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Influence of root canal curvature on the screw-in effect of nickel-titanium rotary files in simulated resin root canal

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ABSTRACT

Objectives: Nickel-titanium (Ni-Ti) rotary instruments have some unexpected disadvantages including the tendency to screw-in to the canal. The purpose of this study was to evaluate the influence of root canal curvatures on the screw-in effect of Ni-Ti rotary files.

Materials and Methods: A total of 80 simulated root canals in clear resin blocks were used in the study. Canals with curvature of 0, 10, 20 and 30 degrees were instrumented with ProTaper instruments SX, S1, S2 and a ProFile of #25/0.06 to 1.0-2.0 mm beyond the initial point of root curvature. The screw-in force was measured with a specially designed device while canal was instrumented with a ProFile of #30/0.06 at a constant speed of 300 rpm. The data were subjected to one-way ANOVA and Scheffe multiple range test for post-hoc test.

Results: Larger degree of canal curvature generated significantly lesser screw-in forces in all groups ($p < 0.001$).

Conclusions: More attention needs to be paid when using rotary instruments in canals with less curvature than canals with more curvatures to prevent or reduce any accidental overinstrumentation. [J Kor Acad Cons Dent 2010;35(5):374-379.]

Key words: Canal curvature; Dynamometer; Nickel-titanium rotary file; Screw-in effect; Simulated resin root canal

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Introduction

Among several factors, success or failure of endodontic therapy depends on the quality of canal preparation.[1] This is essential because preparation determines the efficacy of all subsequent procedures and includes mechanical debridement, creation of space for medicament delivery, and optimized canal geometries for adequate obturation. Unfortunately, canal preparation is adversely influenced by the highly variable root canal anatomy.[2-4] To overcome this, a variety of endodontic instruments and canal preparation techniques have been introduced into the field of root canal treatment.

Canal preparation using stainless steel hand instruments is generally time-consuming and difficult in curved canals especially, because of its stiffness.[5,6] Stainless steel instrument is likely to cause canal aberrations such as zips, elbow, ledges and perforations.[7,8]

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During the late 1980s and 1990s, various types of endodontic instruments were developed with nickel-titanium alloys.[9] The introduction of nickel-titanium alloy for the mechanically driven endodontic instruments has greatly simplified shaping of the root canal systems.[9,10] Reports have shown that nickel-titanium (Ni-Ti) instruments are two or three times more flexible than conventional stainless steel files and that they have more resistance torsional fracture.[11] Thus, these instruments have been found to be better than stainless steel instruments in maintaining the original anatomy and the shape and position of the apical foramen.[6,12]

However, despite the distinct advantages of the new technique, Ni-Ti rotary instruments have several unexpected disadvantages. One of these is the tendency to screw-in to the canal.[13] This tendency is particularly accentuated during root canal preparation, especially when continuously rotating nickel-titanium instruments are used. Lack of tactile sense during the rotary instrumentation makes it more difficult to control the working length than during the hand instrumentation. For this reason, the screw-in effect during rotary instrumentation may cause overinstrumentation beyond the apical foramen.[14] Undoubtedly, instrumentation beyond the apical foramen reduces the success rate of the endodontic treatment.[9,15-19]

Cross-sectional geometry, helical angles, pitch length and taper of files are the factors which have been investigated to be involved in the screw-in effect of Ni-Ti rotary files. Diemer and Calas evaluated the effect of pitch length on the torsional stress and tendency to screw-in using two instruments with same cross-section (triple helix; 0.6% taper).[20] Their results showed that increasing the pitch length decreased torsional load sharing and the tendency to screw in. Schräder and Peter compared torques and forces developed by two sequences of nickel-titanium rotary instruments, using only .04 taper instruments or a combination of 04. and .06 tapers, respectively.[21] Their conclusions were an instrumentation sequence encompassing various tapers seems to be safer in torsional and fatigue failure compared to sequence that used only one single taper. Ha et al. compared the screw-in effect among several Ni-Ti rotary file systems.[13] The results showed that the design of the blade might be the cause of the significant differences of screw-in effect among the tested Ni-Ti rotary instruments. From the result of the study by Sung, rotary files with more taper produced more screw-in effect.[22]

Human dentition always contains root curvatures, and these curvatures may differ from mild to severe. In fact, if the root curvature is severe, then endodontic treatment of the associated pulp canal system becomes difficult. Objectives of the endodontic therapy include debriding the root canal system, continuously tapering in a conical form, and maintaining the original shape and position of the apical foramen.[23] However, ledge formation, transportation of the apical foraman, and nontapered hourglass-shaped preparation are problems frequently observed after the instrumentation on curved root canals.[24,25]

From this point of view, it is necessary to evaluate the effect of the root canal curvature as a factor which is involved in the screw-in effect of Ni-Ti rotary files. However, there has been no report that demonstrate the relation between the screw-in effect and the root canal curvatures.

Therefore, the purpose of this study was to evaluate the screw-in effect on several root canal curvatures by using Ni-Ti rotary files.

