

The Comparison of Root Canal Preparation Using Hand Stainless Steel File Versus NiTi Rotary Instrument Performed by Inexperienced Dentists in Using Rotary Instrument: A Clinical Study

Veera Lertchirakarn

Assistant Professor
Department of Operative Dentistry
Faculty of Dentistry, Chulalongkorn University

Sumalee Songpaisan

Dentist, Dental Hospital
Faculty of Dentistry, Chulalongkorn University

Chantavat Sutthiboonyapan

Assistant Professor
Department of Operative Dentistry
Faculty of Dentistry, Chulalongkorn University

Piyanee Panitvisai

Associate Professor
Department of Operative Dentistry
Faculty of Dentistry, Chulalongkorn University

Correspondence to:

Assistant Professor Dr. Veera Lertchirakarn
Department of Operative Dentistry
Faculty of Dentistry, Chulalongkorn University
Henry Dunant Road, Pathumwan, Bangkok 10330
Tel: 02-2188795, 02-2188785
E-mail: veera.l@chula.ac.th

Abstract

The curvature of prepared root canals using NiTi rotary file (ProFile®) by inexperienced in NiTi rotary instrument postgraduate students were compared with those prepared by using hand stainless steel K-file in clinic. Either mesial roots of mandibular or mesio-buccal root of maxillary molar from 32 molars were randomly assigned into two groups. Group 1 was prepared using K-file with modified stepback technique and group 2 using ProFile® with modified crown-down technique and then both groups were obturated. The pre-instrumentation and post-instrumentation canal angle on radiographic images of root canals and root canal filling were blindly evaluated and the mean differences in angle were statistically compared between groups. The result showed that the original canal curvature was significantly less straightened by ProFile® than hand K-file ($p < .05$). It may be concluded from this study that NiTi rotary instrument (ProFile®) technique better demonstrated the maintenance of canal curvature than hand stainless steel file, although the technique was performed by inexperienced dentists.

Key words: NiTi rotary instrument; root canal preparation

Introduction

The mechanical objectives for cleaning and shaping of the root canal are a continuously tapering preparation, maintained original anatomy and position of the foramen, and keeping the apical foramen as small as practical.¹ Unfortunately, the maintaining of original curvature of the root canal is not an easy goal to obtain, especially in curved canals. The use of files with insufficient or no flexibility contributes to canal transportation, ledging and root perforation.²⁻⁴ The straightening of the curved canal is one of the most common procedural errors, that diminishes the prognosis of endodontic therapy.⁵ Several instruments with modified designs and techniques, therefore, have been introduced to decrease the root canal transportation. A new generation of endodontic instruments made from nickel titanium with a low modulus of elasticity and the great flexibility, compared to stainless steel files was introduced.⁶ The hand nickeltitanium (NiTi) 0.02 taper files was shown to decrease the amount of straightening of canals and procedural mishaps in the predoctoral clinic compared with traditional stainless

steel hand K-files.⁷

Many of the new generation of NiTi rotary instruments with different designs have been developed for root canal shaping and cleansing. ProFile[®], one of NiTi rotary instruments, is machined with safe-ended non-cutting tip to follow a pilot hole and guide the instrument through the canal during preparation procedures and its radial lands keep the instrument centered in the canal. Many studies demonstrated that ProFile[®] created good apical stops, tapering and maintaining the original curvature of root canals or slightly straightening of canals.⁸⁻¹¹ However, these reports were studied in either resin simulated canal blocks⁸⁻¹¹ or extracted human teeth.¹² In contrast, only few clinical studies compared the canal transportation caused by rotary NiTi instruments with hand stainless steel files.^{13,14} The rotary NiTi instrument (FlexMaster[®]) was shown less straightening root canal than hand stainless steel file in only experienced dentists.¹³ On the other hand, the NiTi rotary instruments (ProFile[®] and Lightspeed[®]) were demonstrated no significance in canal transportation when compared with hand stainless steel file in senior undergraduate dental students.¹⁴

The purpose of this clinical study was to compare the canal transportation by hand stainless steel K-files (Flex-O-file[®]), which have been popular and used for a long time, and NiTi rotary instrument (ProFile[®]) used by inexperienced postgraduate students in using NiTi rotary instruments on the extent of straightening of moderate curved root canals.

