ผลกระทบของชนิดของเครื่องมือขยายคลองรากฟันต่อการระบุขนาดเครื่องมือชิ้นแรกที่สัมผัสคลองรากฟันส่วนปลายในฟันกรามล่างแท้

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วัตถุประสงค์: การศึกษานี้มีวัตถุประสงค์เพื่อศึกษาผลกระทบของชนิดของเครื่องมือขยายคลองรากฟันที่หมุนด้วยมือสองชนิด ได้แก่ ไฟล์สเตนเลสชนิดเค และไฟล์นิเกิลไททาเนียมชนิดเค(NiTiflex) ต่อการระบุขนาดไฟล์ตัวแรกที่สัมผัสคลองรากฟันส่วนปลาย

วัสดุอุปกรณ์และวิธีการ: การศึกษานี้ใช้ฟันกรามล่างแท้จำนวน 30 ซี่ ที่เติบโตสมบูรณ์และมีคลองรากฟันแยกกัน 3 คลองรากได้แก่ คลองรากใกล้กลางด้านแก้ม คลองรากใกล้กลางด้านลิ้น และคลองรากไกลกลาง หลังการทำความสะอาดฟัน เปิดทางเข้าสู่โพรงฟันเพื่อกำจัดเนื้อเยื่อในโพรงประสาทฟันและเข้าสู่คลองรากฟันส่วนต้นด้วยไฟล์สเตนเลสชนิดเคขนาด 08 โดยสอดไฟล์เข้าไปในคลองรากฟันถึงจุดติดที่สามารถลงไปได้สลับกับการล้างด้วยน้ำยาโซเดียมไฮโปคลอไรท์ แล้วตามด้วยไฟล์สเตนเลสชนิดเคขนาด ขนาด 10 และ 15 ตามลำดับทำซ้ำจนสามารถทำการขยายคลองรากฟันส่วนต้นและส่วนกลางด้วยไฟล์นิเกิลไททาเนียมชนิดหมุนด้วยเครื่อง Pre-RaCe ถึงความยาวที่สั้นกว่าความยาวรากฟัน 4 มิลลิเมตร แล้วใช้ไฟล์สเตนเลสชนิดเคขนาด 08 สอดเข้าไปจนโผล่ที่รูเปิดปลายรากฟันด้านนอก เพื่อวัดความยาวรากฟันแล้วลบด้วย 1 มิลลิเมตรเพื่อเป็นความยาวทำงานของคลองรากฟัน จากนั้นทำการวัดขนาดไฟล์ตัวแรกที่สัมผัสคลองรากฟันส่วนปลาย 2 ครั้งในแต่ละคลองรากฟันโดยเรียงตามลำดับจากเล็กไปใหญ่ ด้วยไฟล์ที่หมุนด้วยมือสองชนิด ได้แก่ไฟล์สเตนเลสชนิดเคเริ่มจากขนาด 10 และไฟล์นิเกิลไททาเนียมชนิดเค (NiTiflex) เริ่มจากขนาด 15 บันทึกข้อมูลและนำไปวิเคราะห์ด้วยเครื่องมือทางสถิติ paired T-test

ผลการทดลอง: ชนิดของเครื่องมือขยายคลองรากฟันมีผลกระทบต่อการระบุขนาดเครื่องมือชิ้นแรกที่สัมผัสคลองรากฟันส่วนปลายอย่างมีนัยสำคัญทางสถิติ ($p<0.001$) ที่ระดับความเชื่อมั่นร้อยละ 95 การระบุขนาดไฟล์ตัวแรกที่สัมผัสคลองรากฟันส่วนปลายด้วยไฟล์นิเกิลไททาเนียมชนิดเคได้ค่าขนาดของไฟล์ใหญ่กว่าเมื่อใช้ไฟล์สเตนเลสชนิดเค ร้อยละ 76.67(69/90) ของคลองรากฟันทั้งสามกลุ่มรากฟัน โดยในคลองรากใกล้กลางด้านแก้ม และคลองรากใกล้กลางด้านลิ้นให้ขนาดที่ใหญ่กว่า 5 ISO ยูนิตหรือ 1 ขนาด ส่วนคลองรากไกลกลางให้ขนาดที่ใหญ่กว่า 10 ISO ยูนิตหรือ 2 ขนาด