Materials and Methods

1. Specimen preparation

A total of 80 simulated root canals in clear resin blocks (Root Canal Model, Item number: S6-U1, S4-U1, S4-U4, S4-U6; Nissin Dental Prod. Inc., Kyoto, Japan) were used in this study. Specimens were divided into the following groups according to root canal curvatures: 0 (S6-U1), 10 (S4-U1), 20 (S4-U4) and 30 (S4-U6) degree. Twenty specimens were used in each group to obtain the results.

Preflaring of resin blocks were done by following procedures.

1. The shaping procedure commenced with ProTaper instruments (Dentsply-Maillefer, Ballaigues, Switzerland) SX, S1, and S2. The coronal and middle third of the root canal was

shaped if passive penetration was possible.

2. A ProFile (Dentsply-Maillefer) size 25 .06 taper instrument was inserted and used until 1.0-2.0 mm beyond the initial point of root curvature.

This preflaring allowed instruments to reach the canal curvature without any interference. Therefore, it was possible to evaluate the effect of difference in the degree of root canal curvature.

2. Measurement of screw-in force

ProFile.06 was used in the experiment. The tip diameter of the instrument was the same as that of ISO size #30.

All canals were prepared by using a custom-made device (Figure 1) with a 16 : 1 reduction hand-piece powered by an electric motor (SurgiMotor II, Aseptico Corp., Woodinville, WA, USA). The contra-angled hand-piece with the rotary file was mounted on the custom-made device and the files were automatically inserted into the canal of resin block. The position of resin block was marked when the file bound the canal at the first time. The resin block was moved 1.0 mm toward the rotary file. 1.0 mm single pecking motion was generated with screw-in of clock-wise direction. New instrument was used for each canal with saline irrigation.

When the instruments were withdrawn at the end of the pecking movement, a force that resist the withdrawal of the instrument from the root canal was generated. This axial stress caused pulling of the resin blocks. The resistance force was considered as the screw-in force. The dynamometer (K1368-10N, Lorenz Messtechnik Gmbh, Alfdorf, Germany) in the device recorded the transmitted resistance force in mA. The generated signals (mA) were amplified with a sensor-interface with USB (LCV-USB, Lorenz Messtechnik Gmbh, Alfdorf, Germany) and transferred to the computer software. The transferred signals were recorded with a software (LCV-USE-VS, Lorenz Messtechnik Gmbh, Alfdorf, Germany).

3. Statistical analysis

The data were analyzed with one-way ANOVA and Scheffe multiple range test for post-hoc test using SPSS 12.0 KO for windows (SPSS Inc., Chicago, IL, USA). p value of less than 0.05 were regarded as significant.

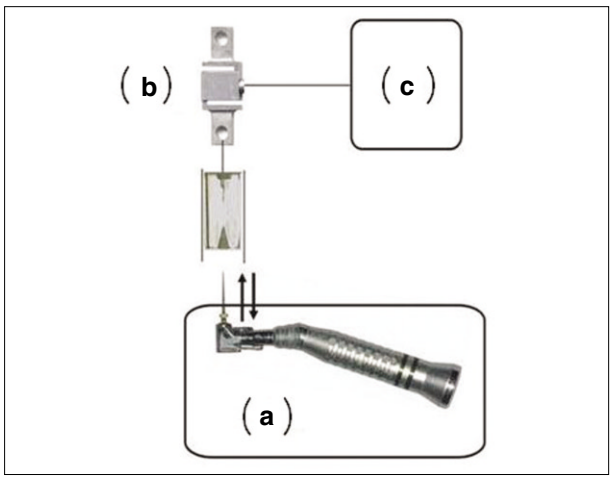

Figure 1. The custom-made device for the measurement of the screw-in effect. The device is composed of a part generating a single pecking movement of the handpiece (a) with a constant speed of 300 rpm, compression / tension sensor (b) and computer (c) for data storage, analysis.

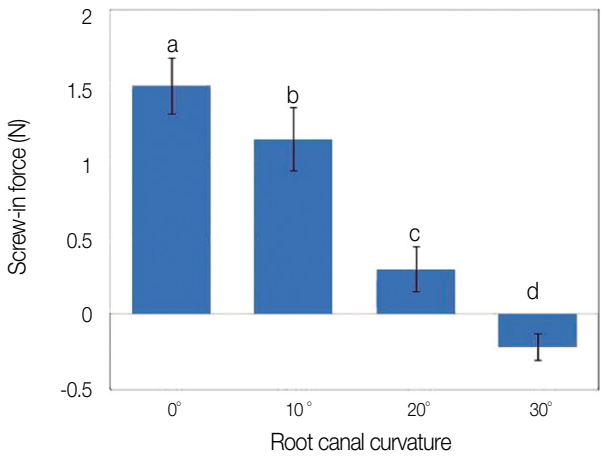

Figure 2. Screw-in force according to the root canal curvature of each resin block (mean ± S.D.). a, b, c, d: Letters indicate significant differences between materials by Scheffe multiple range test; $p < 0.001$.

