± 360°), to obtain accurate and reproducible results according to the protocol established in specification No. 57 of the ANSI/ADA [12]. The points were placed on the equipment projection table (**Figure 1**). The Y pointer was used for the vertical measures and the X pointer for the horizontal measures. For calibration, initial measures were taken starting 3 mm from the tip (D3), with D3 considered the point tip. Then, the diameter was recorded at each millimeter from D3 to D16 under ×10 and ×20 magnification [14]. After the diameters of all 10 points of each model were recorded, the average and standard deviation values were calculated, and the tapers of the points were then established.

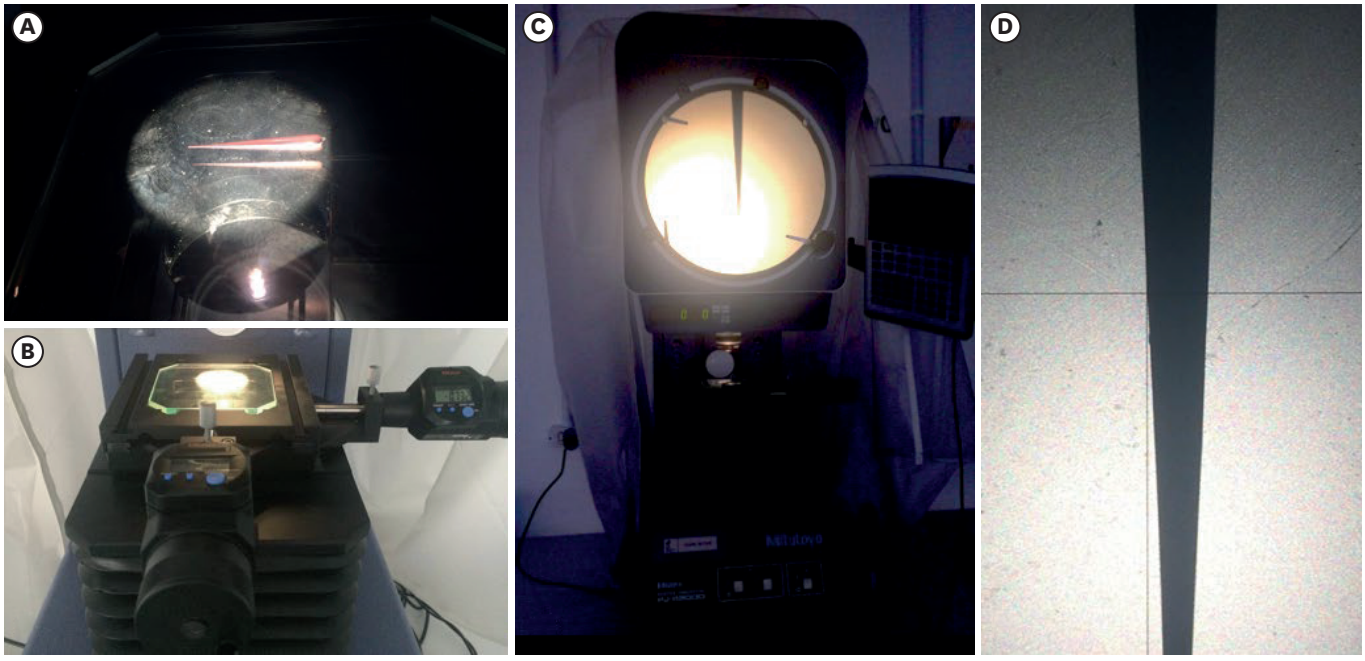

Figure 1. Measurement of accessory gutta-percha points.
(A) Cone positioned on the projector table. (B) Projector table and X and Y digital counters. (C) Profile analyzer model PJ-A3000, Mitutoyo American Corporation. (D) Cone projection screen with X and Y axes.

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3D models

Based on the mean diameters obtained from each AGP model, 3D point models were designed with Autodesk® Fusion 360 (Autodesk Inc., Mill Valley, CA, USA). Similarly, 3D models of each file selected for this study were designed based on the tip and taper values provided by their respective manufacturers. The 3D models of the points and files were overlapped in the software, generating all possible combinations; this enabled an examination of whether the 3D point shapes matched the shapes of the files to determine compatibility. To be considered compatible, the AGP taper had to be the same size or smaller than the instrument, with a maximum difference of 0.005 mm, while the AGP tip also had to be the same size or smaller than the instrument, but with a maximum difference of 0.05 mm.

Statistical analysis

Data corresponding to the tips and tapers of the AGPs, as well as the tip and taper differences between AGPs and instruments, were tabulated in SPSS version 21.0 (IBM Corp., Armonk, NY, USA) and analyzed using descriptive statistics.

