

# Determination of the Minimum Instrumentation Size for Penetration of Irrigants to the Apical Third of Root Canal Systems

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## Abstract

The purpose of this study was to determine the minimum instrumentation size required for the effective penetration of irrigants and elimination of debris and smear layer from the apical third of the root canals. The mesiobuccal canals of 40 freshly extracted human mandibular first molar teeth were instrumented using the crown-down technique. The teeth were divided into four test groups according to the size of their Master Apical File (#20, #25, #30, #35), and two control groups. After final irrigation, the removal of debris and smear layer from the apical third of root canals was determined under a scanning electron microscope. The data was analyzed using Kruskal-Wallis and Mann-Whitney tests. Based on the results, it appears that the minimum instrumentation size needed for penetration of irrigants to the apical third of the root canal is a #30 file. (*J Endod* 2006;32:417–420)

## Key Words

Debris, minimum instrumentation, penetration of irrigants, smear layer

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Many studies have shown the role of bacteria and their by-products in the pathogenesis of pulpal and periapical diseases (1–3). The main objectives of root canal therapy are disinfection and complete obturation of the root canal system, and prevention of reinfection (3). Because of their anatomical complexity, some organic tissues and bacteria are left inside many root canal systems despite using various mechanical preparations (1, 4). Consequently, different irrigants are used during cleaning and shaping root canals for the removal of the smear layer and necrotic tissues (2, 5).

Root canal preparation is accomplished using a combination of mechanical instrumentation and chemical irrigation (6–8). Sodium hypochlorite (NaOCl) has been the most commonly used endodontic irrigant for the past four decades. This irrigant dissolves organic substances and is an effective antimicrobial agent against many bacteria, fungi, protozoa, viruses, and bacterial spores (9–11). Sodium hypochlorite in conjunction with Ethylenediaminetetraacetic acid (EDTA) is able to remove remaining pulp tissue, smear layer, and pre dentine (12–14).

The penetration of irrigants to the apical third of canals and removal of debris are dependent on the final size of the instruments used in the canals (15). Different results have been reported regarding the effectiveness of minimum enlargement size in the apical third of canals to achieve proper penetration of irrigants (2–5, 15).

The purpose of this study was to determine the minimum canal enlargement in the apical part of instrumented canals for the removal of debris and the smear layer.

