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Morphometric Analysis of Mandibular Incisors with Single Canal Systems Using A Developmental Automated Computational Framework

European Endodontic Journal • Article • *Open Access* • 2026 • DOI: 10.65717/eej.2026.26061

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Abstract

Objective: This study developed a computer vision-based framework for quantitative morphometric analysis of mandibular incisors with single root canals using axial video data obtained from micro-computed tomography (micro-CT). Methods: Fifty extracted micro-CT scanned single-rooted mandibular incisors with single root canals (coded $^{1}TN^{1}$ according to Ahmed et al. coding system) were included. After segmentation of the pulp space, video recordings were constructed using Mimics. The video frames were preprocessed through Gaussian filtering and segmented in the hue, saturation and value/brightness colour space domain. The contours were fitted with ellipses to compute morphometric descriptors, including aspect ratio (AR), roundness (R) and form factor. Aspect ratio-based classification was used to categorise canal cross-sections into 4 types (Round, Oval, Long Oval and Flattened). Automated AR measurements were validated against manual reference measurements of the same parameter at the cemento-enamel junction in 30 specimens, using Passing-Bablok and Deming regression, Bland-Altman analysis and the intraclass correlation coefficient; R and FF were not subjected to formal method comparison. Longitudinal trends along all thirds were visualised, and similarity measurement-based grouping comparisons were performed using dynamic time warping (DTW) clustering algorithm. Results: The automated framework successfully processed 8334 axial frames. Within each root third, DTW clustering of AR trajectories resolved 3 morphological strata. Cluster 1 represented canals with the highest R (mean = 0.82) and lowest AR (mean = 1.39). Cluster 2 showed moderate ovality, while Cluster 3 exhibited the most complex morphology with the highest AR (mean = 2.84) and lowest R (mean = 0.40). Only 17 of the 50 specimens (34%) retained the same stratum in all 3 root thirds (mean adjusted Rand index 0.176), indicating that a canal's morphological class frequently changes along the root. Morphometric analysis revealed that canal complexity and flattening reached their peak in the middle third of the root. Conclusion: This study introduces a robust and fully automated framework for quantitative assessment of canal morphology using axial videos. The findings highlight that mandibular incisors often harbour significant morphological complexity in the middle third, which may challenge standard instrumentation. © 2026 The Author(s). Licensee European Endodontic Journal. This article is licensed under the Creative Commons Attribution 4.0 International License (CC BY).

Author keywords

Computer vision; mandibular incisors; medical image processing; morphological analysis; root canal profiling

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