RESULTS

Tables 1 and **2** show the average diameters (D3 and D16) and tapers of all AGP models from both manufacturers (Odous de Deus and Dentsply-Maillefer, respectively). AGP tapers were uniform along the entire lengths of the points for both manufacturers, complying with ANSI/ADA specification No. 57 [12]. Furthermore, while small variations in diameter existed

Table 1. Mean diameters (D3 and D16), SD, and taper of AGPs from Odous de Deus

AGP	D3 (mm)	D16 (mm)	Taper (mm)
	Mean ± SD	Mean ± SD	
MF	0.19 ± 0.026	0.74 ± 0.007	0.042
F	0.20 ± 0.014	0.80 ± 0.043	0.046
FM	0.22 ± 0.011	0.95 ± 0.036	0.056
MX	0.22 ± 0.021	0.97 ± 0.040	0.057
M	0.25 ± 0.025	1.12 ± 0.014	0.067
MLX	0.40 ± 0.055	1.27 ± 0.017	0.067
ML	0.29 ± 0.017	1.37 ± 0.034	0.084
L	0.32 ± 0.027	1.55 ± 0.063	0.095
XL	0.33 ± 0.023	1.67 ± 0.028	0.103
FR (EL)	0.18 ± 0.014	0.75 ± 0.020	0.044
FM (EL)	0.21 ± 0.005	0.95 ± 0.025	0.057
MX (EL)	0.22 ± 0.022	1.00 ± 0.020	0.060
M (EL)	0.26 ± 0.032	1.05 ± 0.015	0.061
ML (EL)	0.26 ± 0.039	1.11 ± 0.048	0.066

SD, standard deviation; AGP, accessory gutta-percha point; MF, medium fine; F, fine; FM, fine medium; M, medium; MX, extra-medium; MLX, extra-large medium; ML, medium large; L, large; XL, extra-large; FR (EL), extra-long fine rotary; FM (EL), extra-long fine medium; MX (EL), extra-long extra-medium; M (EL), extra-long medium; ML (EL), extra-long medium large.

Table 2. Mean diameters (D3 and D16), SD, and taper of AGPs from Dentsply-Maillefer

AGP	D3 (mm)	D16 (mm)	Taper (mm)
	Mean ± SD	Mean ± SD	
MF	0.30 ± 0.006	0.67 ± 0.006	0.028
F	0.34 ± 0.011	0.83 ± 0.010	0.038
FM	0.38 ± 0.014	0.90 ± 0.015	0.040
M	0.44 ± 0.009	1.13 ± 0.009	0.053

SD, standard deviation; AGP, accessory gutta-percha point; MF, medium fine; F, fine; FM, fine medium; M, medium.

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Table 3. AGP models from Dentsply-Maillefer (italic type) and Odous de Deus (non-italic type) with tip and taper compatible with files from different systems

Mtwo	AGP	Reciproc	AGP	RaCe	AGP	K3	AGP	ProDesign Logic	AGP
25.06	MX (EL)	25.08	-	30.04	-	25.04	-	25.06	MX (EL)
25.08	-	40.06	-	35.04	*F*	25.06	MX (EL)	25.08	-
30.05	-	50.05	-	35.06	-	25.08	-	30.05	-
30.06	M (EL)			40.04	*FM*	30.04	-	35.05	-
35.04	*F*			50.04	-	30.06	M (EL)	40.05	-
35.06	-				-	35.04	*F*		
40.04	*FM*					35.06	-		
40.06	-					40.04	*FM*		
50.04	-					40.06	-		
						45.04	-		
						45.06	-		
						50.04	-		
						50.06	-		

AGP, accessory gutta-percha point; F, fine; FM, fine medium; MX (EL), extra-long extra-medium; M (EL), extra-long medium.

for each point model, all fell within the limits allowed by the specification standard except Odous de Deus model L, which had a diameter variation of 0.063 mm.

Table 3 shows the tip and taper compatibility of the AGP models and files. After overlapping the 3D models, we verified that both manufacturers, Odous de Deus and Dentsply-Maillefer, had 2 models of AGP points with tip (D3) and conicity compatible with various mechanical instruments. The Odous de Deus points M (EL) and MX (EL) were compatible with the Mtwo, K3, and ProDesign Logic instruments with conicity of 0.06 and tip sizes 25 and 30; more specifically, they were compatible with the sizes 25/0.06 (Mtwo, K3, and Prodesign Logic) and 30/0.06 (Mtwo and K3) files, respectively. The Dentsply-Maillefer points F and FM were compatible with the Mtwo, RaCe, and K3 instruments with conicity of 0.04 and tip sizes 35 and 40; more specifically, they were compatible with the sizes 35/0.04 (Mtwo, K3, and RaCe) and 40/0.04 (Mtwo, K3, and RaCe) files, respectively. The rotary instruments Mtwo and K3 had the highest number of instruments compatible with the AGPs. No Reciproc instruments were compatible with the AGPs.

DISCUSSION

Based on the present results, the tested hypothesis was partially rejected, since only 2 AGP models from Odous de Deus and 2 AGP models from Dentsply-Maillefer presented tip and taper compatibility with 11 instruments from the different systems. No AGP was compatible with the Reciproc instruments.

