Root canal and dentin changes by offset designed files in mandibular premolars with radicular grooves and two canals: a micro-CT study

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Aims

Radicular grooves in the cervical-apical direction on proximal surfaces is reported in 78.5% of mandibular premolars (1), which are commonly associated with the presence of additional canals (2,3) and relevant to the occurrence of the C-shaped canals (3,4,5,6).These radicular grooves can vary in length and depth and the dentin wall could be thin (2,3). These morphological features are critical to establishing adequate endodontic treatment protocols in order to avoid strip perforations or weakening of the root structure (3,6). Over the years, different instruments have been developed in order to prepare all walls and respect the original anatomy of the radicular canals (7,8,9). The fifth generation of shaping files has been designed such that the center of rotation are offset. In rotation, these files produce a mechanical wave of motion that travels along the active length of the file (7). One of the file systems that offer this technology is the ProTaper Next (PTN). Moreover, the PTN files present the decreasing percentage tapers to enhance flexibility and conserve radicular dentin during shaping procedures (7). To the best of our knowledge, there are no studies that address the canal and dentin changes performed by shaping protocols in mandibular premolars with radicular grooves.Thus, the aim of this study was to evaluate the effects of shaping protocol with PTN system on the root canal geometry and remaining dentine thickness of mandibular premolars with radicular grooves and two canals by means of micro-CT.

Method

Ten mandibular premolars with radicular grooves, and two canals detected by micro-CT scanning were selected. Thus, ProTaper Next (PTN) system was used for the canal shaping and the files were activated by an electric motor (VDW Silver; VDW GmbH, Munich, Germany). The samples were scanned before and after the canal shaping, by using a micro-CT device (SkyScan1176; Bruker-microCT, Kontich, Belgium). The scanner parameters were set at 90 kV, 278 µA, isotropic resolution of 18µm, averaging frames of 2, 180° rotation and rotation step of 0.5°, using a 0.1 mm-thick copper filter. Pre and post shaping images were geometrically aligned using the coregistration tool in DataViewer software (v.1.5.6.2, Bruker microCT). Then, matched images were used to obtain the 2D (area and perimeter) and 3D parameters (volume, surface area and structure model index - SMI) of root canals before and after shaping using CTAn v.1.18.8.0 software (Bruker microCT) as well as untouched canal walls. In the same software, the dentin volume was calculated and a 3D mapping of the dentin thickness was created and saved for structure thickness. Further, the percentage volume of dentin below than 0.5 mm thickness was calculated and the color-coded 3D models of dentin were evaluated qualitatively using CTVox v.3.3.0 software (Bruker microCT). The evaluations were done for the middle and apical thirds. The pre and postpreparation parameters were compared using the paired t test. The significance level was set at 95% (SPSS v17.0; SPSS Inc, Chicago, IL, USA).

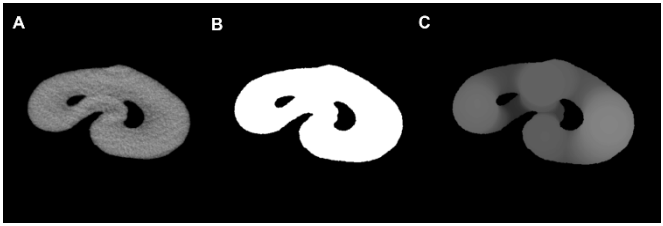


Figure 1. Processing and analysis of reconstructed images in CTAn software. (A) Original reconstructed image. (B) Binarized image. (C) Binarized image based on 3D mapping of the dentin thickness.

Results

The shaping protocol using PTN system increased all 3D and 2D parameters in the middle and apical third (Tables 1 and 2). It was observed 37.36 ± 18.74% of untouched canal walls after canal shaping.

Table 1. Mean (± standard deviation) of the 2D parameters of the root canal system of mandibular premolars with radicular grooves before and after canal shaping.

2D parameters	Root Thirds	
	Middle Third	Apical Third
Area (mm) (initial)	0.38±0.18^{A}	0.13±0.05^{A}
After shaping	1.10±0.41^{B}	0.41±0.18^{B}
%Δ	232.28±109.42	222.17±94.00
Perimeter (mm) (initial)	3.56±0.72^{A}	2.18±0.59^{A}
After shaping	5.72±0.71^{B}	3.66±0.74^{B}
%Δ	68.30±26.72	71.21±27.75

Δ, mean increase. Different letters in the same column indicate statistical difference within parameter (paired t test, p<0.05).

Table 2. Mean (± standard deviation) of the 3D parameters of the root canal system of mandibular premolars with radicular grooves before and after canal shaping.

