



The Intra-Manufacture Diameter Variability of Rotary Files and Their Corresponding Gutta-Percha Cones Using Laser Scan Micrometer

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ABSTRACT

Introduction: As an attempt to simplify the obturation process and create a tight seal, manufacturers offer gutta-percha (GP) cones matching different sizes of endodontic files. The purpose of this study was to evaluate whether intra-manufacture GP diameters matched the diameters of their corresponding files at different horizontal levels of the canal. **Methods and Materials:** Twenty files and corresponding GP master cones of Reciproc R 40/0.08 (VDW, Munich, Germany), WaveOne Large (40/0.08) (Dentsply Maillefer, Ballaigues, Switzerland), ProTaper F3 (30/0.09) (Dentsply Maillefer, Ballaigues, Switzerland), and Mtwo (40/0.06) (VDW, Munich, Germany) were examined using laser micrometer (LSM 6000 by Mitutoyo, Japan) with accuracy of 1 nm to establish their actual diameter at D₀, D₁, D₃ and D₆. Data were analysed using the independent *t*-test. The differences were considered as significant for *P*<0.05. **Results:** The diameter of GP master cones was significantly larger than the corresponding files at all levels with all the above brands. ProTaper GP diameter were closest to the file diameter at D1 (GP=0.35, File=0.35 mm), and D3 (GP=0.48, file=0.49). **Conclusion:** This *in vitro* study showed that within the same manufacturer GP cone diameters do not match the diameters of their corresponding files.

Keywords: Diameter; Gutta-percha Cone; Laser Scan Micrometer; Rotary File; Taper

Introduction

Successful endodontic treatment is based on correct diagnosis, canal debridement and disinfection, obturation and coronal restoration [1]. Good sealing reduces coronal leakage and bacterial contamination, stops influx of periapical tissue fluids and entombs the remaining irritants and surviving bacteria in the canal, where they will die [2-6]. The most common method to fill the prepared canal space is obturating the root canal system (RCS) with gutta-percha (GP) and sealer.

Nickel-titanium rotary files were introduced to endodontics more than two decades ago [7-10]. These files usually have a grater taper than hand instruments [11-13]. Nowadays manufactures offer a plethora of nickel-titanium rotary systems classified by different features (*e.g.* tip-design, cross-section, cutting edge, tapers, diameter, composition, movement).

The preferred filling method is subject to much debate and research. The single cone technique attracted the attention of many investigators because of its speed and effectiveness. Although a perfect match between instrumented canal and GP cone is impossible, if size and taper of the master cone significantly differs from the area prepared by the master file, insufficient obturation may result. Ideally, GP cones should closely match the diameter and taper of the last instrument used to the working length.

Previous studies reported variability in actual sizes of GP [14] and files [11, 15] among different endodontic systems. Chesler *et al.* [16] evaluated the diameter and taper of rotary instruments and their corresponding GP cones within the same manufacturer using scanning electron microscopy (SEM). They observed highly significant differences between file and GP cone regarding their tapers and diameters. However, the use of SEM



Figure 1: Travel crossed roller table connected to a micrometre perpendicular to the scanning laser beam of a laser scan micrometer (LSM 6000, Mitutoyo, Japan). D_0 level was established as a first reading achieved by LSM, where the specimens touched the laser beam; consequently, specimens were moved manually using micrometre ruler for further measurements

to evaluate the dimensional change especially for a thermoplastic material like GP has its own drawbacks due to the special thermal and pressure conditions in the SEM chamber that could influence dimension of GP cones.

A laser-scan micrometer (LSM) system was previously used to measure the diameter changes of different dental materials [17-20]. The device displays the specimen dimensional data rapidly and accurately using a highly directional parallel-scanning laser beam. LSM is a non-destructive, non-contact measuring system, which combines high rate scanning with a highly accurate measurement (0.00001 mm) [21]. A laser beam is directed at a polygonal mirror rotating at high speed in exact synchronism with highly stable pulses from the system clock. The reflected beam is rotating clockwise as it sweeps across the input surface of a collimating lens but changes direction to be always horizontal after the lens' exit surface as it moves, or scans, downward. This horizontal beam enters the measuring space and, with no work piece present, reaches a receiver *via* a condensing lens to produce an output signal. When a simple work piece (a GP cone, for example) is put into the measuring space, the beam will be interrupted for a time during its sweep and this time, as indicated by clock pulses occurring while the receiver signal is absent, is proportional to the work piece dimension in the downward direction.