สรุปผล: การศึกษานี้แสดงว่าชนิดของเครื่องมือขยายคลองรากฟันมีผลกระทบต่อการระบุขนาดเครื่องมือชิ้นแรกที่สัมผัสคลองรากฟันส่วนปลาย ภายหลังจากการขยายคลองรากฟันส่วนต้นและกลาง พบว่าการระบุขนาดไฟล์ตัวแรกที่สัมผัสคลองรากฟันส่วนปลายด้วยไฟล์นิเกิลไททาเนียมชนิดเคได้ค่าขนาดของไฟล์ใหญ่กว่าเมื่อใช้ไฟล์สเตนเลสชนิดเค ซึ่งจะทำให้การประมาณขนาดเส้นผ่าศูนย์กลางเส้นสั้นของคลองรากฟันส่วนปลายรากที่ความยาวทำงาน มีความคลาดเคลื่อนน้อยลงกว่าการระบุขนาดโดยใช้ไฟล์สเตนเลสชนิดเค

คำสำคัญ: การระบุขนาดไฟล์ตัวแรกที่สัมผัสคลองรากฟันส่วนปลาย ชนิดของเครื่องมือขยายคลองรากฟัน ไฟล์ตัวแรกที่สัมผัสคลองรากฟันส่วนปลาย ไฟล์สแตนเลสชนิดเค ไฟล์นิเกิลไททาเนียมชนิดเค

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The Effect of Root Canal Instrument Types on Initial Apical File Size Determination

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Abstract

Objective: The aim of this study was to evaluate the effect of the instrument type (stainless steel K-file and nickel-titanium K-file) on the determination of the initial apical file at the working length in all root canals of the permanent mandibular molars.

Materials and methods: Thirty permanent mandibular molars with fully formed roots and three separated canals: mesiobuccal, mesiolingual and distal root canals were included in this study. After teeth were cleaned and cusps were leveled, standard access was made to clean the content in the pulp chamber. Each canal was negotiated with K-file size #08 to the resistance and irrigated with 2.5% sodium hypochlorite followed by size #10 and #15, respectively and passively. The files were repeatedly advanced into the canal until the cervical preflaring could be performed with Pre-RaCe rotary instrument sizes 35/08 and 30/06 orderly and left 4 mm short of the untouched root length. K-file size #08 was inserted into the canal until the file was visible at the apical foramen to measure the root length and the working length was obtained by subtracting 1 mm. By tactile sensation, each canal was sequentially sized twice starting with stainless steel K-file size #10 or NiTiflex size #15 randomly to determine the initial apical file size. Data were recorded and statistically evaluated with paired T-test.

Results: The type of instrument had a highly significant effect on the initial apical file size determination after preflaring in three root canal groups. ($p<0.001$) The initial apical file diameters registered with NiTiflex were larger than with stainless steel file in 76.67% (69/90) of all root canals. The difference of initial apical file diameter in MB and ML root canal groups was 5 ISO units (one ISO size) larger and 10 ISO units (two ISO sizes) larger in the D root canal group.

Conclusion: This study demonstrated that type of instrument significantly affected the initial apical file size determination after preflaring. The use of NiTiflex to determine the initial apical file size resulted in larger file size compared with the use of stainless steel K-file and less underestimation of the short apical canal diameter at the working length.

Key words: Apical file size Determination, Instrument type, Initial apical file, K-file, NiTiflex

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Introduction

Endodontic therapy aims to maintain the natural teeth so that patients can retain their natural teeth in function and esthetics. Traditionally, endodontic treatment can be divided in three main phases: (i) proper access preparation into the pulpal space, (ii) cleaning and shaping of the root canal, and (iii) obturation of the root canal system [1]. Cleaning and shaping of the root canal system has been considered one of the most important steps and the foundation for successful endodontic therapy because it achieves effective disinfection of the root canal and also obtains the proper root canal configuration for the three-dimensional obturation. Classical bacteriological studies have indicated that mechanical instrumentation alone resulted in a significant reduction of bacterial counts [2]. Effective canal debridement depends on the accurate determination of working length (WL) and adequate apical canal enlargement [3]. Hence, the two essential early steps of root canal debridement are to determine the WL and the size of the apical foramen before shaping of the root canal to accomplish the adequate disinfection of the root canal. The WL, to which to root canal should be instrumented and irrigated, can be identified mostly with the aid of radiographic confirmation, and modern electronic apex locator devices [4-7].