Materials and Methods

Case selection and operators

The protocol of this study was approved by the research committee of Faculty of Dentistry, Chulalongkorn University, before the study was commenced. Thirty-two first and second maxillary and mandibular molar teeth in patients who needed endodontic treatment were recruited based on the canal curvature in the endodontic clinic, Department of Operative Dentistry, Chulalongkorn University. The canal curvature of the selected mesio-buccal root of those maxillary molars and the mesial roots of mandibular molars were classified as moderately (11°-24°) and severely (>25°) curved canals according to the method proposed by Pettiette and co-workers⁷. Each patient was informed about the details of this study and a consent form was signed before the treatment started. All teeth were systematically randomly divided into two experimental groups with the mean degree of canal

curvature in each group showing no significant difference. Two teeth in each group were systematically randomly assigned to each of eight postgraduate students who had clinical experience in using hand K-file but not NiTi rotary instrument. However, those postgraduate students had been trained and practiced in using the NiTi instrument in a certain number of extracted molar teeth. Each student randomly performed two endodontic cases with hand stainless steel K-files (Flex-O-file[®], Dentsply, International Inc., Maillefer, Switzerland) and two other endodontic cases with rotary NiTi instruments (ProFile[®], Dentsply, International Inc., Tulsa, USA.).

Radiographic procedure

In the first appointment, a preoperative radiograph of the tooth was taken with an XCP precision instrument.⁷ A custom silicone bite block (Provil[®] novo-Putty, Heraeus Kulzer, Hunau, Germany) was attached to the precision instrument and placed on the tooth. The patient then bit into the mixed silicone material covered on the block forming a bite registration. Using this method, an accurately reproducible position and alignment of the tooth and final root canal filling on the radiograph taken later on could be obtained.

Root canal preparation

The modified stepback technique using Flex-O-file[®] was employed in this study as a hand instrumentation technique. An access was opened and the canal terminus was negotiated with size 8-15 file. The coronal third of the canal was flared with size 15 to 35 K-files using serial preparation and size 2 to 4 Gates-Glidden burs were used to create space. The initial apical file (IAF) and the working length were then determined. The apical part of the canal was prepared to master apical file (MAF) at least three sizes larger than IAF and the root canal was flared with stepback technique at least five sizes larger than MAF.

The modified crown-down technique was used in the canals that were instrumented with NiTi rotary instrument (ProFile[®]). The ATR motor (Dentsply, International Inc., Tulsa, USA.) with the program set up for ProFile[®] was utilized. The working length was estimated from the preoperative radiograph and an access was opened. The canal terminus was negotiated with size 8 to 15 files. The coronal third of root canal was prepared using the same method as in the previous group. Then, the middle third of root canal was prepared using the crown-down technique to 3 mm short from the estimated working length with orifice shapers (OS 3, OS 2), then .06 and .04

ProFiles® (.06/25, .04/25, .04/20). After that, the IAF and the working length were determined. The apical part of root canal was then prepared using .04 ProFiles® (.04/20, .04/25, 04/30). The final size for the root canal shaping was at least .06/25 ProFile®. Glyde® was used as lubricant for rotary instrumentation cases. Copious irrigation with 2.5% NaOCl was used throughout the preparation in both groups. Calcium hydroxide was used as an inter-appointment medicament. In the final visit, the canal was obturated with gutta-percha and zinc oxide root canal cement using lateral condensation technique.

Analysis of root curvature and degree of straightening

The degree of canal curvature was determined using computerized digital image processing system as previously described by Pettiette and co-workers⁷. The preoperative and postoperative radiographs were scanned using a film-scanner with 1,000-dpi resolution,

24 bit color in an uncompressed TIFF-file format. To allow the superpositioning of tracings from one radiograph over the others, three reference marks were drawn on each of them. Two horizontal marks were on the interdental alveolar crests of the cortical plate and the other was on a coronal structure such as restoration, enamel cusp, etc.

All radiographs, two axis lines were drawn. The first line was the straight-line axis of the coronal third of the root canal and the second was through the axis of the canal in the apical third. The angle between these two lines was defined as canal angulation, representing the degree of deviation of the apical axis from the coronal one. The method of measurement of root canal degree of curvature was shown in Fig. 1.

