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Comparison of Vertical Forces during Root Canal Filling with Three Different Obturation Techniques

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A B S T R A C T

The aim of this study was to examine and compare vertical forces exerted during root canal obturation with the cold lateral condensation technique, Thermafil technique and ProTaper guttapercha. Fourty-five single-rooted permanent teeth were used in the study. All specimens were instrumented using the ProTaper rotating technique and were randomly divided into three experimental groups (n=15 per group). In the first group, root canals were obturated using the cold lateral condensation technique. In the second group, the Thermafil technique was used to obturate root canals. In the last group, a ProTaper gutta-percha of the same taper as the instrumented root canals was used for root canal obturation. Vertical forces were measured using the device developed for simulation of endodontic treatment. The results showed a statistically significant difference (p=0.0001) for vertical forces when cold lateral condensation obturation technique was used in comparison to other techniques. No statistically significant difference was found for vertical forces during obturation with Thermafil and ProTaper gutta-percha (p=0.16). The cold lateral condensation technique exerted higher vertical forces in comparison to the Thermafil and ProTaper obturation techniques.

***Key words**: lateral condensation, vertical force, root canal obturation*

Introduction

For eradication of bacteria causing periradicular infections, extended endodontic chemo-mechanical treatment is required. Purpose of the root canal obturation as the final step of an endodontic treatment is to create an adequate seal, preventing survival or growth of bacteria in the root canal[1–3].

Different root canal obturation techniques have been developed. Most of the techniques available combine gutta-percha with sealer. Sealer fills the gaps between gutta-percha point and root canal walls, simultaneously obturating lateral and accessory canals[4]. Gutta-percha has the property to compact under pressure and soften when heated, which is essential for adequate root canal obturation[5].

The most common technique used for root canal obturation is the cold lateral condensation technique[6–9]. In order to condense gutta-percha points inside the root canal, nickel titanium (NiTi) or stainless steel spreaders are used. NiTi spreaders penetrate deeper into the curved canals, transfer forces more equally to the canal walls and generate less stress on the tooth structure[10,11]. Finger spreaders generate lower forces than the hand ones[12]. High forces could result in vertical root fracture, but on the other hand, if the exerted forces are too low, gutta-percha will not deform and obturation of the root canal will fail[13].

Vertical root fracture is longitudinally orientated crack extending from the root canal towards parodontium, mostly in vestibulo-oral direction. Vertical root fractures usually appear in endodontically treated teeth and manifest with pain, inflamation, root and bone resorption, inevitably leading to tooth loss[14,15]. Spreader design, speed of penetration and loading force, canal flare and root dimensions may affect the formation of vertical root fractures[16–18].

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According to Meister et al.[19], 84% of all vertical root fractures are caused by forces exerted during gutta--percha condensation. Values ranging from 1–3 kg are generally accepted as safe when condensing gutta-percha and vertical fractures will not occur[16,20,21]. However, vertical fracture may not occur during condensation of gutta-percha. During condensation of gutta-percha, microscopical fractures may appear inside the tooth structure. These microfractures weaken the tooth and make it prone to the full scale fracture sometime in the future, during mastication or tooth restorative procedures. The period in which the vertical tooth fracture may occur can range up to 2,5 years[15].

The purpose of this study was to examine and compare vertical forces exerted during root canal obturation using the cold lateral condensation technique, Thermafil and Single cone technique.

