Poster number #002

Basic Research

A novel AI-driven tool for automated root canal segmentation of single and bi-rooted teeth on cone-beam computed tomography

Rocharles Cavalcante Fontenele [1*], Airton Oliveira Santos-Junior [1,2], Frederico Sampaio Neves [1,3], Reinhilde Jacobs[1,4,5]

[1] OMFS IMPATH Research Group, Department of Imaging and Pathology, Faculty of Medicine, KU Leuven, Leuven, Belgium
[2] Department of Restorative Dentistry, São Paulo State University, School of Dentistry, Araraquara, Brazil
[3] Department of Propedeutics and Integrated Clinic, School of Dentistry, Federal University of Bahia, Salvador, BA, Brazil
[4] Department of Oral and Maxillofacial Surgery, University Hospitals Leuven, Leuven, Belgium
[5] Department of Dental Medicine, Karolinska Institute, Stockholm, Sweden

Email address from the presenter: rocharlesf@gmail.com

Abstract

Purpose: To develop and validate a novel artificial intelligence (AI)-driven tool for automated root canal (RC) segmentation in single and bi-rooted teeth on cone-beam computed tomography (CBCT).
Methods: A total of 81 CBCT scans acquired from two devices with distinct protocols were collected and randomly split into the training (n=65; 183 teeth) and validation (n=16; 32 teeth) of the AI networks. Afterwards, 61 CBCT scans (120 single and 70 bi-rooted teeth) were employed to test the performance of the developed AI-driven tool. The CBCT scans from the testing sample were automatically segmented, and the resulting three-dimensional (3D) RC models were exported in the standard triangle language (STL) format. An experienced oral and maxillofacial radiologist assessed the quality of the segmentation and made refinements to create refined-AI 3D models (AI-R). The performance of the AI tool was conducted by comparing the AI and AI-R models. Additionally, 30% of the testing sample was randomly chosen to assess the time consumed for performing three different segmentation methods (manual, AI, and AI-R).
Results: The AI-driven tool exhibited highly accurate RC segmentation for both single teeth (Dice similarity coefficient (DSC): 89-93%; 95% Hausdorff distance(HD): 0.10-0.13 mm) and bi-rooted teeth (DSC: 88-93%, 95% HD: 0.13-0.16 mm). In terms of time analysis, automated segmentation proved to be the fastest method, taking 42±10.5 seconds ($p<0.05$), marking a 64-fold reduction compared to manual segmentation (2687±815.7 seconds).
Conclusions: The novel AI-driven tool showed a highly accurate and fast performance for segmenting the root canal of single and bi-rooted teeth on CBCT scans.
Keywords: Artificial Intelligence; Cone-beam Computed Tomography, Root Canal, Segmentation.

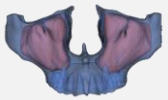
Background

Integration of **Artificial Intelligence** & **CBCT** has revolutionized dentistry for diagnosis and treatment planning


Tooth


Prosthetic crown & Implant


Mandible & Mandibular canal


Maxillofacial complex & Maxillary sinus


Endodontic application

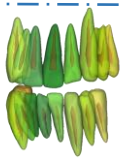
State of Art

Lack of literature

Purpose

To develop and validate **a novel AI-driven tool**

Automated root canal segmentation in single and bi-rooted teeth

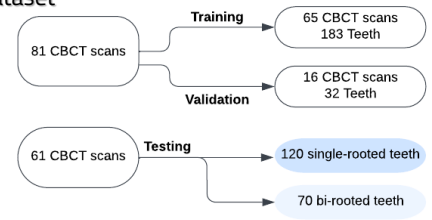


CBCT images

Materials & Methods

The present study was approved by the local Institutional Ethics Board under protocol number S67798

1 Dataset



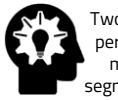
Inclusion criteria
CBCT scans with a complete permanent dentition & satisfactory image quality

Exclusion criteria
CBCT scans with a greater expression of metal & motion artefacts

Table 1. Acquisition protocols of the dataset collected within each CBCT device

CBCT Device	kVp	mA	Voxel size	FIELD OF VIEW
NewTom VGI EVO	110	3-20	0.125 – 0.300 mm	8x8, 10x10, 12x8, 16x16 & 24x19 cm
3D Accuitomo	90	5	0.125 – 0.250 mm	8x8, 10x10, 14x10 & 17x12cm

2 Training and Validation of AI Networks


Two experts performing manual segmentation


3D U-Net Architecture

3 Testing of AI Networks

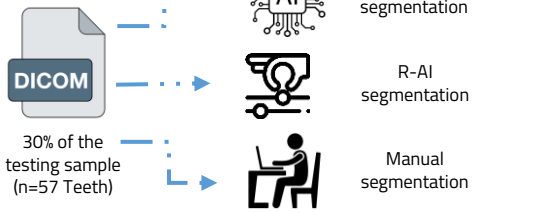

Each CBCT scan was uploaded to the AI platform

AI PERFORMANCE
Accuracy metrics obtained by comparing AI vs R-AI models for each tooth


3D root canal models revised by one operator

3D Refined AI (R-AI) models were generated

4 Human vs AI Performance (Timing analysis)



Results

1 AI Performance

Table 2. AI performance based on mean (standard deviation) values of accuracy metrics.

SINGLE-ROOTED TEETH


Upper Central Incisors
DSC = 90% (5)
95% HD = 0.13 mm (0.06)


Upper Lateral Incisors
DSC = 89% (8)
95% HD = 0.12 mm (0.04)


Upper Canines
DSC = 89% (6)
95% HD = 0.10 mm (0.03)


Lower Incisors
DSC = 89% (5)
95% HD = 0.12 mm (0.04)


Lower Canines
DSC = 93% (4)
95% HD = 0.11 mm (0.08)


Single-rooted Premolars
DSC = 90 % (4)
95% HD = 0.12 mm (0.04)

BI-ROOTED TEETH


Upper First Premolars
DSC = 89% (6)
95% HD = 0.16 mm (0.06)


Upper Second Premolars
DSC = 93% (3)
95% HD = 0.13 mm (0.07)

DSC, Dice Similarity Coefficient ; HD, Hausdorff Distance.

Figure 1. AI segmentation of an upper canine (#13). A, Comparison between AI and R-AI models; B, 3D model of the tooth (in yellow) and root canal (in red); C, CBCT reconstructions showing the segmentation map.

2 Timing analysis

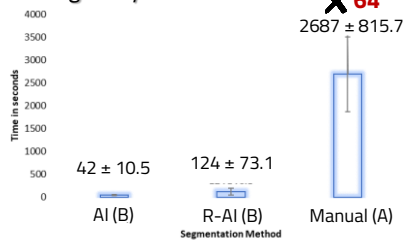
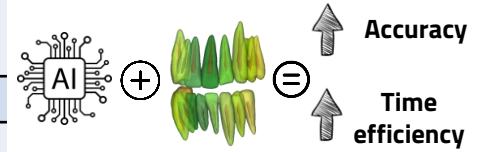


Figure 2. Timing analysis graph. Mean ± standard deviation of the time consumed according to segmentation method

Conclusion



References