# Stress Generation during Pecking Motion of Rotary Nickel-titanium Instruments with Different Pecking Depth

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## Abstract

**Introduction:** The aim of this study was to evaluate the effect of different pecking depth on the stress generated by the screw-in forces of a rotating endodontic file in simulated canals. **Methods:** Twenty simulated resin blocks with a J-shaped curvature were used. Twenty OneG files (MicroMega, Besançon, France) were assigned for a screw-in test depending on the pecking depth in 2 groups ($n$ = 10). The files were operated at 300 rpm, and the up and down speed was controlled at 1 mm/s stroke velocity and a 10-millisecond dwell time using a customized device. The distances (pecking depth) for the pecking motion were 2 mm or 4 mm for each group; "6 mm forward and 4 mm backward" and "6 mm forward and 2 mm backward" movements were applied, respectively, for the 2 pecking groups. During the operation, the positive and negative apical loads were recorded at a rate of 50 Hz using customized software attached to the device. The maximum negative apical load (screw-in force [SF]) was recorded, and the total energy during pecking motion until the file reached the working length (cumulative screw-in forces [CSFs]) was computed. The data were analyzed using an independent $t$ test at a significance level of 95%. **Results:** No significant difference in SF was found between the 2 groups of pecking depths. However, the longer pecking depth (4-mm group) showed a significantly larger CSF compared with the shorter pecking depth group ($P$ < .05). **Conclusions:** The shorter pecking depth may generate lower overall stresses for the root dentin as well as the instrument. *(J Endod 2017;■:1–4)*

## Key Words

Instrument fracture, nickel-titanium rotary file, pecking depth, screw-in force, stress generation

### Significance

A shorter pecking depth may generate lower stresses on the root dentin as well as the instrument. This suggests that a shorter pecking depth while using a NiTi rotary instrument may reduce the risk of root cracks and instrument separation.

There is a consensus that nickel-titanium (NiTi) rotary instruments are more efficient than stainless steel files for root canal shaping. NiTi alloy also allows the instrument to better preserve the original root canal anatomy, especially curvatures (1, 2). However, NiTi instruments do have a few disadvantages, such as high cost and fatigue fracture. Another concern for some file systems is the "screw-in tendency" or the sensation of being "pulled" into the canal when the file rotates (3, 4). The screw-in tendency might cause unwanted penetration of the instrument beyond the apical foramen, thereby enlarging the apical foramen unnecessarily, which certainly is against Schilder's 5 mechanical objectives (5). The instrument tip may also become engaged into the dentin very quickly, giving rise to an instantaneous increase in torsional stress and risk of instrument fracture (6).

Some studies have examined the inter-relationship between the file design and the screw-in tendency. Most of those have compared different brands of instruments using mechanical tests in simulated resin canals or simulated screw-in tendency with standard geometric models using a numeric analysis approach (3, 4, 7). Various other stresses, apart from the screw-in stress, are generated during the rotation friction between the file and root dentin. These stresses can build up and eventually might increase the risk of root cracks and/or instrument fracture.

An in-and-out motion, also known as the pecking motion, of NiTi rotary instrumentation has been recommended to reduce the risk of fracture through distribution of the flexural stress of the instrument (8). The pecking motion is intended to be a controlled movement against the screw-in forces (SFs) by the rotating instruments. In previous studies on cyclic fatigue, the NiTi instrument has rotated freely on an inclined metal plate or in a simulated metal canal (8–11). Under those conditions, the inter-relationship between instrument and dentin in generating torsional and screw-in stress is not tested at all (811). During actual clinical situations, stress generation in the file and dentin may vary with different pecking depths, and different pecking depths may have a different effect on stress distribution. Therefore, the aim of this study was to evaluate the stress generation by SFs during the file rotation and pecking motion according to the different pecking depth.

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## Materials and Methods

Twenty simulated resin blocks (Dentsply Maillefer, Ballaigues, Switzerland) with a J-shaped curvature (35°) were used. Considering the size and anatomy of a simulated root canal (0.15 mm in diameter and a parallel taper except the coronal entrance), the OneG (Micro-Mega, Besançon, France) file, which has a 3% taper and ISO tip size #14, was selected. The canal length and apical exit diameter of the simulated resin block were 16.5 mm and ISO #15, respectively (12, 13). The working length was determined as 16.0 mm, which was 0.5 mm short from the canal exit, and was reconfirmed with a #10 K-file (Dentsply Maillefer) under a stereomicroscope (Leica S6D; Leica Microsystems, Wetzlar, Germany).