Materials and Methods

Preparation of specimens

Forty five anterior permanent human teeth extracted for periodontal reasons were used in the study. After extraction, teeth were stored in 10% formaline solution. Extraneous tissue and calculus were removed using curettes and teeth were stored in saline prior to instrumentation. The crowns of the teeth were removed using a water-cooled diamond drill. A size #15 K-file (Dentsply Maillefer, Ballaigues, Switzerland) was introduced into each canal until it was just visible at the apical foramen and the working length was determined by withdrawing the instrument 1 mm. All specimens were then shortened using a water-cooled diamond drill (GV878K.314. 014, Diacut, Edenta, Switzerland) to length of 11 mm. The working length was 10 mm for each specimen. The root canals were instrumented with rotating ProTaper instruments (Dentsply Maillefer, Ballaigues, Switzerland). First, S1 and SX instruments were inserted to 2/3 of the working length. After that S1, S2, F1, and F2 were inserted to the full working length. Rotation speed was 300 rpm and the torque was adjusted according to the manufacturer's instructions. During instrumentation, Glyde root canal lubricant (Dentsply Maillefer, Ballaigues, Switzerland) was used. After the use of each file, each canal was irrigated with 2 mL of 2,5% sodium hypochlorite using a disposable syringe and a needle No. 27-gauge needle (BD Microlane 3; BD, Drogheda, Ireland). In order to remove the smear layer, root canals were rinsed with 5 mL of 17% EDTA (pH 7.7) each for 3 min. Final irrigation of the samples was carried out with 2,5% sodium hypochlorite, after which the canals were dried using ProTaper paper points size #25 (Dentsply Maillefer, Ballaigues, Switzerland).

Root canal obturation

The prepared specimens were randomly divided into three experimental groups (n= 15 per group). In the first group, master gutta-percha cone size #25 (VDW GmbH, Munich, Germany) was coated with the AH Plus sealer (DeTrey Dentsply, Konstanz, Germany), gently seated to the full working length and laterally condensed with a stainless steel finger spreader size #25. (VDW GmbH, Munich, Germany) Accessory gutta-percha cones size #25 (VDW GmbH, Munich, Germany), coated with the same sealer, were inserted until the finger spreader no longer penetrated deeper than two millimeters into the mass of gutta-percha.

In the second group, root canals were coated with AH Plus sealer using a size #25 K-file (Dentsply Maillefer, Ballaigues, Switzerland). Thermafil obturator size #25 (Dentsply Maillefer, Ballaigues, Switzerland) was heated in Thermaprep Plus owen (Dentsply Maillefer, Ballaigues, Switzerland) and inserted in the canal to the full working length.

In the third group (Single cone technique), ProTaper gutta-percha point for (Dentsply Maillefer, Ballaigues, Switzerland) size F2 was coated with AH Plus and inserted in the canal to the full working length.

Excess gutta-percha, Thermafil obturator and ProTaper gutta-percha were removed from the coronal cavities with a heated hand plugger ISO 45 (Hu-Friedy, Berhard Quentin GmbH, Leimen, Germany).

The force measurement device

The force measurement device (Figure 1), developed at the Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb, was used to measure vertical forces (Figure 2). The device consists of clamps, body containing four sensors and vacuum pins that elastically attach it to the working desk. One sensor measures compression and tensile forces in vertical direction, while other three independent sensors measure lateral forces in all directions**.** Before test started, the device was calibrated in accordance to manufacturer´s orders with 0,5 kg weight.

High resolution oscilloscope ADC-216 (Pico® technology Limited, St Neots, UK) was used to digitalize ana-

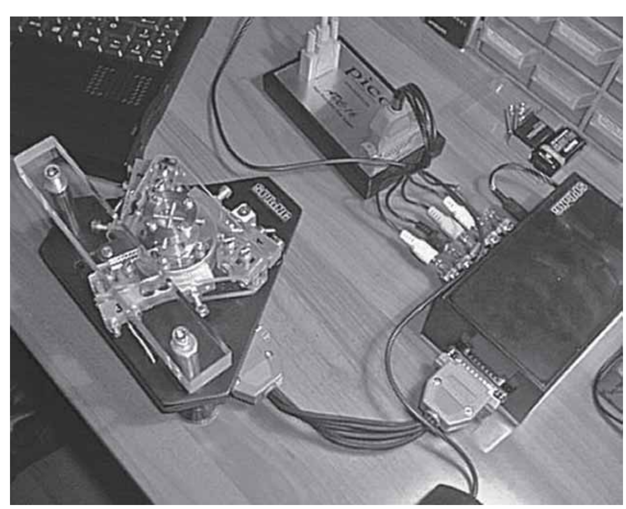

Fig. 1. The measurement device and Pico oscilloscope.

Fig. 2. Lateral condensation of gutta-percha cones in the tooth attached to the measurement device

logue values obtained from the measurement device and save them in both numerical and graphical form on the computer.