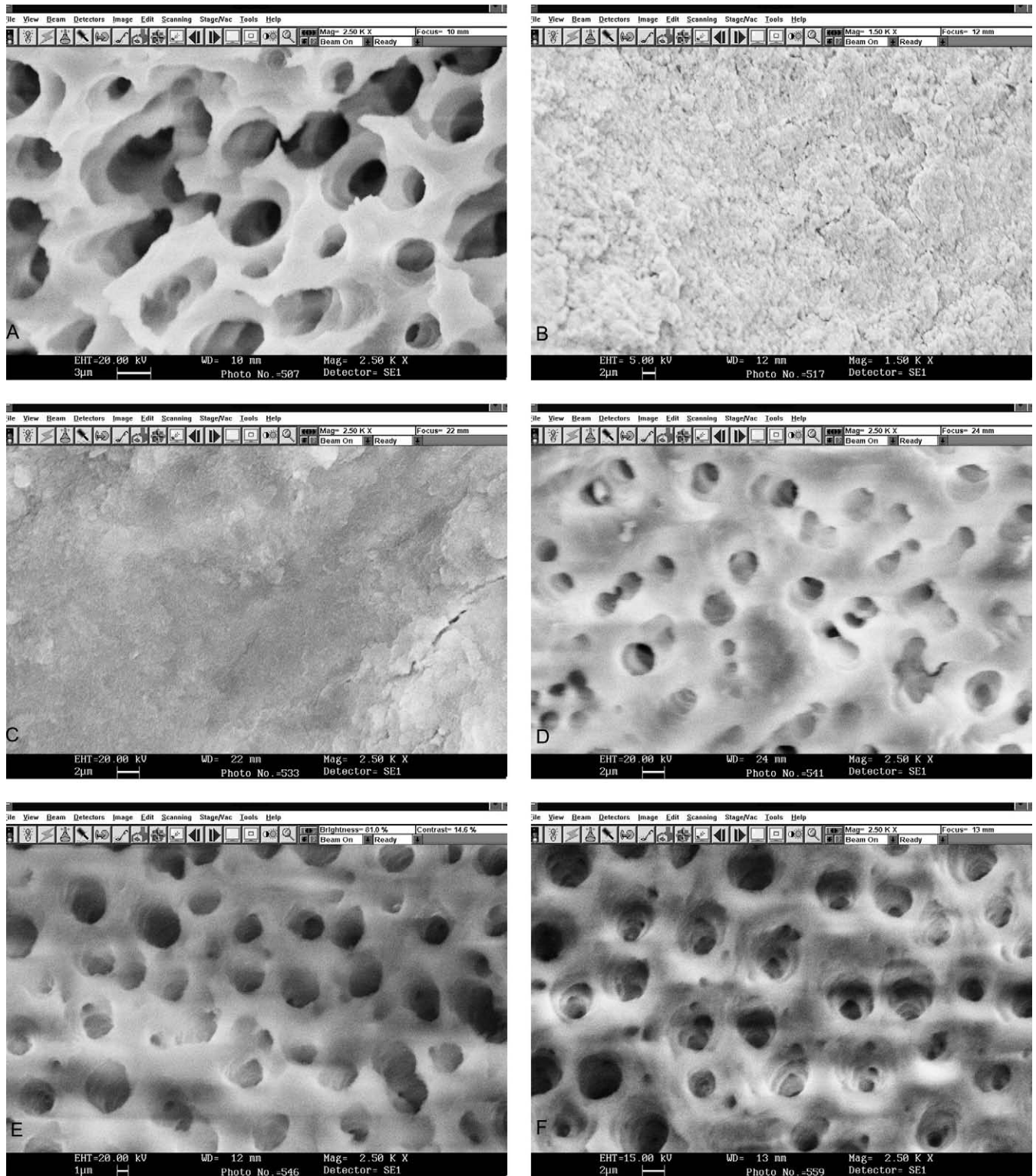
## Materials and Methods

Forty freshly extracted human mature mandibular molar teeth with two separate mesial canals, lengths of 20 to 23 mm, and a curvature of 15 to 25 degrees were used in this study. Studies have shown that 95.2% of these teeth have two canals in the mesial root (16), and two separate apical foramens 87.06% of the time (17).

After establishing a straight line access cavity using a diamond fissure bur (Tizkawan, Tehran, Iran) in a high-speed handpiece, the working length of mesiobuccal canals was visually determined by a K-File #10 (Maileffer, Switzerland) 0.5 mm short of the apical foramen. Then, the root end of each tooth was covered with melted wax to disable the operator from seeing root canal instrumentation during cleaning and shaping.

The teeth were divided into four experimental groups with eight teeth in each, and two control groups with four teeth in each. The mesiobuccal canals were instrumented by crown-down technique using hand files (Maileffer) and rotary files (Flexmaster, VDW, Germany). Each canal in the four experimental groups was enlarged at the working length to a #20 file in group 1; #25 file in group 2; #30 file in group 3; and #35 file in group 4. Each canal in the two control groups was enlarged at the working length to a #40 hand NiTi file.

Root canals in all groups were irrigated with 2 ml of 5.25% NaOCl using a 27-gauge needle after each instrument. In the four experimental groups and the positive control group each canal received a final irrigation of 5 ml of 17% EDTA for 5 min followed by 5 ml of 5.25% NaOCl for 5 min. Final irrigation in the negative control group was only with 5 ml of 5.25% NaOCl for 5 min. Root canals in all groups were irrigated with 5 ml of distilled water to remove any effects of irrigants. Two grooves without entrance into the canals were created on the buccal and lingual surfaces of the mesial root; each root



**Figure 1.** Photomicrographs of the apical third of canals under SEM ( $\times 2500$ ). (A) Positive control group: The entire removal of smear layer and erosion at orifices of dentinal tubules is seen. (B) Negative control group: The smear layer has covered the surface of the canal completely and dentinal tubules are closed. (C) First test group, or file #20: The smear layer has covered the entire surface of the canal and dentinal tubules are closed. (D) Second test group, or file #25: A great amount of debris and smear layer has been removed, but some smear layer and closed dentinal tubules are still observed. (E) Third test group, or file #30: The dentinal tubules are completely open and the entire surface is devoid of smear layer. (F) Fourth test group, or file #35: The dentinal tubules are completely open and the entire surface is devoid of smear layer. Some regions of dentinal erosion are seen in peritubular dentine.

was split longitudinally in a buccolingual direction. One-half of each root was randomly selected and placed in a 2% glutaraldehyde solution for 24 h.

The fixed specimens were rinsed three times with a sodium cacodylate buffered solution (0.1 M, pH = 7.2), incubated in osmium tetroxide for 1 hr, dehydrated with ascending concentration of ethyl alcohol (30-100%) and placed in a desiccator for at least 24 h. Each specimen was then mounted on an aluminum stub, coated with 25  $\mu\text{m}$  of gold palladium and examined under a scanning electron microscope (SEM). Photomicrographs of the apical third of each canal with a magnification of  $\times 2500$  were taken for final evaluation.

In a blind manner, three investigators scored the presence or absence of smear layer on the surface of the root canal or in the dentinal tubules from the coded photomicrographs.

A score of 1 through 8 was used for the evaluation of photomicrographs (18):

Score 1: The surface is devoid of debris and smear layer.