The final size of the apical preparation has been crucial for successful debridement of the root canal system. The rule of the "three sizes larger from the first file to bind" has been used with some modifications. Initial apical file (IAF) is defined as the smallest instrument that reaches the apical area of the root or WL and binds at the physiological foramen area. It has been suggested that when the initial file size is known, the cross-sectional area of the root canal at the apical constriction is also revealed. When the apical third of the tightest root canal as IAF size equals size #10 is prepared up to three sizes larger than the IAF, i.e., file size #25, the area of the apical root canal increases approximately 6.25 times. Thus, the infected dentine of the root canal is significantly reduced [1,8] . Traditionally, detecting the apical constriction and determining IAF relies on the operator's tactile sensation. This technique is based on assumption that the root canal narrows toward the apex into the apical constriction or physiological foramen [9] and the file would pass without interference until the apical area was reached [3]. This premise was accurate only in cases in which the physiological foramen and apical root canal were round [10]. However, root canal morphology varies with no standardized apical canal shape and size. The study reported that the majority of the shapes of physiological foramen of molar teeth were oval [11]. Wu et al. reported that a discrepancy between the diameter of the first file that binds to the canal wall at the WL and the diameter of the apical area at the same length [12]. As a result, enlargement of the root canal at the working length (WL) with three instrument sizes larger did not guarantee complete removal of the infected dentine from root canal walls. The traditional method in determining IAF was not precise and underestimated the real diameter of the apical region [13, 3]. Despite

these differences, most authors still agree that the currently starting point for apical shaping is the IAF. Therefore, the accuracy of this determination would be noteworthy to investigate.

Several factors such as canal shape, length, taper, curvature, root canal contents and canal wall irregularities may affect the accuracy of determining the IAF because they affect the clinician's tactile sense [14]. Instrument types and manipulation technique in the apical area were also found to affect this determination [15]. Philippas (1961) reported that continuous and progressive dentine formation in the pulp space created dentine projections that narrowed the root canal diameter, mainly at the cervical third [16]. Leeb (1983) demonstrated that the sensation of file fit did not necessarily occur because of its contact at the apex, as was assumed, but instead may be a result of interference in the coronal and middle thirds of the canal [17]. Irregularity of the walls and/or curvatures of the root applied pressure against the file and interfered with the clinician's ability to pass a file to the apex and their tactile sensation to determine contact and tightness of the apical constriction. Because of these interferences, current techniques to determine the first file that binds at the apical region may not provide a reliably predictable methods [18]. Several authors suggested that it was advantageous to remove the middle and coronal third interferences before approaching the apical area. This would allow the instrument to approach the apical one third more easily because only this area remained untouched [20]. Many studies have reported that preflaring of the cervical and middle thirds of the root canal improved tactile sensation of the apical constriction and the determination of apical diameter [3,18-20]. The researchers also reported that the enlargement of the cervical and middle thirds of the root canal significantly affects the determination of the IAF size and allows a more accurate assessment of the true anatomical diameter. Cervical preflaring of the root canal increases the size of IAF that binds at the apex and consequently increases the size of master apical file [18] resulting in removal of more infected dentine and adequate debridement of the apical third region.

Cervical preflaring may be performed with either manual or rotary instruments. Flaring with rotary instrument has an advantage in that it is more rapid than manual and thus reduces treatment time. Ashwini and Bhandari reported that cervical preflaring performed by RaCe instruments (FKG Dentaire, Switzerland) led to the best results in apical size determination [21]. A new generation of endodontic instruments has been developed from nickel-titanium (NiTi) alloys which exhibit superelastic behavior, shape memory effect and higher resistance to cyclic fatigue [22]. The instruments are manufactured in both hand and rotary versions. The advantage of NiTi files over stainless steel files has been demonstrated by producing superior shaping of narrow and curved root canals without causing aberrations because of their flexibility [23-25].