Root canal obturation with gutta-percha points and sealer is typical in endodontics [1,15]. For this treatment step to succeed, some important clinical details must be understood, such as the final measurement of the root canal after shaping and the tip and taper of the instrument last used [13,14]. Therefore, a gutta-percha point compatible with the tip and taper of the last instrument may be used as a master cone for root canal obturation [13,14]. However, if the point tip is not properly adapted to the apical region, the root canal sealing will be compromised, as the apical region may be filled with sealer only [6,15]. In this scenario, the sealer contacts the periapical fluids and may disintegrate and become solubilized over time, allowing reinfection of the site [16]. Furthermore, non-adaptation

of the master cone may facilitate sealer extrusion into the periapical region, triggering an inflammatory process or directly injuring the adjacent tissues [17,18].

In addition to the difficult task of obturating the apical region, proper sealing of the root canal walls is desired [19]. The more gutta-percha compacted against the root canal walls, the less thick the sealer film [19]. Consequently, the risk of reinfection [1] due to shrinkage of the filling material is lower [6,7]. Root canal obturation using a master cone with the same tip and taper as the final instrument used for shaping ensures a faster and more efficient execution of this clinical step [19]. Moreover, smaller quantities of accessory points and sealer are used in this process, enabling more solid and compact obturation [19].

As such, in the present study, the AGP tip diameter and taper were evaluated for application in clinical practice as a master cone after root canal cleaning and shaping when using various rotary and reciprocating instruments. Thus, the AGP tips and tapers were measured at D3 (3 mm from the actual tip), as at this point, the AGP tip and taper were assumed to be more compatible with the dimensions of the instrument. Superimposition of 3D models in Autodesk 360 facilitated the determination that 4 AGP models had tip and taper compatibility with 11 different instruments. According to ANSI/ADA specification No. 57 [12], the tip diameter and taper of each AGP model must be established by its manufacturer. The same standard also establishes that the point taper must be uniform along its entire length, with a maximum variation of ± 0.005 mm, which allows it to be precisely and consistently used in root canal obturation. An AGP that is compatible with the root canal ensures the replicability of its application along with the chosen mechanized instrumentation system.

Other than ANSI/ADA specification No. 57 [12], no standards exist describing or regulating the specifications of AGPs. This may be a limitation, as both manufacturers evaluated in this study used the same nomenclature (such as MF, F, FM, and M) for the same point models, but with different tip and taper values established by each. This may cause mistakes in clinical practice.

Although compatible with Mtwo, K3, and ProDesign Logic instruments, in most AGP models from Odous de Deus, the D3 measurement was smaller than 0.30 mm. According to some authors, ideal obturation is achieved when apical preparation is performed using instruments with tips larger than 0.35 mm [20,21]. In contrast, other AGP models with D3 greater than 0.30 mm presented greater taper values, ranging from 0.067 to 0.103 mm; this generates excessive wear at the middle and cervical thirds of the root canal, making the tooth more susceptible to fracture [22]. Conversely, a greater taper may be useful in specific and complex cases in which cervical enlargement is necessary, such as endodontic reintervention or incomplete root canal development [23,24]. Additionally, the EL models have a mean length of 34 mm, facilitating their use for teeth with long root canals. In turn, no Dentsply-Maillefer AGP had a D3 value smaller than 0.30 mm or a taper greater than 0.053 mm, allowing for superior root canal shaping in most cases requiring endodontic treatment [20,21].

One of the most critical limitations affecting AGP customization and posterior adaptation to the root canal walls is the deviation between No. 57 and No. 58 ANSI/ADA specifications [12,25]. According to specification No. 58 [25], the allowed diameter variation of the tip and taper of instruments is ± 0.02 mm. However, for AGPs, specification No. 57 [12] establishes that D3 and D16 may vary by ± 0.05 mm. Therefore, a failure in AGP adaptation of greater than 0.07 mm is possible, even when the cone and instrument theoretically have the same tip and taper measurements.

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As laboratory research, the present study has limitations. Further *in vitro* studies using different methods of analysis, such as laser scan micrometry, stereomicroscopy, and microcomputed tomography imaging, should be performed to assess AGP compatibility with different mechanized instrumentation systems.

In-depth knowledge regarding instruments and materials used in the various steps of endodontic treatment is essential for clinical practice, particularly when clinicians desire to hybridize different mechanized systems in a single treatment [10,11]. Therefore, the specificities of endodontic therapy, such as the characteristics of the infection, the root canal morphology, treatment costs, and time spent during root canal management, must be considered [1].

CONCLUSIONS

Within the methodology of the present *in vitro* study, the Odous de Deus MX (EL) and M (EL) AGPs were compatible with the sizes 25/0.06 and 30/0.06 instruments, respectively, of the Mtwo, K3, and ProDesign Logic systems. The Dentsply-Maillefer F and FM AGPs were compatible with the sizes 35/0.04 and 40/0.04 instruments, respectively, of the Mtwo, K3, and RaCe systems. In the future, evaluation of the tips and tapers of AGPs from other commercial brands would also be interesting, as this will allow the AGP compatibility to be determined with additional instrumentation systems, enabling the wider application of these AGPs in endodontic treatment.

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