Statistical analysis

ANOVA and *post hoc* LSD (least significant difference) test were used for statistical analysis of the vertical forces. The p value was set at 5%.

Results

Figures 3–5 show graphs representing vertical forces exerted during three different obturation techniques.

The force peaks from the measurement of the vertical forces exerted during obturation of every tooth in all three experimental groups were included into the statistical analysis. Maximum vertical force values (peaks) were used to calculate mean force values for the each group. Results are shown in Figure 6.

The results showed a statistically significant difference ($p=0.0001$) for vertical forces when cold lateral condensation obturation technique was used in comparison to other techniques. No statistically significant difference was found for vertical forces during obturation with Thermafil and Single-cone technique ($p=0.16$).

Discussion

Several different methods are used for testing vertical forces that develop during root canal obturation; Instron and Endographe testing devices[5,13,15], photoelastic measurements[22] and finite element analysis[25]. Endographe device has the ability to measure forces as a function of time, while the other methods analyze forces or pressures only at one moment[5,13]. In the present study, a device similar to the Endographe was used to measure vertical forces during obturation. An oscilloscope was plugged to the testing device in order to digitalize measured analogue values and convert them into graphs and numbers.

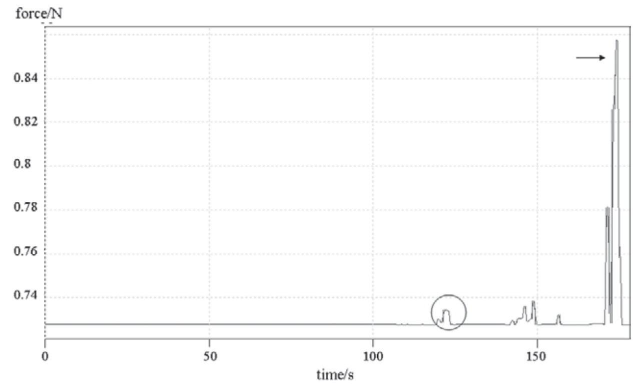

Fig. 3. Encircled peaks shows the moment of the Thermafil gutta-percha cone insertion. Peaks are much lower than ones on the figure 5. Arrow points to the final vertical condensation caused by the plugger (not included in the statistical analysis).

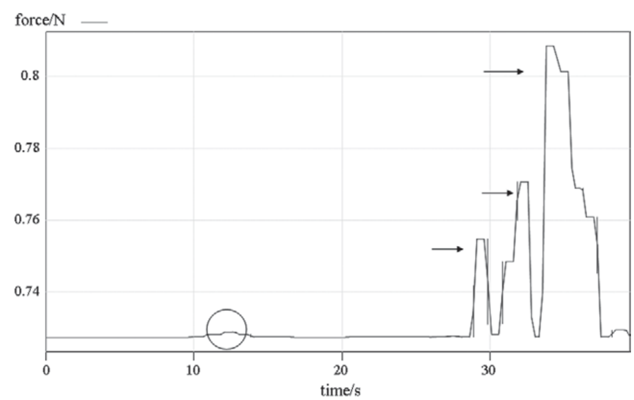

Fig. 4. The graph shows that the Single cone obturation produces vertical forces similar to the Thermafil obturation vertical forces. Arrow points to the final vertical condensation caused by the plugger (not included in the statistical analysis).

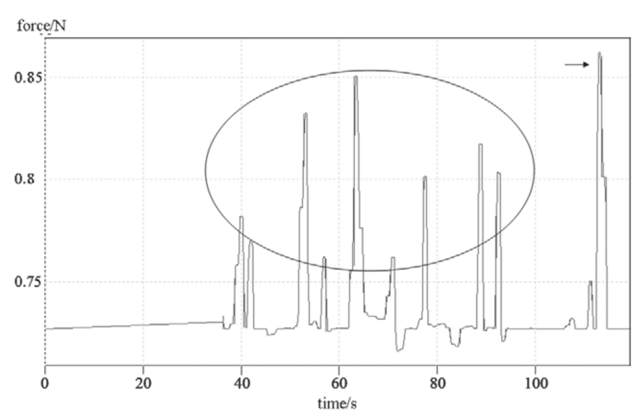

Fig. 5. Encircled peaks represent vertical forces during lateral condensation with the spreader. Arrow points to the final vertical condensation caused by the plugger (not included in the statistical analysis).