To date, there are no published papers comparing diameters of nickel-titanium rotary files including those with reciprocating

motion, to matching GP cones with the use of LSM as a non-destructive method. The aim of this study is to evaluate the diameter of four brands of rotary files and their adjusting GP cones, using LSM.

Materials and Methods

The following rotary files and their corresponded GP cones were investigated: Reciproc (R 40/0.08, VDW, Munich, Germany) WaveOne Large (#40/0.08, Dentsply Maillefer, Ballaigues, Switzerland), ProTaper (F3 30/0.09, Dentsply Maillefer, Ballaigues, Switzerland) and Mtwo (#40/0.06, VDW, Munich, Germany). Based on pilot data and a power analysis, it was determined that 20 specimens from each brand would meet the constraints of $\alpha=0.05$ and power=0.80. After receiving the materials, they were conditioned at $23\pm 2^\circ\text{C}$ and $50\pm 5\%$ humidity.

Rotary file and GP cone measurement

Specimens were randomly assigned a number between 1 to 160 in order to keep the operator blind during the measurement process. Specimens were mounted on a special jig using prepared impression of composite (Z250, 3MSPE, Germany). Jig was settled on a travel crossed roller table connected to a micrometre (148-104, Mitutoyo, Japan) with accuracy of 0.1 μm perpendicular to the scanning laser beam of a laser scan micrometer (LSM 6000, Mitutoyo, Japan) in order to obtain accurate reproducible results (Figure 1). Diameters (D) were measured at four levels of 0, 1, 3 and 6 mm from the tip of the files or cones. D_0 level was established as a first reading achieved by LSM, where the specimens touched the laser beam. Consequently, specimens were moved manually using micrometre ruler for further measurements (Figure 1). All the measurements were performed at room temperature of 23 ± 2 degree and normal humidity ($50\pm 5\%$).

Statistical analysis

Shapiro-Wilk normality test revealed that data were normally distributed. The comparisons between files and GP cones diameters were analysed with the independent *t*-test using SPSS/PC version 17 (SPSS Inc., Chicago, IL, USA). The differences were considered as significant for $P<0.05$ and highly significant for $P<0.01$.

Table 1. Diameter measurements of four endodontic systems at four levels: 0, 1, 3 and 6 mm

Level of measurement	0 mm		1 mm		3 mm		6 mm	
File system and reported size	File (SD)	GP (SD)*	File (SD)	GP (SD)*	File (SD)	GP (SD)*	File (SD)	GP (SD)*
Mtwo (40/0.06)	0.09 (0.03)	0.28 (0.01)	0.34 (0.07)	0.50 (0.03)	0.47 (0.09)	0.60 (0.03)	0.62 (0.11)	0.79 (0.02)
ProTaper F3 (30/0.09)	0.12 (0.01)	0.18 (0.01)	0.34 (0.00)	0.35 (0.02)	0.47 (0.01)	0.48 (0.03)	0.61 (0.01)	0.67 (0.03)
WaveOne Large (40/0.08)	0.09 (0.00)	0.25 (0.00)	0.40 (0.02)	0.49 (0.02)	0.53 (0.02)	0.60 (0.03)	0.66 (0.01)	0.76 (0.03)
Reciproc (40/0.08)	0.09 (0.00)	0.23 (0.01)	0.30 (0.02)	0.47 (0.02)	0.47 (0.02)	0.56 (0.02)	0.63 (0.06)	0.68 (0.02)

* The intra-manufacture diameters of GP cones were significantly higher than the corresponding files ($P<0.0001$)

