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RESEARCH ARTICLE

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Cone-Beam Computed Tomography Evaluation Of The Root Morphology Of The Anterior Maxillary And Mandibular Human Teeth In A Moroccan Subpopulation/ Number Of Roots And Tooth Length (Part 1)

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ABSTRACT

Objective: The purpose of this study is to use CBCT to assess the number of roots and tooth length of a Moroccan subpopulation's anterior maxillary and mandibular teeth.

Methods: The number of roots and tooth length of 231 cone beam acquisitions representing a total of 1479 teeth was analyzed using "Planmeca viewer" software. Statistical analysis was carried out using the Epi info software.

Results: Results showed that, except for 4 mandibular canines, all anterior teeth were single-rooted. We found that the root lengths of the maxillary anterior incisors (23.68mm and 22.57mm) and the root lengths of the maxillary canines (26.52mm) varied significantly. The same was noticed for the root lengths of the mandibular anterior incisors (20.94mm and 22.38mm) and the root lengths of the mandibular canines (25.469mm). Both the maxillary and mandibular canines were found to have greater root lengths than the corresponding incisors.

Conclusions: Morphological analysis of permanent anterior dentition revealed diversity in the tooth length. All anterior teeth had a single root, except for the mandibular canines where two-rooted teeth were found. This study emphasizes the value of CBCT in root detection and clinical evaluation of root canal morphology.

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Introduction

One of the biggest challenges for endodontists in clinical practice is the complexity of the root canal anatomy since it is crucial to understand the specifics of the interior areas that are unique to each human tooth. Clinical significance of understanding root canal anatomy has been linked to successful treatment obtaining complete access to internal tooth areas during the root canal filling and disinfection processes. Parallel to this, the main reason for failure is the persistence of microbes following root canal therapy. Both destructive and non-destructive methods have been used to assess the anatomical features of human teeth, including the number of roots, root canals, apical foramina, root canal isthmuses, root ramifications, root curvatures, and developmental abnormalities. Decalcification, radiography, vertical and cross-sectional cutting, histological analysis, stereomicroscopy analysis, surgical microscopy, plastic casts, scanning electronic microscopy, cone beam computed tomography (CBCT), and micro-computed tomography (MCT) are some of the techniques described in the literature [1].

The most popular method for analyzing the anatomy of the root canals in endodontic research and practice is periapical radiography (PR). However, this method has an important disadvantage because the actual multi-dimensional nature of tooth structures cannot be seen when simply observed in two dimensions. CBCT and MCT, two cutting-edge alternatives to examine internal root canal anatomy, have been suggested [2,3].

Time-consuming and material-costing issues are the primary problems with MCT. Cone-beam CT (CBCT) imaging, on the other hand, enables a three-dimensional (3D) assessment of teeth and the structures surrounding them [4,5]. CBCT images are displayed in axial, sagittal, and coronal sections, and reduce the superimposition of anatomic structures, which facilitate the clinician's understanding of the thorough morphology of the root canals.

In order to determine the root canal morphology and anatomical characteristics, numerous studies have been carried out. However, investigations analyzing the structure of root canals utilizing 3D radiography technologies have never been conducted on the Moroccan population.

The aim of this study is to evaluate the number of roots and tooth length of the anterior maxillary and mandibular teeth of a Moroccan subpopulation using CBCT.

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Materials and Methods

The Hassan II University School of Dentistry's Ethical Committee, located in Casablanca, Morocco, gave the study their stamp of approval (#104/15). No cone-beam examination has been specifically indicated for this study in accordance with the principles of radioprotection (principles of justification and optimization) of ionizing radiation tests.

The analysis sample for our study consisted of 231 cone beam acquisitions made of 53.27% of females (*n* = 122) and 46.72% of males (*n* = 107), representing a total of 1479 teeth analyzed, selected from a database of a radiology center in the Casablanca region between January and July 2022, who presented with fully formed incisors and canines, with no root canal filling, post or crown restorations, and free from teeth anomalies. CBCT examinations presenting the kinetic of metallic artifacts, which could lead to a difficult interpretation, were excluded. Our sample included 201 maxillary central incisors, 226 maxillary lateral incisors, 241 maxillary canines, 254 mandibular central incisors, 267 mandibular lateral incisors, and 290 mandibular canines. The cone beam images were taken on a Planmeca Promax 3D plus machine. The technical parameters were set as follows: Voltage of 90kV, amperage of 10mA, field of view of 601x601x601 and voxel size of 150µm.