Tan and Messer investigated the effect of instrument type and the impact of preflaring on IAF and found that traditional methods for determining the IAF have underestimated the real diameter of the apical canal. Preflaring and use of hand-held Light Speed (NiTi) instruments have

resulted in an increase in instrument size that binds at the WL. Their study was conducted using variety of premolars and molars [3]. To date, no study has compared the effect of the instrument type with the same design after preflaring regarding the accuracy of the IAF size determination. The purpose of this study was to determine the effect of two different root canal instrument types: conventional stainless steel K-file(SS) and nickel-titanium K-file (NiTiflex) on the tactile determination of the IAF after cervical preflaring of the root canal.

Materials and methods

Tooth selection

Thirty human mandibular permanent molars were selected and stored in the closed bottle containing alcohol 70% until the time of study. All teeth radiographically displayed normal pulp chambers, patent root canals and fully formed roots without previous root canal treatment. Only teeth with the characteristic of three canals composed of two separated foramina of the mesiobuccal (MB) and mesiolingual (ML) canals at the apical region and one distal (D) canal were selected. Teeth with external root resorption, extreme root curvature, complicated anatomy and joined MB and ML canals at the apical area were excluded.

Tooth preparation and cervical preflaring

Teeth were immersed in 2.5% Sodium Hypochlorite for 15 minutes and surface was cleaned with ultrasonic scaler. Caries and restorations were totally removed. The cusps were leveled to provide a definite reference plane. Each tooth was stored in an individually labeled, capped bottle containing normal saline solution. Standard access cavities were prepared and canal orifices were located. The pulp chambers were cleaned and canal contents were removed with small stainless steel K-files (SS) size # 08 (Sybron Endo, USA). These 30 teeth yielded three canals, providing a total of 90 canals used in this study. Each root canal was negotiated with SS size # 08 (SybronEndo, USA) to the resistance and irrigated with 2.5% sodium hypochlorite followed by size #10 and #15 respectively and passively advanced in the canal until the cervical preflaring could be performed with Pre-RaCe rotary instruments (FKG Dentaire, Switzerland) sizes 35/08 and 30/06 sequentially, to eliminate the obstacle in the coronal and middle third of the canal and facilitate the negotiation to the apical end. Preflaring with RaCe was limited to 4 mm short of tooth length to leave the apical third unprepared. The canal was abundantly irrigated and canal patency was checked. The precise root canal length was determined by inserting size #08 SS file in the canal until the file was visible at the apical foramen. The working length was set 1 mm. short of the apical foramen and recorded.

Determination of the Initial Apical File size

After completing cervical preflaring, two types of root canal instruments, stainless steel K-files (SS) (SybronEndo, USA) and nickel-titanium K-files (NiTiflex) (Dentsply, Maillerfer, Switzerland) were used to determine the IAF size that was assumed to correspond with the apical canal diameter. Each canal was sized twice with both

instruments at random. Consequently, larger files were inserted passively in the canal to WL with a light 'watch-winding' action, and care was taken to avoid any force during sizing. Measurement was undertaken starting from ISO size #10 K-file for SS whereas for NitiFlex, measurement began with size #15, which was the smallest size of this type of file. The first file that gave the researcher the sensation of a snug fit at the WL and inability to pass beyond that depth was recorded. A one size larger file was used to ensure that it could not reach the same WL. The same procedure was performed for each canal. Following the method of Tan and Messer [3], these precautions were taken to reduce bias during measurement:

1. The first instrument used for determination the IAF size, either SS or NiTiFlex, was alternated.

2. Sizing with the second file type was conducted in a random manner, without knowledge of the previous measurement result.

3. Each measurement was recorded on a separately prepared form for each type of instrument to prevent the researcher from knowing the previous reading.

The only information the researcher had each time before each IAF determination was the WL and its corresponding reference point.