Results

The screw-in forces at different canal curvatures are shown in Figure 2. Larger degree of canal curvature generated significantly less screw-in forces in all groups ($p < 0.001$).

Discussion

One aspect of canal configuration that has been shown to have an important influence on instrumentation is canal curvature. The amount of canal curvature may affect on access for instrumentation and also on the risk of instrument separation. Enlargement of curved canals may be difficult due to the potential complications of ledging, zipping, stripping, and apical debris compaction.[24] However, despite the importance of canal curvature in endodontic treatment, there was no research investigated on the outcomes regarding the screw-in effect of Ni-Ti rotary files on the severity of the root curvatures. Thus, in the present study, we evaluated the screw-in effect of Ni-Ti rotary files at various root curvature.

The fact that roots are curved was appreciated by stating the angle of the curve and then categorizing roots as mildly (< 5°), moderately (10° to 20°) or severely (> 20°) curved.[26] Thus, in the present study, specimens were divided into four groups according to the canal curvatures; 0, 10, 20 and 30 degree.

Determination of the real anatomical diameter is difficult when no preflaring is performed. This accuracy may be enhanced when anatomical diameter determination is performed after flaring.[27-29] Thus, in the present study, ProTaper Shaping Files (SX, S1, S2) and ProFile size 25 .06 taper instrument were used for preflaring in order to eliminate possible factors which may influence the result.

In the present study, simulated canals in resin blocks were used to eliminate variations of canal anatomy without using lubricants which may limit the number of variables and avoid stress measurement because of axial or transversal irrigation force.[30] However, although simulated canals in resin blocks allow comparisons between root canal curvatures under identical conditions, i.e, the standardization of shape, taper, and curvature of canal, there are certain disadvantages as their surface texture, abrasion behavior and hardness as well as cross-sections differ from those in natural teeth.

The results of present study showed that larger degree of canal curvature generated significantly lesser screw-in forces in all groups. It may be considered that following two reasons are the cause of this outcome.

As an instrument rotates in the canal, it binds against tooth structure, which places friction on the instrument called torque. The amount of torque generated while rotating in the canal is positively related to the mass of the instrument. Larger sized and greater taper files, although being stronger and having better torque resistance, will create more torque value on contact with the canal wall.[31,32] Canal curvature is the important factor in the determining the torque value. If the canal curvature is larger, it results in higher torque on file. As a result, it may be speculated that lesser screw-in force occurred in severely curved groups on this experiment.

In other point of view, the other reason may be that file with increased taper are likely to bind along the shaft. When the rotary instruments are continuously rotating, the stresses generated in the instruments are increased. Thus, more tapered instruments screw into dentin with more forces.[22] Moreover, most root canals are curved, whereas endodontic instruments are manufactured from straight metal blanks. This results in uneven force distribution in certain contact areas[3,34] and a tendency of the instrument to straighten itself inside the root canal.[35] If the degree of canal curvature decreases, files are likely to bind more along the shaft. As a result, it is assumed that the stresses generated in the instruments increase. Therefore, greater screw-in force to dentin occur.

In conclusion, within the condition of the present study, larger degree of canal curvature generated lesser screw-in forces. More attention should be paid when using rotary instruments in canals with less curvatures than canals with more curvatures to prevent or reduce the screw-in forces. Further research is needed to evaluate the relationship between the screw-in effect and root canal curvatures on natural

teeth and to find out the techniques to control this screw-in effect during rotary instrumentation.

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국문초록

모형 레진근관에서 근관의 만곡도가 니켈-티타늄 전동 파일의 screw-in effect에 미치는 영향

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연구목적: 근관의 만곡도가 니켈-티타늄 전동파일의 screw-in effect에 미치는 영향을 평가하고자 하였다.
연구 재료 및 방법: 0, 10, 20, 그리고 30도의 만곡을 가지는 80개의 레진모형근관 (Nissin Dental Prod. Inc.)에서 0.06 경사도 30번 전동화일 (ProTaper, Dentsply-Maillefer)을 분당 300회전, 단일 pecking 동작으로 기구조작하였으며 dynamometer를 이용하여 발생한 screw-in force를 측정하였다. 결과치는 one-way ANOVA로 통계처리 하였고, Scheffe multiple range test를 사용하여 95% 수준에서 유의성을 검정하였다.
결과: 근관의 만곡도가 작을수록 screw-in force가 높게 나타났으며 ($p < 0.001$), 모든 그룹 간에 유의성 있는 차이를 보였다.
결론: 이 결과로 미루어 볼 때, 근관의 만곡도가 작을수록 screw-in force가 많이 발생하는 것으로 보여지며, 따라서 기구조작 동안의 screw-in force를 방지 또는 억제하기 위해서는 만곡도가 작은 근관을 성형할 때 더 많은 주의가 요구될 것으로 생각된다.

주요단어: 근관만곡도; 니켈-티타늄 전동화일; 모형 레진근관; Dynamometer; Screw-in effect