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Comparison of Dental Defects in Oval Root Canals Prepared with Two Distinct Endodontic Rotary Files: An In Vitro Analysis

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ABSTRACT

Aim: This study aims to investigate and compare the occurrence of dentinal fractures during root canal preparation using a scanning electron microscope (SEM).
Materials and Methods: Thirty extracted human mandibular premolars were divided into three groups of ten: two experimental groups and one control group. In the experimental groups, root canals were shaped using Group I: the Waldent Walflex file and Group II: the Trunatomy (TRN) file. Group III served as the control group with no canal preparation. After sectioning the roots at 3, 6, and 9 mm from the apex, the surfaces were analyzed using SEM.
Results: Data were analyzed using the Chi-square test. The untreated control group (Group III) showed no signs of cracks. Dentinal cracks were primarily observed in the Waldent Walflex group, particularly between the 3 mm and 6 mm intervals.
Conclusion: The study highlights that dentinal cracks are more pronounced with the Waldent Walflex file. These findings underscore the need for careful selection of endodontic instruments to minimize the risk of dentinal defects during root canal procedures. Further research is warranted to explore the long-term implications of these findings on treatment outcomes.

Introduction:

The successful treatment of endodontic diseases relies heavily on effective root canal preparation, which aims to remove infected pulp tissue and create a suitable environment for filling the canal system. One of the critical challenges faced

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during this process is the potential for dentinal fractures, which can compromise tooth integrity and long-term prognosis. The advancement of rotary instrumentation has introduced various endodontic rotary files designed to enhance canal shaping efficiency while minimizing mechanical stress on dentin.1,2

Dentinal cracks may occur as a result of inappropriate instrumentation techniques, file design, or the inherent mechanical properties of the tooth structure. The location and severity of these defects are significant, as they can lead to complications such as the need for retreatment or even tooth loss. Previous studies have indicated that the incidence of dentinal fractures can vary based on the type of rotary file used, with significant differences observed among various instruments.3,4

This study aims to provide a comprehensive analysis of the extent to which different rotary files contribute to the formation of dentinal cracks during root canal preparation. By employing scanning electron microscopy, we aim to gain insights into the microstructural changes induced by the Waldent Walflex and Trunatomy (TRN) files in human mandibular premolars. This comparative approach will not only elucidate the mechanical impact of these endodontic instruments but also highlight their clinical implications in preserving tooth structure during treatment. Ultimately, understanding the behavior of these tools in relation to dentinal integrity can guide practitioners in choosing the most suitable file systems for their patients, enhancing the efficacy of endodontic therapy while minimizing risks.

Materials and methods:

Thirty human mandibular premolar teeth with closed apices were extracted from individuals. A periodontal scaler was employed to clean the teeth thoroughly and remove any soft tissue debris. Following this, a 0.1% thymol solution was used to disinfect the teeth. Radiographs were obtained from both mesiodistal and buccolingual perspectives. Teeth exhibiting root fractures, cracks, open apices, curved canals, multiple roots, carious lesions or fillings, significant anatomical variations, calcified canals, or resorption were excluded from the study.

For root canal preparation, a size #10 K-file (Mani Co, Tokyo, Japan) was used to verify that the canals were patent, and working lengths were established at 1 mm short of the apex. A size #15 K-file was then utilized to create a glide path (Mani Co, Tokyo, Japan). The roots were subsequently embedded in self-curing acrylic resin, and a hydrophilic vinyl polysiloxane impression material was applied to simulate the periodontal ligament (PDL).

Based on the different nickel-titanium (Ni-Ti) files utilized for canal preparation, the specimens were categorized into three groups: two experimental groups and one control group (n = 10). Group I consisted of the Waldent Wal-Flex files, while Group II included the Trunatomy files. Group III functioned as the control group with no canal preparation.

The cleaning of the root canals was performed using an X-Smart (Dentsply) endodontic motor, set to the manufacturer's recommended torque and speed specifications: 1.8–3 Ncm and 300 rpm for the Waldent Wal-Flex files, and 2.5–3 Ncm and 300 rpm for the Trunatomy files. To eliminate potential bias, all procedural steps were conducted by a single, experienced operator.

In Group I, the Waldent Wal-Flex files were used in the following order: W1 (17/0.08), W2 (19/0.02), W3 (20/0.04), W4 (20/0.06), and W6 (25/0.06). Group II utilized the Trunatomy files, including the TRN orifice modifier (20/0.08), TRN glider (17/0.02), and TRN Prime (26/0.04), until the designated working length was achieved.

Each file was used only once for the instrumentation of a single canal. The instrumentation process involved a full rotation of the file, complemented by light pecking movements in and out. In the control group, no preparation was conducted on the canals.