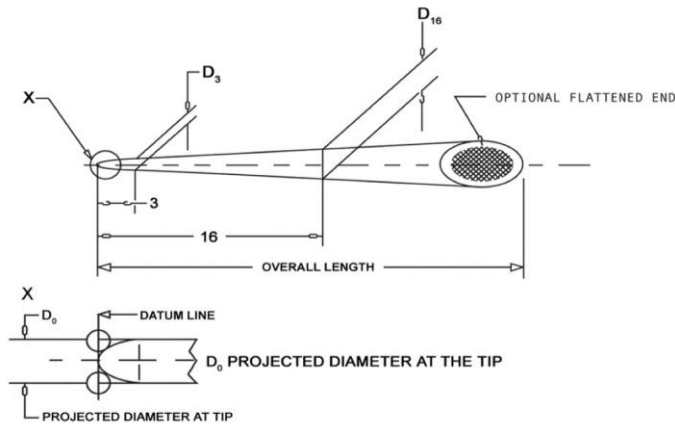


Figure 2: Diagram representation of tapered sized cones and measurement sites for diameter (D_0) (Adapted from ANSI/ADA specification No. 78)

Results

The diameters of GP cones were significantly larger than the diameters of corresponding files at all levels for all brands (Table 1). For each tested brand, the independent t -test revealed highly significant differences ($P < 0.0001$) between GP cone diameter and corresponding file at all measurement levels. The intra-manufacture mean differences for diameter at D_1 were 0.17 ± 0.04 , 0.003 ± 0.01 , 0.1 ± 0.003 , 0.17 ± 0.005 for Mtwo, ProTaper, WaveOne, and Reciproc, respectively. WaveOne Large revealed the best match with the manufacture claimed size at D_1 (40 ± 0.02). Despite a significant difference between GP cones diameters and their corresponding files, ProTaper F3 showed a better match considering the measurements at different levels (D_1 , D_3 and D_6).

Discussion

Previous studies of dimensional variability of GP cones and files, used a measuring microscope according to the protocol outlined in ANSI/ADA specifications No. 78 [9-10] or SEM according to ANSI/ADA specifications No. 101 [11]. This is the first investigation using LSM to study the diameter variability of rotary systems.

LSM could be used under controlled environmental conditions such as temperature, humidity and pressure. GP cones are partially crystalline viscoelastic polymeric materials and any environmental change may cause a dimensional variation. Hence the use of SEM could bring flaws into the accuracy of the data, as cones should be saturated and later be placed in the SEM chamber under a high pressure.

Thanks to the LSM, in the current study diameter could be measured at 0 mm level, however, in a recent article Chesler *et al.* [11] were unable to measure the diameter at the tip of the files or GP cones under SEM and therefore they provided the data from the D_1 . Two studies reported data for D_0 using measuring microscope, which meets the ANSI/ADA specifications (Figure 2), while it's not the diameter at the tip [9-10]. Considering the data from the current study the manufactures' provided size will actually corresponded to D_1 and not D_0 . It may not be clinically important but may need a revision on definition of D_0 , especially for the manufactures' reported specifications.

Previous studies investigated the taper of the files and found most examined files had taper measurement smaller than the nominal taper [9-11]. However, in the current study tapering of the specimens was not reported, as ProTaper and WaveOne have variable tapers with no clear industry standard.

In this study GP cones were always larger than the corresponding file in diameter at each level, which is in agreement with the study by Chesler *et al.* [11]. Although these findings might not be a significant problem for the skilled endodontist, the inexperienced clinician may find it frustrating and time consuming. This is especially true as fitting master cones larger than the master file result in premature binding or poor adaptability of GP to the canal walls, and consequently shorter fillings. Since the length of the root canal filling is an outcome predictor for endodontic treatment, the importance of a well fitted master cone is obvious [1, 22].

The diameter variability of GP cones may be caused by the high plasticity of GP. Despite standard procedures during manufacturing and packing, mechanical deformation can occur. Likewise during transportation and storage due to temperature extremes shrinkage or/and expansion can result. GP master cones are better kept refrigerated, however there seems to be a lack of information on influence of environmental changes such as temperature on GP cones.

Variability between nickel-titanium rotary file and GP cone sizes exists within tested manufacturers' systems. Therefore clinicians should respect individual root canal anatomy and choose a master cone based on the clinical result of the instrumentation and not on the advertised size. Clinicians are still advised to check if the master GP cone fits using radiographs, and in case of miss-match they can use a smaller size tip diameter and use a GP gauge to cut the tip to the appropriate diameter.

Conclusion

Within the same manufacturer GP cone diameters do not match the diameters of their corresponding files.

Conflict of Interest: 'None declared'.

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