Diameter and Taper Variability of Single-File Instrumentation Systems and Their Corresponding Gutta-percha Cones

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Abstract

Introduction: Manufacturers offer single-file instrumentation systems with matching gutta-percha (GP) cones to simplify root canal preparation and obturation. The purpose of this study was to determine whether file diameters and tapers match with corresponding cone diameters and tapers (precision) as well as industry standards (accuracy). **Methods:** Twenty files and corresponding GP cones from each size of F360 (#25, #35, #45, #55 with .04 taper) and Reciproc (#25, #40, #50 with variable tapers) instruments were examined by using optical microscopy (×32) to determine their diameter and taper. Precision was evaluated by using one-way analysis of variance (α = 0.05) with Scheffé post hoc tests and *t* tests with Bonferroni correction. Accuracy was calculated by subtracting the nominal values from the measured values of all files and GP cones, and mean diameter and taper differences were compared by using one-way analysis of variance (α = 0.05) and Scheffé post hoc test for pairwise comparison. **Results:** For F360, the majority of file and cone diameters were within the tolerance levels, but most of the file diameters were significantly larger than GP cone diameters ($P < .05$), but the majority of all measured values were within the tolerance levels. For Reciproc, file and cone diameters at D1 and D3 mostly approached the nominal values. At the coronal end, file diameters #25 and #50 were significantly smaller than cone diameters ($P < .05$). For both instrumentation systems, almost all file and cone tapers matched with the preset tolerance ranges. For Reciproc, significant differences between file and GP cone demonstrated either smaller cone or smaller file diameters and tapers, depending on the size. Most of the measured values were within the acceptable range, but diameters at the coronal end exhibited the highest percent difference from the nominal values. **Conclusions:** Despite the call for standardization, variability in diameter and taper dimensions between single-file instrumentation systems and their corresponding GP cones can be expected. *(J Endod 2018;■:1–6)*

Key Words

■■■

Significance

The aim was to determine diameters and tapers of single-file instrumentation systems and their corresponding cones. Although most dimensions are within the specifications, dentists should be aware of dimensional variability, and cone fitness should be verified after instrumentation with single-file systems before obturation.

Rotary endodontic nickel-titanium (NiTi) instruments were introduced several years ago and have revolutionized the ability of shaping root canals to allow effective disinfection and adequate root canal obturation (1). After root canal preparation and disinfection, the aim of the root canal filling is to create a sufficient seal to prevent reinfection (2, 3). This is best achieved when files and gutta-percha (GP) cones are manufactured to the same standard. Previously, a lack of standardization of root canal instruments as well as GP cones has been reported (4–6). In 1975, the International Organization for Standardization (ISO) formulated specification 3630-1 for root canal instruments, which was updated to the latest version in 2008 (7). In addition, in 1976 the American National Standards Institute/American Dental Association (ANSI/ADA) established specifications for endodontic files (8), which were updated in 1981 to require a 0.02 taper (9) and then again in 2001, allowing a taper tolerance of ±0.05 (10). The 2 current standards specifications for dental obturating cones are ISO 6877, published in 1995 (11), and ANSI/ADA Specification No. 78, published in 2000 (12).

F360 (Komet Dental, Lemgo, Germany) and Reciproc (VDW, Munich, Germany) have been introduced as single-file NiTi instrumentation systems with corresponding GP cones to facilitate root canal filling. Four different sizes for F360 and 3 sizes for Reciproc are available. According to the manufacturer, the GP cone diameters and tapers match with those of the file. However, even if the manufacturers produce their products according to the current standards, there is still a diameter tolerance of ±0.02 mm for files up to size #60 and ±0.04 mm for files larger than size #60 (8). The allowed tolerance levels for GP cones vary from 0.05 mm to 0.07 mm, depending on the cone

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size (12). For taper, the tolerance is ±0.05 mm for any size of both file and GP cone (10, 12).

Several studies have been conducted on the variability of hand files with 0.02 taper (4, 13, 14), rotary endodontic instruments with larger taper (2, 15–17), and also on the variability of GP cones (15, 18), demonstrating that diameter and taper may vary significantly among most brands. Analysis of ProTaper Next #25/.06 and WaveOne #25/.08 GP cones (Dentsply Sirona, Ballaigues, Switzerland) indicated significantly larger cone diameters than their corresponding files (19). However, none of these investigations examined all available sizes of single-file instrumentation systems and measured each millimeter of cone and file diameters of multiple tapered systems.