However, it is common that two canals in the mesial roots of

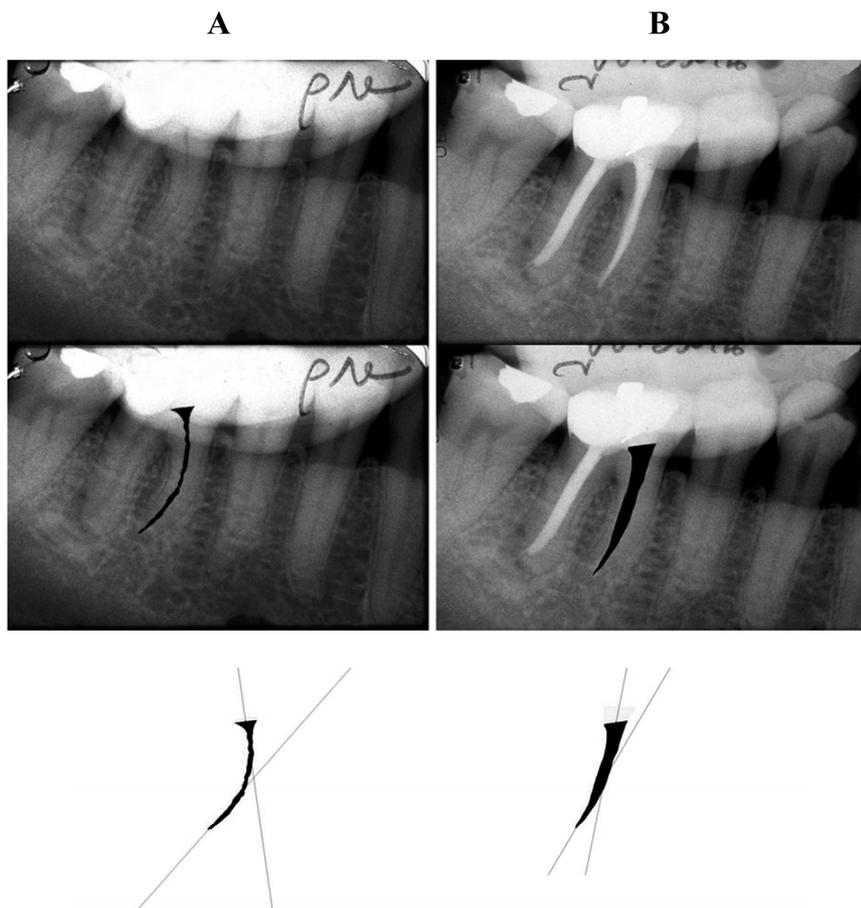


Fig. 1 Demonstrate the method of measurement of root canal degree of curvature.

- A. Pre-operative radiographs and tracings.
- B. Post-operative radiographs and tracings.

both maxillary and mandibular molars may radiographically overlap with each other, rather than demonstrate two separated identifiable canals in each root. In these cases, the pre-operative root angulation, rather than the canal angulation, was measured instead and then compared with the angulation of the final gutta-percha filling.

To facilitate visualization, measurements and recording, all pre-operative and post-operative tracings were then grouped and copied to a blank page. This allowed the tracings to be observed without other interference. A circle was drawn with its center on the vertex of each angle to form an arc, the computer software then provided the value in degrees. This procedure allowed a simple accurate measurement of the pre-operative and post-operative canal angulations. The difference in angles found between the pre-operative and post-operative tracings was defined as the degree of apical straightening of the canal. The interpreter who evaluated the different degree of root canal did not know which number of sample was in which group of experiment.

Results

The degree of canal curvature in pre and post-operative radiographs, and different angle between the pre and the post-operative radiographs were calculated and recorded as shown in Table 1. The mean different degree of the angle for hand instrument group was 15.45 ± 10.53 degree (mean \pm SD), and for the ProFile[®] group was 8.74 ± 8.29 degree (mean \pm SD). The difference of the angle between the pre and the post-operative radiographs in each group was determined the distribution of data. Then, the data were statistically analyzed using independent t-test for equality of means to determine whether there was a significant difference between the two groups. The result showed that the difference of the angle were significantly greater in hand instruments group than in the ProFile[®] group ($p < .05$).