The data were collected in DICOM (Digital Imaging for Communication in Medicine) format, and the images were analyzed using the "Planmeca viewer" software (version 3.2.7) Serial sagittal, coronal, and axial views of the CBCT images from the coronal portion to the root apex of each tooth were examined carefully by an experienced radiologist and an endodontist according to the following features: the roots' number (Figures 1, 2) and the tooth length (Figure 3).

Statistical analysis was performed using the software Epi info (Version 6, Centers for Disease Control and Prevention (CDC), Atlanta, Georgia (US)). The roots' number data were described as percentages and the length data were described as mean and standard deviation.

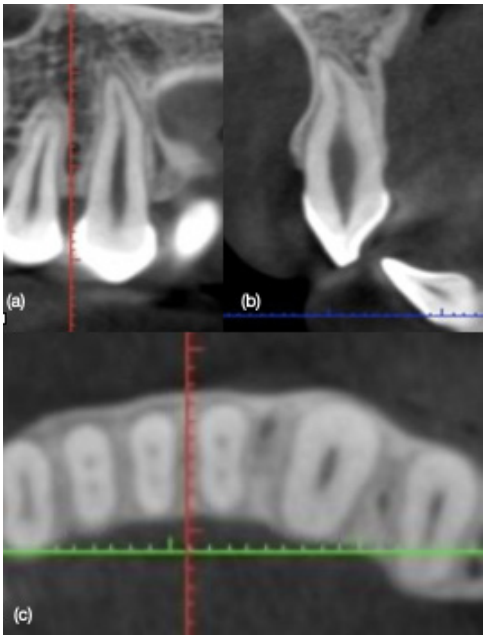

Figure 1: Cone-beam computed tomography images showing the number of roots of maxillary incisors (a) coronal section;(b) sagittal section;(c) axial section.

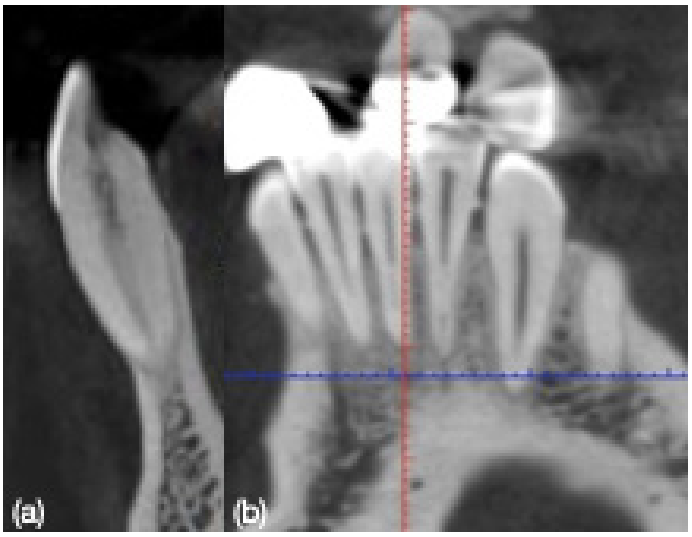

Figure 2: Cone–beam computed tomography images showing the number of roots of mandibular canines (a) sagittal section; (b) coronal section.

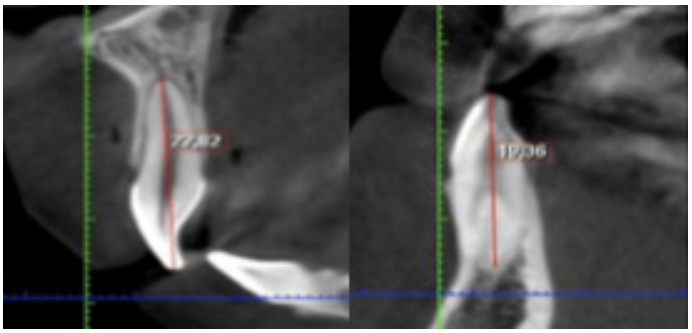

Figure 3: Cone-beam computed tomography images showing the length measurement in the sagittal section.

Results

Maxillary Incisors

Among the analyzed maxillary central incisors and maxillary lateral incisors, 100% were single rooted, with a mean length of 23.68 ± 2.275mm, and 22.57 ± 2.240mm, respectively.

Maxillary Canines

All the analyzed maxillary canines (100%) were single rooted, with a mean length of 26.52 ± 2.624mm.