F360 and Reciproc are well-investigated with regard to cutting efficiency, canal shaping, extrusion of debris, and fracture resistance (20–26), but there is a lack of information concerning the congruence between file and corresponding cone. Therefore, the aim of the present study was to determine whether all available sizes of these 2 single-file instrumentation systems were within the industry standard for the diameter and taper (accuracy) and whether the rotary file diameters and tapers match with the corresponding cones (precision). Because of the multiple tapers, measurements for Reciproc were performed at 1-mm intervals from the tip.

The null hypotheses tested were that NiTi files match with their corresponding GP cones and that diameter and taper of files and GP cones correspond to the nominal values listed by the manufacturer.

Materials and Methods

NiTi rotary files and corresponding GP cones from 2 different single-file instrumentation systems, F360 (#25, #35, #45, #55 with .04 taper) and Reciproc (#25, #40, #50 with variable tapers), were used for this study (Table 1).

For each size, 20 files and 20 matching cones were selected for measuring diameter and taper. On the basis of preliminary tests, an absolute measuring error of 10 μm was determined. Each sample was secured in the horizontal axis of a measuring table, and digital images (Canon EOS 1100D; Canon Inc, Tokyo, Japan) were taken under the view of an optical microscope (Stemi SV11 Apo; Zeiss, Oberkochen, Germany) at ×32 magnification using the corresponding software (SPOT Basic Image Capture Software, Burroughs, MI). The images were calibrated to a pixel size of 2.6 μm, and diameter dimensions were determined using the software Axio Vision (Zeiss) according to the guidelines outlined in ANSI/ADA Specification No. 101 (10). Specimens were stored at 20°C ± 5°C for 10 hours before measurement. The error of the measurement was determined by a preliminary test where 1 file and 1 cone were measured several times and photographed, and the image was measured 10 times at D1, D3, and D16 by the same examiner with renewed positioning under the microscope and analysis in Axio Vision software, resulting in a. The standard error was 100.4 μm.

According to the specifications, the nominal diameters are measured at D0, D3, and D16. In the present study, measurements were carried out at D1 instead of D0, because it was impossible to make reliable measurements at D0. For F360, tapers were determined according to Lask et al (2) by using diameters at D3 and D16 (Taper = Diameter (D16 – D3)/(Distance DL16 – D3L3), with D representing diameter and L distance from D0 reference. This equation is also defined in the ISO 3630-1 protocol for obtaining file taper from the measured file diameters D3 and D16 (7). Because of their multiple tapers, diameters of Reciproc files and cones were measured each millimeter from the tip, which resulted in 15 different tapers over

TABLE 1. Precision of File and Corresponding GP Cone Diameters

Single-file system	Size	Measuring point	$P < .05$	Interpretation	Size	Measuring point	$P < .05$	Interpretation	Size	Measuring point	$P < .05$	Interpretation
F360	#25/.04	D1	*	file > cone	#35/.04	D1	*	file > cone	#45/.04	D1	*	file > cone
		D3				D3	*	file > cone		D3	*	file > cone
		D16	*	file > cone		D16	*	file > cone	#50	D16	*	**file < cone**
Reciproc	#25	D1			#40	D1	*	file > cone		D1		
		D2				D2	*	file > cone		D2		
		D3	*	file > cone		D3	*	file > cone		D3		
		D4				D4	*	file > cone		D4		
		D5				D5	*	file > cone		D5		
		D6				D6	*	file > cone		D6		
		D7				D7	*	file > cone		D7		
		D8				D8	*	file > cone		D8		
		D9				D9	*	file > cone		D9		
		D10				D10	*	file > cone		D10		
		D11				D11	*	file > cone		D11		
		D12				D12				D12		
		D13				D13				D13		
		D14	*	**file < cone**		D14				D14	*	**file < cone**
		D15	*	**file < cone**		D15				D15	*	**file < cone**
		D16	*	**file < cone**		D16				D16	*	**file < cone**

Interpretations in bold demonstrate significantly smaller file diameters than cone diameters.
*Significant differences ($P < .05$) between file and cone diameter.