The IAF sizes are presented either in ISO sizes or in diameters (x10-2 mm),e.g., an ISO size #15 is equal to a file tip diameter of 15 x10-2 mm; file sizes typically increase in increments of 5 ISO units, or 5 x10-2 mm. This study presented file diameters (x10-2 mm) for greater accuracy and better recognition of the clinicians to estimate the diameter of the root canal at the apical area.

Statistical analysis

The data of IAF size registered with both SS and NiTiflex were recorded and analyzed with Paired t-Test to investigate the effect of the root canal instrument type when determining the IAF in the three canal groups. All statistical analyses were performed at the 0.05 level of significance using SPSS version 6 (SPSS Inc., Chicago, IL, USA).

Results

The range, mode, mean, standard deviation and confidence interval of the IAF diameter registered with SS and NiTiflex in the three canal groups are shown in Table 1. The instrument type had a highly significant effect on IAF determination in all canal groups ($p < 0.001$, Paired t - test) at 95% confidence interval (MB canal=2.47 – 5.19, ML canal=3.16 – 5.51, D canal=6.84 – 9.16). More than 76.67% (69/90) of all canals showed the IAF size reading by NiTiflex to be larger than the corresponding SS file readings (Figure 1).

Table 1. Range, mode, and mean ($X10^{-2}$ mm) of the IAF diameter registered with Nitiflex and SS.

	Diameter of IAF ($X10^{-2}$mm)						
Canal-Instrument	**Min**	**Max**	**Mode**	**Mean**	**SD**	**95% Confidence Interval**	
MB-SS	10	25	15	17.17	3.869	15.72	18.61
MB-NiTiflex	15	35	20	21.00	5.632	18.9	23.10
ML-SS	10	20	10	14.33	4.302	12.73	15.94
ML-NiTiflex	15	30	15	18.67	5.074	16.77	20.56
D-SS	10	40	20	24	7.812	21.08	26.92
D-NiTiflex	15	50	30	32	8.570	28.80	35.20

Paired T-test, $p<0.001$ in all canal groups, at 95% confidence interval.

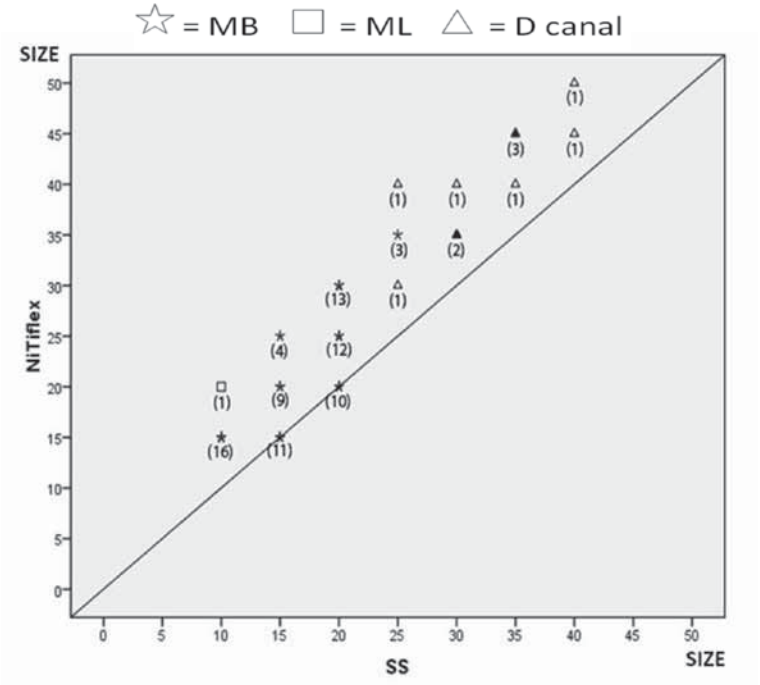

Figure 1. Scatter plot of the IAF sizes registered by NiTiflex and SS after flaring (total = 90 canals). Points above the line indicate larger Nitiflex size; points on the line indicate same size. Note: dark signs represent the superimposed area on the same place. Number in parenthesis indicates the frequency.