Discussion

The aim of this study is to compare the canal curvatures before and after instrumentation using radiographic images. The radiographic angulation is crucial for the result evaluation. Custom-made bite blocks, therefore, were used to reproduce the same radiographic angulation as in the previous study.⁷ Although, the use of a two-dimensional radiograph to evaluate for straightening of the canals in a three-dimensional system may result in some inaccuracy, this method is still in some reliable and valid in clinical studies.^{7,13}

In addition, the mesial roots of both maxillary and mandibular molars being evaluated in this study are common to have two canals that overlap radiographically, rather than two separated roots. In these cases, the pre-operative root angulation, rather than canal angulation, was measured and compared with the angulation of the final gutta-percha filling. Thus, the result from this study might show the deviation of both canals in some cases when compared with the root angulation.

Kfir and co-workers¹⁴ demonstrated in their clinical study that there were some procedural errors and no difference was found between stainless steel K-file and rotary NiTi file performed by senior dental students. On the other hand, the rotary NiTi instrument was shown to cause less canal deviation than hand stainless steel file in the other clinical study.¹³ The NiTi theoretically should create less procedural errors because of its mechanical properties.⁶ In addition, hand NiTi instrument was also reported to have less straightening of curved canal when compared with hand stainless steel file.⁷ The difference among these studies may be attributed to operators who might not have the same level of skill. The operators in the study by Schafer and co-workers¹³ were the experienced dentists whereas the operators in Kfir and co-workers' study¹⁴ were the senior dental students who were not only inexperienced in dental treatment but also in endodontic procedures. This may be explained for the increase in procedural errors when the rotary NiTi instrument was used in their study.

Table 1 The pre-, post-operative and difference in angle of root canal in both groups.

	Mean canal angle (degree)		
	Pre-operative	Post-operative	Difference
Hand file	32.29 \pm 10.77	16.84 \pm 10.03	15.45 \pm 10.53
NiTi rotary	30.02 \pm 10.04	21.28 \pm 7.71	8.74 \pm 8.29

In this study, the authors also evaluated the canal transportation resulted from using hand stainless steel K-files (Flex-O-file®) and NiTi rotary instrument files (ProFile®) used by clinical inexperienced in NiTi rotary instrument postgraduate students. The operators in this study are experienced in endodontic procedures, especially using hand stainless steel K-files in clinic but familiar with NiTi rotary instruments only in working on extracted teeth. According to the results, canal preparation with rotary NiTi system demonstrated less transportation than hand stainless steel files. This observation agreed with the findings of previous experimental and clinical studies.¹¹⁻¹³ However, the degree of canal transportation of this study was significantly different at p -value close to .05 ($p = .045$, hand K-file 15.45 ± 10.53 degree, ProFile® 8.74 ± 8.29 degree). In contrast, the result from this study was different from Kfir and co-workers' study.¹⁴ This may be attributed to the different experience of the operators in both studies.

The degree of canal transportation by NiTi rotary instrument in this clinical study was greater than that in the former study which was only 1.12 degree.¹³ This result may be directly influenced by the experience of the operators since the ProFile® instrument was designed with non-cutting tip and should better maintain the curvature of root canal. The incidence of procedural errors was also reported to be much higher in root canals prepared by dental students than endodontists.¹⁵

The original curvature was significantly better maintained with rotary ProFile® instrument than with hand instrument. Thus, it can be hypothesized that the hand instrumentation left the possibility of the canal space, un-instrumented dentin, which might result in adequate obturation of the root canal space.⁷ It is more important to eradicate bacteria by combining instrumentation with the use of anti-bacteria irrigants, intra-canal medications, such as calcium hydroxide before obturation.¹⁶ However, it may be questioned that the small amount of canal deviation in this study, 15.45 ± 10.53 degree K-file vs 8.74 ± 8.29 degree ProFile®, is of any clinical significance in terms of success and failure of treatment. Therefore, follow-up on success rate of these cases should be examined and analyzed.

In the present study, there was neither hand file nor the rotary instrument separated or any procedural errors during the study. This may due to the fact that all participated operators in this study are experienced with hand K-file clinically and NiTi rotary instrument in extracted teeth. Recent studies also found that the incidence of procedural errors was much higher when root canal preparation were performed by dental students compared with endodontists.^{13,15}

The results of this study imply that ProFile® and its design (non-cutting tip) may be a suitable NiTi rotary instrument for dentists who have little experience in using rotary instrument to develop their skill in clinical practice without having critical errors. However, the experience in using hand file to develop a tactile sensation and practicing rotary instrument in extracted teeth are still necessary. Further studies comparing the efficacy of various NiTi rotary instruments with different designs should be carried out to search for the most proper instrument for inexperienced operators to use in root canal preparation.