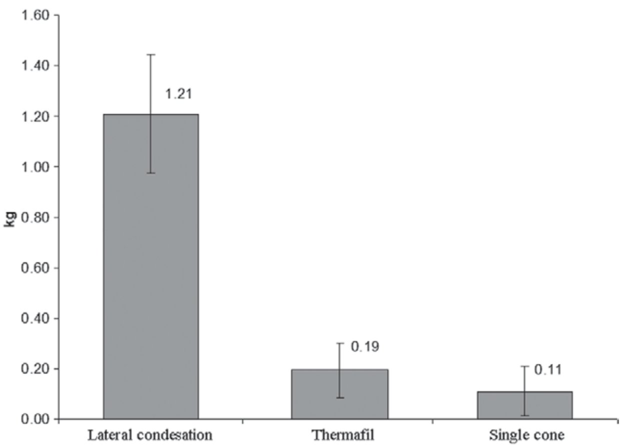

Fig. 6. Presentation of the mean values of the vertical forces for each obturation technique.

The cold lateral condensation is the most used root canal obturation technique[26]. It represents a certain standard to which all modern techniques like Thermafil and Single cone can be compared.

In this study statistically significant higher forces (1,21 kg) were found in the cold lateral condensation group in comparison to the other two groups. Usage of the finger spreaders for lateral gutta-percha condensation in the cold lateral condensation technique could explain such results. The spreader is used more than once so the high load and stress occurs repeatable. Correlation was found between high loads during lateral condensation of the gutta-percha and vertical root fractures formation[5,14,15,22].

Vertical forces ranging from 1–3 kg are usual during lateral condensation of the gutta-percha[5,16,20,21], which is in accordance with the results of the present study. Although forces ranging from 1–4.9 kg are considered as relatively safe for the tooth structure[16,20,21,27], vertical root fractures can occur even inside that »safe« range, starting from 1,5 kg[24].

Gutta-percha compaction occurs during vertical insertion of the spreader. Blum et al.[13] concluded the highest forces exerted during gutta-percha condensation are not the lateral but the vertical ones, so in this study only the vertical forces were noted.

Spreader is not required for Thermafil and Single-cone techniques because gutta-percha points have the same taper as the instrumented root canals, which could explain the lack of high loading vertical forces when these obturation techniques were used in this study. The forces obtained with Thermafil and Single-cone technique are almost six times lower than those exerted during the cold lateral condensation technique. Similar results for the forces obtained with Thermafil obturation technique were reported by Blum et al.[5]. Low vertical forces during root canal oburation using Thermafil and Single-cone techniques mean less stress on the tooth structure and lower risk of vertical root fracture formation. However, Saw & Messer[28] found higher vertical forces during Thermafil obturation. Possible explanation for such results could be that Saw & Messer[28] were recording final vertical compactions with the plugger which then led to much higher mean values of vertical forces. In the present study, final vertical compaction with the plugger was not included in the results in order to clearly show the vertical forces during gutta-percha cones insertion and compaction with the spreader.

The cold lateral condensation technique exerted higher vertical forces in comparison to the Thermafil and ProTaper obturation techniques. There was no difference in vertical forces exerted during Thermafil and Sigle-cone obturations.