Mandibular incisors

Of all the mandibular central and lateral incisors examined, only one root was present, with a mean length of 20.94 ± 1.742mm, and 22.38 ± 1.955mm, respectively.

Mandibular Canines

Most of the mandibular canines were single rooted (98.6%), and only 4 (1.4%) of them was two rooted. The mandibular canines presented a mean length of 25.469 ± 6.195 mm.

Discussion

In this study, we performed an evaluation of the number and length of roots for each tooth from cone beam acquisitions. Traditional periapical radiographs are useful diagnostic tools for evaluating root canal morphology *in vivo*. However, because of inherent flaws such as the distortion and superimposition of bone and dental structures, these radiographs are unreliable [6].

CBCT is frequently used in implantology and maxillofacial reconstruction. This method is also utilized in endodontic diagnostics to assess root filling removal, canal preparation, and obturation in situations requiring surgical endodontics. According to a recent study, CBCT was just as accurate at identifying root canal shape as the modified canal staining and tooth clearance approach [7]. The nondestructive nature of CBCT imaging, as well as the 3D reconstruction and viewing of the exterior and interior anatomy of both the teeth and surrounding bone structures, are its primary benefits [8]. The most notable advantages of CBCT over conventional CT are its high accuracy, much lower effective radiation dose or short exposure duration (2-5 seconds), and reduced cost. Furthermore, because CBCT voxels (3D pixels containing data) are isotropic, CBCT measurements are geometrically accurate [8,9]. In particular, CBCT is very useful for distinguishing between multi-root canals and radicular grooves (RGs).

Numerous techniques have been used to study root canal morphology in the Moroccan population, including conventional radiography, which is still a two-dimensional investigation, sectioning, which is an invasive procedure that can change the root canal anatomy, and no study has been performed by analyzing cone beam radiographs. Cone beam computed volume tomography, on the other hand, has been used to investigate many other populations.

DICOM was used to collect data for the present study. It is widely recognized as the most commonly used standard process for managing and exchanging medical images. DICOM allows for the integration of diverse image types produced by medical imaging devices such as CBCT into picture archiving and communication systems that may be used by other applications in healthcare delivery [10].

The current study examined the length of each tooth from the coronal to the root apex. Several researchers evaluated the accuracy of utilizing CBCT to measure tooth length. It has been shown to be more accurate and reliable than standard periapical radiography in determining preoperative working length [11] and tooth length measurements [12]. Variations in tooth length and root count have been attributed to a variety of factors, including race and gender. Doctors must be fully aware of these variations in order to treat patients more efficiently [13]. The permanent maxillary and mandibular anteriors are usually single-rooted, but evidence indicates that an accessory root may be present [14].

In this study, all maxillary anterior teeth were found to be single-rooted, which is in line with studies conducted in various populations including Turkish, Malaysian, Indian and Brazilian population groups [15-18]. This suggests that the number of roots in maxillary anteriors does not differ amongst populations; nonetheless, it is worth noting that a few case studies have recorded the presence of double-rooted maxillary anteriors [14]. All mandibular incisors evaluated in this study had single roots, which is in line with some studies [19-23]. However, two studies found lateral incisors with two roots (0.5%) [24] and (0,3%) [25].

In this study, 4 mandibular canines (1.4%) demonstrated two roots, which is in line with studies conducted in Malaysian (0.3%) [16] Saudi (2.7%) [26] Iraqi (2.1%) 27 Iranian (4.7%) [28], Brazilian (3%) [1], Israeli (1.9%) [29] and Chinese (0.6%, 0.7%, 0.8%, 1.3%) populations [25,30-33). This suggests that dental practitioners and endodontists should employ precaution when evaluating preoperative radiographs in order to avoid the negative repercussions of root canal-treated mandibular canines with missing anatomy.

Regarding the mean length of the maxillary central incisor, few studies have been conducted on this tooth, the majority of authors have studied only the root length that was measured as the distance from the CEJ to the root apex, such as Yu Chen et al. [34] who did a cone-beam computed tomography investigation in the Chinese population, and found an average root length of 13.39 ± 1.69mm for the right central and 13.32 ± 1.74mm for the left central. The average root length of anterior dentition in Brazil was 12 mm in both maxillary and mandibular central incisors [35]. It was reported that for the Korean population, the mean root length of maxillary central incisors was 12.3 mm for males and 11.75 mm for females [36]. Only Choquet J [37] had studied the total length of the central incisor, he found an average total length of 22.5mm. Our findings regarding the mean length of the maxillary central incisors (23.68+/- 5.17mm) were slightly higher than to those reported by Choquet J.