Twenty new OneG files were randomly assigned into 2 groups to test the effect of 2 different pecking depths on screw-in stress ($n$ = 10 for each group) (Fig. 1*A* and *B*). Before the experiments, all of the files were also observed under the stereomicroscope to rule out any visible defect in the files. The simulated resin canals were filled with tridistilled water for lubrication. The files were operated at 300 rpm, and the up and down speed was controlled at 1 mm/s stroke velocity and a 10-millisecond dwell time using AEndoS (DMJ System, Busan, Korea; Fig. 1). The pecking depths during pecking motion were 2 mm or 4 mm in each group. In the group with a 2-mm pecking depth, the files penetrated 2 mm deeper into the apical direction in each pecking motion by 6-mm forward and 4-mm backward movements (Fig. 2*A*). Similarly, 6-mm forward and 2-mm backward movements resulted in 4 mm penetration in each pecking motion (Fig. 2*B*). During the tests, the positive and negative apical loads were recorded at a rate of 50 Hz using customized software attached to the AEndoS. After the experiments, the files were examined again under the stereomicroscope for any distortion or unwinding.

The maximum negative apical load (SF) was recorded, and the total energy during pecking motion until the file reached the working length (cumulative screw-in forces [CSFs]) was computed from the area under the plot using Origin v 6.0 Professional (Microcal Software Inc, Northampton, MA). The data were analyzed statistically using an independent $t$ test at a significance level of 95% using SPSS software (Version 22 for Mac; IBM Corp, Armonk, NY).

## Results

The representative strip charts recording the SFs are presented in Figure 2. The results are shown in Table 1. No significant difference in the maximum SF was found between the 2 groups of pecking depths. However, the longer pecking depth in the 4-mm group showed a significantly larger cumulative screw-in force (CSF) than the shorter pecking depth group ($P < .05$). No instrument after the experiments was found to have unwinding and/or fracture.

## Discussion

During rotary instrumentation, contacts exist between the instrument and dentin surface that create a reaction torque in the instrument and internal stresses in the root dentin (4, 7, 14, 15). This is especially evident in a curved root canal in which stresses are concentrated in the part of the rotary instrument near the shortest radius area. In this clinical condition, the pecking motion and its working distances are important features for distributing the stress concentration during rotation of the file. The longer pecking depth may distribute the stress further to the expanded/longer area of the file shaft than a shorter pecking depth (8). Until now, there have been no reports about the effect of the pecking depth.

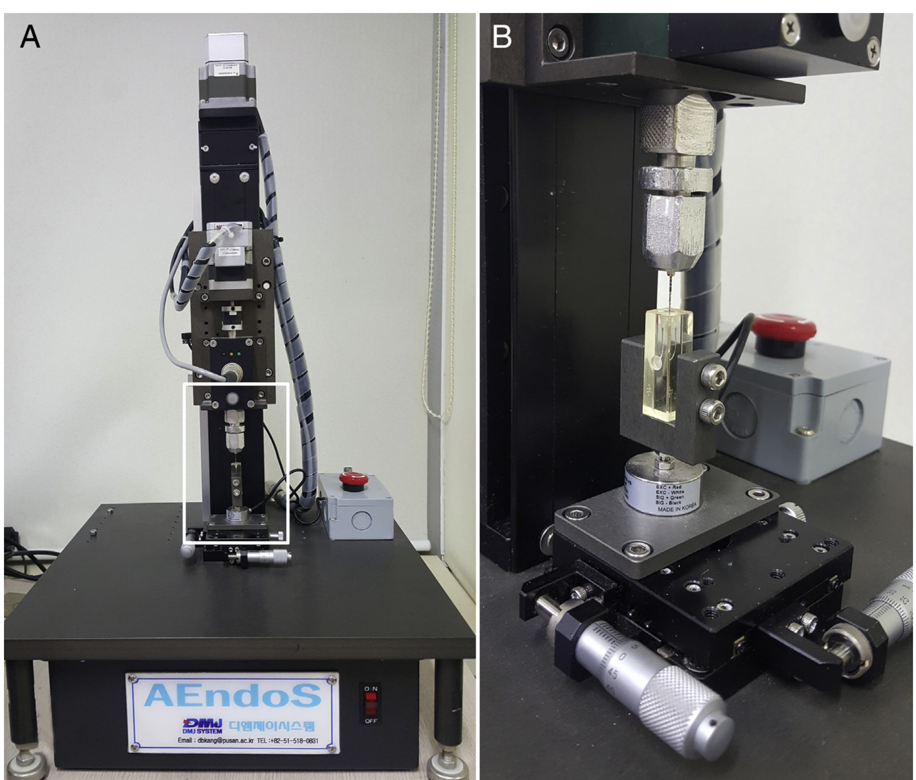


**Figure 1.** (*A*) The experimental device (AEndoS) used to simulate pecking motion and to measure the apical load during file movement. (*B*) (The *white box* from *A*) The simulated canal block is attached to the device for measuring the apical load.