During the cleaning process, the canals were irrigated with 2 mL of 3% sodium hypochlorite (Prime Dental Products Pvt Ltd.), followed by 5 mL of saline (Disopovan, HMD health Care), and 5 mL of 17% ethylene diamine tetraacetic acid (Prevest Dentpro) after each instrument change. The final rinse consisted of 2 mL of sodium hypochlorite. Additionally, the teeth were trimmed using a diamond disc cooled with water, positioned 16 mm from the tip.

To evaluate dentinal cracks, each sample was sectioned using a diamond disc into slices measuring 3 mm (apical), 6 mm (middle), and 9 mm (coronal) from the root apex, cut perpendicular to the long axis of the teeth. These slices were then examined under SEM. A crack was defined as a defect originating from the inner root canal space and propagating outward toward the external tooth surface, while other defects, such as craze lines that did not arise from the canal wall, were not classified as cracks.

All collected data were analyzed using appropriate statistical methods. The findings were then interpreted to assess the incidence of dentinal cracks among the different groups.

Results:

The control group displayed no defects at any level. A significant difference was observed between the experimental groups ($P < 0.05$) compared to the control. In Group I (Waldent), there were 5 cracks at 3 mm, 2 at 6 mm, and none at 9 mm, while Group II (TRN) had 2 cracks at 3 mm, 1 at 6 mm, and none at 9 mm. SEM results confirmed this trend, with Waldent at 70% and TRN at 30%, significant difference was found between the groups ($p < 0.05$).

Table 1: Defects in the dentinal cross sections at 3, 6, and 9 (mm) (n=10), viewed in SEM

Groups	3mm	6mm	9mm	Total number of specimens presenting defects (%)	Inter-group comparison
Group 1 (Waldent Wal Flex)	5	2	0	7 (70.0)	1-2 (<0.05*)
Group 2 (Truanatomy)	2	1	0	3 (30.0)	1-3 (<0.05*)
Group 3 (Control group)	0	0	0	0 (0.0)	2-3 (<0.05*)
$\chi 2$ value	3.110	2.131	--		

*Significant

Discussion:

Biomechanical preparation of the root canal with various rotary NiTi endodontic files may lead to strain and stress, which can cause the formation of dentinal microcracks in root dentine.5-7 This study aimed to evaluate the incidence of dentinal cracks during root canal preparation using two different nickel-titanium (Ni-Ti) rotary files—Waldent Walflex and Trunatomy (TRN)—in extracted human mandibular premolar teeth. The findings highlight crucial insights into how different instrumentation techniques can influence the integrity of dentin, an essential consideration in endodontic therapy.

The control group exhibited no defects across all measuring points, underscoring the importance of using standardized, unprepared teeth for baseline evaluations. This result serves as a vital reference, reinforcing that cracks can arise specifically from the preparation process rather than pre-existing conditions in the teeth.

When comparing the two experimental groups, a significant difference in the incidence of cracks was noted ($P < 0.05$) relative to the control group. In Group I, which used the Waldent Walflex files, there were more cracks at both the 3 mm and 6 mm levels - 5 and 2, respectively—indicating that this particular file may exert greater stress on dentin during instrumentation. This observation aligns with previous literature suggesting that some rotary files can lead to an increased likelihood of micro-crack formation due to their design, cutting efficiency, and motion dynamics.8,9

In contrast, Group II, utilizing the TRN files, exhibited fewer crack - 2 at 3 mm and 1 at 6 mm. This reduced number suggests that the TRN file design may be more effective in maintaining the structural integrity of dentin during canal preparation. The results are particularly relevant as they provide a comparative assessment of the biomechanical impacts of different rotary instruments, a critical factor in successful endodontic treatment outcomes. Despite the trend favoring TRN files there is a need for larger sample sizes or further investigation into other contributing factors that might unveil differences in performance under varying conditions.

Overall, the results obtained in this study provide valuable information for clinicians regarding the selection of rotary files in endodontic procedures. The tendency of Waldent files to cause greater dentinal cracks may influence a clinician's choice, particularly in teeth with thinner walls or extensive pre-existing conditions. The findings suggest that while both files deliver acceptable outcomes in terms of canal preparation, the TRN files might offer a more conservative approach to dentin preservation.

Future research could benefit from exploring other variables, such as working speed, irrigation protocols, and different tooth morphologies, to provide a fuller understanding of the biomechanical interactions involved in root canal instrumentation. Additionally, longitudinal studies tracking post-treatment outcomes would be valuable in assessing the long-term implications of using different rotary file systems on tooth integrity and clinical success rates in endodontic therapy.10

Conclusion:

Dentinal fissures were created by every rotary file used in the tests. Cracks were more common in the Waldent walflex files group compared to the TRN files group. Defects were found to be substantially higher in the apical region of samples than in the median and coronal sections.

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