Score 2: The surface is devoid of smear layer, but little debris is observed.

Score 3: The surface has been cleaned, but both smear layer and debris are dispersedly observed.

Score 4: The surface has been cleaned, but the level of smear layer and debris is also noticeable.

Score 5: The clean surface is a bit greater than unclean surface.

Score 6: Almost half of smear layer and debris have been removed.

Score 7: The greater part of smear layer and debris are left.

Score 8: The surface is completely covered with smear layer and debris.

After scoring the photomicrographs, the information was recorded and analyzed using Kruskal-Wallis and Mann-Whitney tests.

## Results

All of the specimens in the positive control group were devoid of smear layer and had significant erosion at the orifices of the dentinal tubules. Each specimen in this group received a score of 1. All the specimens in the negative control group were covered with smear layer and debris. Each specimen in this group received a score of 8.

All of the specimens in the experimental group 1 (instrumented at the working length to a #20 file) were covered with smear layer and debris. Each specimen in this group received a score of 8. The mean score for specimens in the experimental group 2 (instrumented at the working length to a #25 file) was 3.4. This score translates to removal of 76% of debris and smear layer in this group. All of the specimens in experimental group 3 (instrumented at the working length to a #30 file) scored 1, indicating that 100% of debris and smear layer was removed in this group.

Similar observations were made in all the specimens in experimental group 4 (instrumented at the working length to a #35 file).

Representative samples from experimental and control groups are shown in Fig. 1. Figure 2 is a barograph of the percentage of smear layer removal from the apical third of canals in all six groups.

Statistical analysis of data using Kruskal-Wallis and Mann-Whitney tests showed that the difference was statistically significant ( $p < 0.05$ ) between groups 1 and 2, as well as between groups 2 and 3. No significant statistical difference was noted between groups 3 and 4.

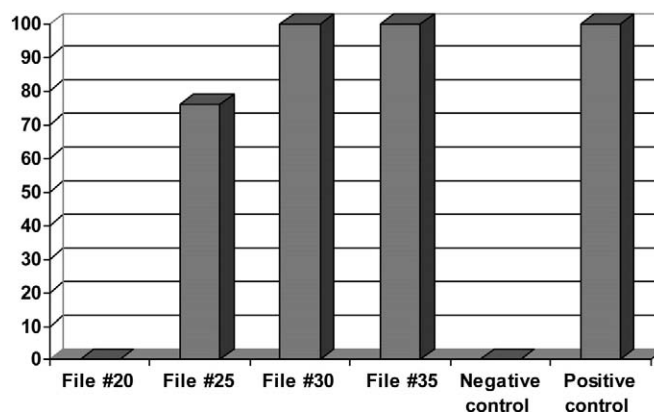


Figure 2. Smear layer removal from the apical third of the canal in six groups (percent).

## Discussion

A number of studies have shown instrumentation to files larger than #30 reduces the bacterial counts, enhances the antibacterial effects of intracanal irrigants and prevents late bacterial growth after cleaning and shaping of root canals (15, 19–21). Wu and Wesselink (4) and others (22–24) have recommended enlarging the canals to sizes over #40 files to remove more debris from the canals and achieve better cleaning in the apical thirds of the root canals. However, these authors do not mention that instrumentation to these sizes increases the risk of perforation, ledge, and transportation, especially in narrow and curved root canals.

In contrast to these findings, the study by Yared and Dagher (25) reports that a #25 file was as efficient as a #40 file for reducing residual microorganisms. Based on their findings, Coldero et al. (26) conclude that no excessive apical enlargement is necessary for intracanal bacterial reduction. Albrecht et al. (27) instrumented the canals with various tapers of Profile GT files and observed a significantly greater percentage of remaining debris in the apical areas of the canals enlarged to the size #20 preparations compared to larger instruments. Based on these studies and our findings, which show the minimum instrumentation for proper penetration of irrigants to the apical third of the canal is a #30 file, it appears unnecessary to remove dentine in the apical part of the root canal when a suitable coronal taper is achieved. Proper tapering allows satisfactory irrigation of the root canal system with antimicrobial agents. Our results are also consistent with the findings of Mirzabagherian (28), who used orographin as a contrast media to trace penetration of irrigants into the apical third of instrumented canals. In contrast to our findings, Senia et al. (29) reports minimum penetration of NaOCl to the apical part of canals enlarged to #30 files. This difference may be related to the taper of instruments used in these studies (0.02 in their study versus 0.06 in our study).

Despite the findings of many studies that recommend canal preparation with files larger than #30/35 for better penetration of irrigants and elimination of bacteria during cleaning and shaping, we found that apical instrumentation to a #30 size file with 0.06 coronal taper is effective for the removal of debris and smear layer from the apical portion of root canals.

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