REFERENCES

1. HAAPASALO M, ENDAL U, ZANDI H, COIL JM, Endod Topics, 10 (2005) 77. — 2. TROPE M, BERGENHOLTZ G, Endod Topics, 1 (2002) 40. — 3. WHITWORTH J. Endodontic Topics, 12 (2005) 2. — 4. ZHANG W, LI Z, PENG B. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 107 (2009) 79. — 5. BLUM JY, MACHTOU P, MICALLEF JP, J Endod, 24 (1998) 223. — 6. HOMMEZ GMG, DE MOOR RJG, BRAEM M, Int Endod J, 36 (2003) 344. — 7. SECCOMBE GV, PhD Thesis, University of Newcastle, UK, 2000. — 8. QUALTROUGH AJ, WHITWORTH JM, DUMMER PM, Int Endod J, 32 (1999) 406. — 9. JENKINS SM, HAYES SJ, DUMMER PMH, Int Endod J, 34 (2001) 16. — 10. GHARAI SR, THORPE JR, STROTHER JM, MCCLANAHAN SB, J Endod, 31 (2005) 198. — 11. SOBHI MB, KHAN I, J Coll Phys & Surg – Pakistan, 13 (2003) 70. — 12. LERTCHIRAKARN V, PALAMARA JEA, MESSER HH, J Endod, 25 (1999) 99. — 13. BLUM JY, ESBER S, MICALLEF JP, J Endod, 23 (1997) 340. — 14. MORFIS AS, Oral Surg Oral Med Oral Pathol, 69 (1990) 631. — 15. PITTS DL, NATKIN E, J Endod, 9 (1983) 338. — 16. HARVEY TE, WHITE JT, LEEB IJ, J Endod, 7 (1991) 151. — 17. ONNINK PA, DAVIS RD, WAYMAN BE, J Endod, 20 (1994) 32. — 18. SOROS C, ZINELIS S, LAMBRIANIDIS T, PALAGHIAS G, Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 106 (2008) 64. — 19. MEISTER F JR, LOMMEL TJ, GERSTEIN H, Oral Surg Oral Med Oral Pathol. 49 (1980) 243. — 20. DULAIMI SF, WALI AL-HASHIMI MK, Int Endod J, 38 (2005) 510. — 21. LERTCHIRAKARN V, PALAMARA JEA, MESSER HH, J Endod, 25 (1999) 99. — 22. DANG DA, WALTON RE, J Endod, 15 (1989) 294. — 23. OBERMAYR G, WALTON RE, LEARY JM, KRELL KV, J Prosthet Dent, 66 (1991) 181. — 24. HOLCOMB JQ, PITTS DL, NICHOLLS JI, J Endod, 13 (1987) 277. — 25. RICK-WILLIAMSON LJ, FOTOS PG, GOEL VK, SPIVEY JD, RIVERA EM, KHERA SC, J Endod, 21 (1995) 362. — 26. CAILLETEAU JG, MULLANEY TP. J Endod, 23 (1997) 394. — 27. LINDAUER PA, CAMBELL AD, HICKS ML, PELLEU GB, J Endod, 15 (1989) 345. — 28. SAW LH, MESSER HH, J Endod, 21 (1995) 314.

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USPOREDBA VERTIKALNIH SILA KOD TRI TEHNIKE PUNJENJA KORIJENSKIH KANALA

S A Ž E T A K

Svrha istraživanja bila je ispitati i usporediti vertikalne sile koje nastaju pri punjenju korijenskih kanala tehnikom hladne lateralne kondenzacije, Thermafil tehnikom i ProTaper gutaperkama. Za istraživanje je rabljeno 45 jednokorijenskih trajnih zuba. Kanali su obrađeni ProTaper tehnikom. Pripremljeni uzorci slučajnim odabirom podijeljeni su u tri skupine (n=15 po skupini). U prvoj skupini kanali su napunjeni tehnikom hladne laterane kondenzacije.U drugoj skupini rabljena je Thermafil tehnika punjenja korijenskih kanala. U trećoj skupini kanali su napunjeni ProTaper gutaperkom istog koniciteta kao i instrumentirani kanali. Vertikalne sile izmjerene su uređajem razvijenim s ciljem simulacije endodontske obrade ljudskog zuba. Vertikalna sila kod tehnike hladne lateralne kondenzacije je bila statistički značajno veća u usporedbi s ostalim tehnikama (p=0,0001), dok između Thermafil tehnike i punjenja korijenskih kanala ProTaper gutaperkama nije bilo statistički značajne razlike u iznosu vertikalne sile (p=0,16). Tijekom punjenja korijenskih kanala tehnikom hladne lateralne kondenzacije razvijaju se veće vertikalne sile nego kod Thermafil tehnike i tehnike punjenja ProTaper gutaperkom.