3D parameters	
Volume (mm^3) (initial)	3.21±3.41^{A}
After shaping	8.17±4.74^{B}
%Δ	194.25±109.21
Surface area (mm^2) (initial)	32.29±14.47^{A}
After shaping	49.40±15.91^{B}
%Δ	59.19±27.85
SMI (initial)	2.42±0.39^{A}
After shaping	3.05±0.38^{B}
%Δ	27.77±21.61

Δ, mean increase. Different letters in the same column indicate statistical difference within parameter (paired t test, p<0.05).

Regarding root dentin, there was a reduction of 3.03 ± 2.79% in the total volume. Furthermore, the percentage volume of dentin below 0.5 mm was 0.71±0.34% before shaping and there was an increase in this percentage for 1.16 ± 0.71% after shaping. The 3D color-coded models based on the dentin thickness distribution showed higher dentin reductions in proximal walls, especially toward the radicular grooves in the lingual aspect (Figure 2). There was a perforation in this groove region in only one specimen after canal shaping (Figure 3).

Figure 2. Representative 3D models in proximal (A, B, and C) and cross-sectional (D and E) views. Color-coded models revealing the dentin thickness throughout the middle and apical third of the root before (A) and after (C) canal shaping with PTN system. (B) Transparent 3D models showing the canal systems before (in green) and after (in red) shaping. Color-coded crosssections before (D) and after (E) canal shaping along the middle (m) and apical (a) third. Thick structures are indicated in blue and green, while the red color indicates areas of thin dentin in CTVox software.

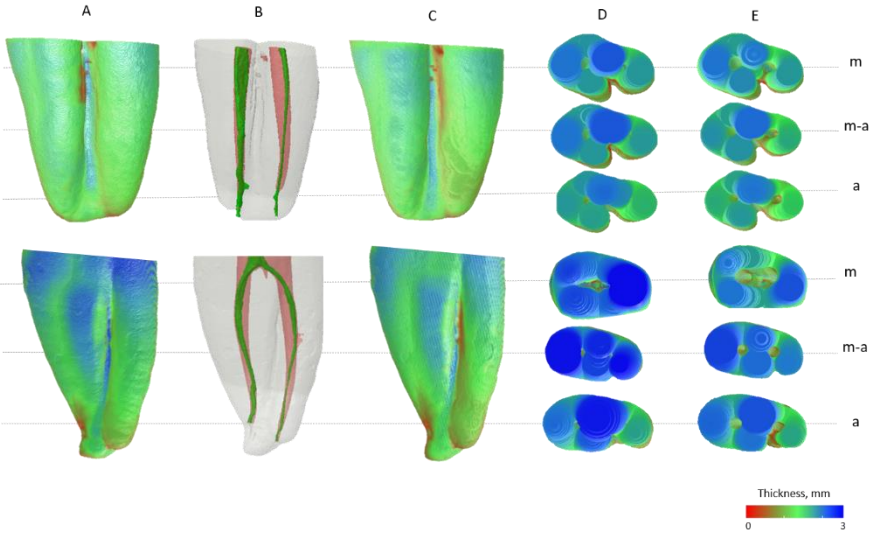
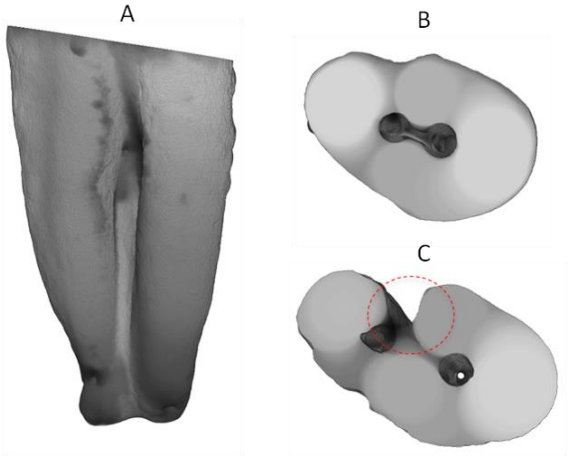


Figure 3. (A) Three-dimensional model of the specimen which a lateral perforation occurred in the region of the radicular groove. (B) Axial section of the cervical third where there is no groove and perforation. (C) Axial section of the middle third with presence of perforation (red circle).



Conclusion

It may be concluded that the microcomputed tomography method is suitable to quantitative and qualitative evaluation of root canal and dentin thickness of mandibular premolars with radicular grooves after canal shaping. Furthemore, although design features of PTN files this study showed change in the internal morphology of the root canal system as well as reduced dentin thickness, especially in the proximal walls related to the radicular groove of mandibular premolars, favoring the occurrence of perforation.

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