Acknowledgements

This study was supported by a grant of dental research fund, Faculty of Dentistry, Chulalongkorn University.

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บทวิทยาการ

การเปรียบเทียบการเตรียมคลองรากฟันด้วยมือโดยใช้ตะไบเหล็กกล้าไร้สนิมกับการเตรียมด้วยเครื่องมือชนิดหมุนโดยใช้ตะไบนิเกิลไททาเนียม โดยทันตแพทย์ที่เพิ่งเริ่มมีประสบการณ์ในการใช้เครื่องมือชนิดหมุน: การศึกษาทางคลินิก

วีระ เลิศจิราการ

ผู้ช่วยศาสตราจารย์ ภาควิชาทันตกรรมหัตถการ
คณะทันตแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย

สุมาลี ส่งไพศาล

ทันตแพทย์ประจำโรงพยาบาลฟัน

คณะทันตแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย

ฉันทวัฒน์ สุทธิบุญพันธ์

ผู้ช่วยศาสตราจารย์ ภาควิชาทันตกรรมหัตถการ
คณะทันตแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย

ปิยาณี พาณิชยวิสัย

รองศาสตราจารย์ ภาควิชาทันตกรรมหัตถการ
คณะทันตแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย

ติดต่อเกี่ยวกับบทความ:

ผู้ช่วยศาสตราจารย์ ทันตแพทย์ ดร.วีระ เลิศจิราการ
ภาควิชาทันตกรรมหัตถการ
คณะทันตแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
ถนนอังรีดูนังต์ ปทุมวัน กทม. 10330
โทรศัพท์: 02-2188795, 02-2188785
อีเมล: veera.l@chula.ac.th

บทคัดย่อ

การศึกษานี้เป็นการเปรียบเทียบความโค้งของคลองรากฟัน ภายหลังจากการทำความสะอาดและขยายคลองรากฟันด้วยมือโดยใช้ตะไบเหล็กกล้าไร้สนิม กับ การใช้ตะไบนิเกิลไททาเนียม ชนิดหมุนด้วยเครื่อง ในผู้ป่วยที่ได้รับการรักษาโดยทันตแพทย์ผู้ซึ่งกำลังศึกษาอยู่ในหลักสูตรบัณฑิตศึกษา ซึ่งเพิ่งเริ่มมีประสบการณ์ในการใช้เครื่องมือชนิดหมุน รากใกล้กลางของฟันกรามล่างและรากใกล้กลางทางด้านแก้มของฟันกรามบน จำนวน 32 ราก ถูกแบ่งเป็น 2 กลุ่ม กลุ่มแรกได้รับการขยายคลองรากฟันด้วยมือโดยใช้ตะไบชนิดเคและสเตปแบ็กเทคนิคประยุกต์ กลุ่มที่สองได้รับการขยายคลองรากฟันด้วยไฟรไฟล์ โดยใช้คราวน์ดาวน์เทคนิค ภายหลังจากอุดคลองรากฟันแล้ว ความโค้งของคลองรากฟันที่ได้ประเมินจากภาพรังสีโดยใช้โปรแกรมคอมพิวเตอร์ ก่อนและหลังการขยายคลองรากฟัน ถูกนำมาวิเคราะห์เปรียบเทียบทางสถิติ ผลการศึกษาพบว่าการใช้ไฟรไฟล์ สามารถคงความโค้งของคลองรากฟันได้ดีกว่า การใช้ตะไบแบบเคขยายคลองรากฟันด้วยมืออย่างมีนัยสำคัญทางสถิติ ($p < .05$) การศึกษานี้แสดงให้เห็นว่าตะไบนิเกิลไททาเนียมชนิดหมุนด้วยเครื่องมีความปลอดภัยแม้ใช้งานโดยทันตแพทย์ที่เพิ่งเริ่มมีประสบการณ์ในการใช้เครื่องมือชนิดดังกล่าว