Regarding the mean length of the maxillary lateral incisor, the average root length according to Yu Chen is 13.48 ± 1.54mm for the right lateral, and 13.40 ± 1.49mm for the left lateral [34]. The total length of the lateral according to Choquet J. (10) is 22mm, according to our measurements, the average length of the maxillary lateral incisor was 22.57mm. Our result is close to that of Choquet J [37].

Yu chen et al. found a root length of the maxillary canines of 16.6 mm. [34] While It was reported that for the Korean population, the mean root length of maxillary canines was 15.83 mm for males and 15.23 mm for females [36]. In a study in which the Cone beam was used in the American population, Ash and Nelson [38] reported a mean coronal length of 10mm and a mean root length of 17mm, thus a total length of 27mm. The results of our study are very close to those of Ash and Nelson; we found a mean total length of 26.52mm.

Research from India indicated that the average root length of the mandibular central incisor was 12.9 mm [39]. While in Chinese population, the average root length was 12.2 mm [34]. According to a study conducted by Leoni et al. [40] in the Brazilian population, which used micro-tomography for examination, the mandibular central incisor's total length ranged from 16.01 to 27.18mm, with a mean length of 20.71+/-1.69mm. In their

examination of the Iranian population employing cone beam, Aminsobhani et al. [28] revealed that the mean total length was 20.9+/-0.11mm for males and 21.1+/-0.12mm for females. Our findings, which indicated a mean total length of 20.94mm, are consistent with those in the literature.

Regarding the mean length of mandibular lateral incisors, it was reported that for Indian population, the average root length was 12.83 mm [39]. While research from china indicated that lateral incisors had an average root length of 13.4 mm [34]. The overall length of the tooth was measured by Leoni et al. [40], who discovered a mean length of 21.56 ± 1.82mm. With a standard deviation of 1.955mm, we obtained a mean tooth length of 22.38mm.

Amardeep et al. [17] assessed the length of the mandibular canine by using a cone beam to examine the morphology of mandibular canines in the Indian population. They found that the average length of the crown is 8.70mm and the average length of the root is 15.51mm. Research from India indicated that the average root length of the mandibular canine was 14.8 mm, [39] while in china it was 15.5 mm [34]. As for our results, the average total length was 25.46mm with a standard deviation of 2.489mm.

We could not compare the root lengths of Moroccan population to participants of all previous reports because the previous results were greatly influenced by measuring methods, and all related studies have adopted different protocols.

Dentists may face clinical challenges as a result of root canal architecture. Overcoming these issues is one of the most significant challenges that may arise during endodontic operations. Potential difficulties during RCT can be predicted with a thorough study and knowledge of RCS in each group of teeth.

However, the internal and external morphology of teeth might differ depending on age, race, gender, and geographic region. These variances may explain the significant disparities in tooth architecture within the same or different regions [41].

Many studies have reported the frequency of multi-root canals in mandibular incisors, with micro computed tomography (micro-CT) being commonly employed in verifying multi-root canals. Milanezi de Almeida et al. [42], for example, revealed that 340 mandibular incisors with type I and III Vertucci configurations represented 92% of all mandibular incisors.

Micro-CT allows for extensive examination of both the external and internal anatomy of the tooth, which can be viewed concurrently or independently from different angles by reconstructing 3D pictures. However, micro-CT has primarily been used to study extracted human teeth in vitro, and most research to date have been conducted ex vivo.

We discovered several, complicated canals in the mandibular anterior teeth, including oval and flattened canals, and the mesial and distal surfaces frequently included long depressions known as RGs (Radicular grooves) when we examined the CBCT images. The changes in the mandibular anterior tooth root canal systems may be connected to the depth of the RGs. Because just a few research have looked at RGs in mandibular anterior teeth, analyses of the link between numerous canals and RGs may have substantial therapeutic implications [25].

Conclusion

All anterior teeth had a single root, except for the mandibular canines where two-rooted teeth were found with an average length of 25.46 ± 2.489mm.

This study highlights the value of CBCT in root detection and clinical assessment of root canal shape. On the other hand, it will be advisable to favor reduced field examinations in order to minimize the dose delivered to the patient while having a high precision image. The current data may provide clinicians practicing in Morocco with a more thorough understanding of root canal morphology.

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