Table 2 shows mean differences of IAF diameter were 3.83, 4.33 and 8.0 X10-2 mm while the most common differences, i.e., mode, were 5, 5 and 10 ISO units in MB, ML and D canal groups, respectively. This implied that NiTiflex gave one file size larger than SS in the MB and ML canal groups, which were smaller canals and two file sizes larger in D canal group which were wider canals in the same tooth.

Table 2. Range, mode, and mean ($X10^{-2}$ mm) of the IAF diameter difference registered with Nitiflex and SS.

	Diameter of IAF ($X10^{-2}$mm)						
Canal group	**Min**	**Max**	**Mode**	**Mean**	**SD**	**95% Confidence Interval**	
MB(NiTiflex-SS)	0	10	5	3.83	3.64	2.47	5.19
ML(NiTiflex-SS)	0	10	5	4.33	3.14	3.16	5.51
D (NiTiflex-SS)	0	15	10	8	3.11	6.84	9.16

Discussion

This finding was consistent with the study of Tan and Messer [3] which stated that after cervical preflaring of the coronal and middle part of the root canal, the instrument type had highly significant effect on determining the IAF at the WL. The results were also similar to many studies [18-21].

Tan and Messer reported that both before and after cervical preflaring, IAF size readings registered by NiTi instrument (Lightspeed) increased two sizes larger than the corresponding canal registered by SS K-file in all specimens, composed of premolars and molars, both mandibular and maxillary teeth. In this study, all specimens were mandibular molars with three root canals; MB, ML and D. They exhibited more consistency in morphology, i.e., diameter of the canal at the apical area, than those from the previous studies. Another difference was determining the IAF size. Measurement was undertaken starting from ISO size #10 K-file for SS whereas for NiTiflex, measurement began with size #15, which was the smallest size of this type of file, while Tan and Messer used Lightspeed, for which the smallest size was 20. This may have affected the accuracy in determining IAF size in the small canal as the mesial canal of the mandibular molar. The results of this study showed that NiTiflex readings were one size larger than the SS file readings in MB and ML canal groups whereas two sizes larger in the D canal group. This might be due to the difference in the root canal morphology, which would affect the penetration of the instrument. The mesiobuccal and mesiolingual root canals in mandibular molars are considered as having smaller and greater curvature than the distal canals.

The researcher noticed that after pre-flaring, the last 4 mm of the root length and the apical foramen could be approached with less interference in the apical part of the canal using watch winding motion of the K-file size #08. This cervical preflaring is worth performing before routine IAF size determination and root canal mechanical instrumentation.

The types of instrument had a significant effect in determining IAF. The NiTiflex gave a larger size than the SS in all groups. The effect of instrument type was more obvious especially when the file size was larger than #20 because at this diameter the stainless steel file loses its flexibility to follow the canal curvature. This can be explained regarding the difference in type of material made. The NiTiflex files are ISO standard K-file that made of nickel-titanium which is 3 to 4 times more flexible than stainless steel and is completely compatible to stainless steel K-file in size and shape. Thus, the clinicians could be familiar using this type of file easily.

Despite the indication that the IAF size does not imply the real diameter of the apical canal [3], the IAF should be determined. Without knowledge of the original apical width and the optimal width preparation to which the root canal preparation should end, clinicians would be making treatment decisions without any supporting scientific evidence [14]. To date, no more appropriate clinical guidelines exist to direct the clinician how large the canal should be prepared. IAF determination and the canal preparation at least three sizes larger still remain the optimal clinical guidelines for clinicians to identify the master apical file. Therefore, the reliable technique for IAF determination is necessary.

The present study proposed that the initial cervical preflaring of the root canal followed using the NiTi instrument with ISO standard in IAF determination proved to result in larger size IAF and less underestimated apical diameter. The results can be expected both in vitro [3,18-20] and in vivo [21].

Conclusion

This study demonstrated that type of instrument significantly affected the IAF size determination after preflaring. The use of NiTiflex to determine the IAF size resulted in larger file size compared with the use of stainless steel K-file and less underestimation of the short apical canal diameter at the working length. Following the stated regimen of this study, the larger the IAF sizes were possibly determined, the larger the master apical files were expected to be used. Therefore, better canal debridement is obtained resulting in improved outcome of the root canal treatment.

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