Legal Medicine 28 (2017) 31–36

Contents lists available at ScienceDirect

Legal Medicine

journal homepage: www.elsevier.com/locate/legalmed

Age assessment in canine and premolar by cervical axial sections of cone-beam computed tomography

Hichem Nemsi[a,*], Nidhal Haj Salem[a], Ines Bouanene[b], Sami Ben Jomaa[a], Meriem Belhadj[a], Mohamed Amin Mosrati[a], Abir Aissaoui[a], Faten Ben Amor[c], Ali Chadly[a]

[a] Department of Forensic Medicine, Laboratory of Research Anthropology and Bone Biomechanic (LR12SP14) Faculty of Medicine, University of Monastir, 5000, Tunisia
[b] Department of Epidemiology and Preventive Medicine, Faculty of Medicine of Monastir, University of Monastir, Tunisia
[c] Laboratory of Research in Oral Health and Oral Rehabilitation, LR12ES11, Tunisia

ARTICLE INFO

Keywords:
Age estimation
Cone beam computed tomography
Pulp/tooth area ratio
Axial section
Forensic odontology
Dentin deposition

ABSTRACT

Age estimation in adults is a challenge in both anthropological and forensic situations compared to sub-adults age estimation. The present study explored, for the first time, the cervical zone of single rooted teeth. The deposition of secondary dentin is responsible for a decrease in the volume of the dental pulp cavity with aging, and therefore is often used as an age indicator. The current study aimed at estimating the chronological age among adults by measuring the pulp/dentin area ratio (physiological ratio) by axial sections at cervical region of maxillary canine and mandibular second premolar. The sample consisted of 120 cone beam CT images of 120 Tunisians whose age ranged from 22 to 67, from the database of a private clinic of radiology. The first axial section of chosen teeth without enamel was selected. Linear regression models were derived for canine, premolar and for all variables to predict the age. They indicated that dentin deposition on canine and premolar have almost the same correlation with age ($r = -0.838$ and -0.837 respectively). The residual standard errors (RSE), when these regression equations applied for the entire sample, were ranged between 8.27, 8.29 and 7.06 for canine, premolar and for all variables respectively.

Tested for younger ages (from 22 to 44 years) the RSE decreased considerably and thus ranged between 4.32, 4.72 and 4.05.

The outcomes of this study show that the physiological ratio is a useful variable for assessing age with a satisfying accuracy.

1. Introduction

Age estimation in adults is a challenge in both anthropological and forensic situations compared to sub-adults age estimation.

It is difficult to estimate the age in adults because the processes of skeletal and dental maturation are complete and techniques that are based on degenerative processes are not as accurate as those based on tooth development used in the sub-adult age. This is likely due to the slow degenerative phenomena and the effect of environmental factors.

In living subjects, the situation is more complicated and the number of available methods is greatly reduced because the methods usually employed for human remains are too invasive and pathless in living subjects [1].

A rising demand exists for age estimation in living adults. The aim is to solve civil litigation like pensionable age and age of majority.

The degenerative changes in the skeleton, such as modifications in the pubic symphysis [2] or in sternal rib ends [3] are used in adults' age estimation.

Odontological techniques are extensively used. Some age estimation methods apply various forms of the tooth degenerative process, including wear [4], root dentin transparency [5], tooth cementum annulations [6] and racemization of aspartic acid [7]. Nevertheless, these methods are invasive and require tooth extraction and often destruction, which is unfeasible in living individuals.

After root completion, secondary dentin is deposited in the pulp cavity wall as long as the tooth is still vital, reducing the pulp chamber. It is least influenced by other environmental factors [8]

The amount of secondary dentin can be an indicator of age and can be employed in age assessment [9–11], these age-related changes can be evaluated by extracting and sectioning a tooth [12], which is impractical in living adults. The use of radiographic methods, based on measuring the pulp chamber size reduction, for age estimation, is a practical method especially in living individuals, as it is simple, non-destructive and a reliable method. Moreover, it can be used in dead persons as well as in skeletal remains [13].

* Corresponding author at: Department of Forensic Medicine, Fattouma Bourguiba Hospital, Monastir 5000, Tunisia.
E-mail address: hichem_ne@yahoo.fr (H. Nemsi).

http://dx.doi.org/10.1016/j.legalmed.2017.07.004
Received 22 December 2016; Received in revised form 16 June 2017; Accepted 11 July 2017
Available online 21 July 2017
1344-6223/

Kvaal et al. [14] introduced an age estimation method by indirectly measuring secondary dentin deposition on radiographs and proposed a number of length and width measurements of tooth and pulp. In 2004, Cameriere et al. [15–17] analyzed the pulp/tooth area ratio of canines and mandibular premolars using two dimensional dental radiographs.

In diverse studies, three-dimensional images obtained from Cone beam CT and CT scan have been applied to investigate the probable relationship between the age and volume ratio of the pulp cavity to the entire tooth and concluded that is a useful indicator for age [8,18–22].

Since secondary dentinal deposition was the greatest in the cervical area of the root [23] and enamel is subjected to attrition and abrasion, the present study sought to assess the Cameriere's method using an axial section of cone beam computer tomography (CBCT) images. In addition, a population specific formula for age assessment was established.

The left maxillary canine and lower left second premolar were chosen because they have the longest functional survival rate in the mouth and have the largest pulp area among single-rooted teeth.

2. Materials and methods

2.1. Materials

The sample consisted of 120 cone beam CT images of 120 Tunisians whose age ranged from 22 to 67, from the database in a private clinic of radiology.

The birth date and date of examination of all subjects was figured in the menu of the section manipulation software, the chronological (actual age) was noted by subtracting date of birth from the date of radiograph.

The selected teeth were the left maxillary canines and left second mandibular premolars. If a tooth presents an exclusion criterion, the right side will be chosen. Consequently, only one maxillary canine and one mandibular second premolar in each person were included for analysis.

In the present study, canines and premolars presenting any pathology, such as malaligned teeth, caries, periapical lesions, prosthetic fittings and orthodontic appliances, pulpal calcification and endodontic treatment, were excluded from the study. Poor quality cone beam CT with inadequate exposure were also excluded. Normal dental anatomy should be shown.

2.2. Cone-beam CT technology and software

All the CBCT images were acquired with a CBCT unit GALILEOS Sirona Comforts*. Performance features are shown in Table 1.

The manipulation of sections was made by "Galileos viewer 1.9 software".

The Adobe Photoshop CC, image-editing software program (Adobe Systems Incorporated, San Jose, CA, USA), used to manipulate selected sections to determine the number of pixels.

Table 1
Overview of performance features.

Imaging volume	15.4 cm spherical imaging volume collimated 15 × 8.5 cm (UJ/lJ)
3D resolution: isotropic voxel size	0.25/0.125 mm
Scan time/exposure time	14 s/2–6 s
X-ray generator	98
KV	3–6
MA	
Effective dose	16–90 μSv (Ludlow)
(ICR P 2007)	Standard: 75 μSv
Minimum space need (depth × width × height)	1600 × 1600 × 2250 mm
Patient positioning	Standing/seated chin rest/bite block for head support and head fixation

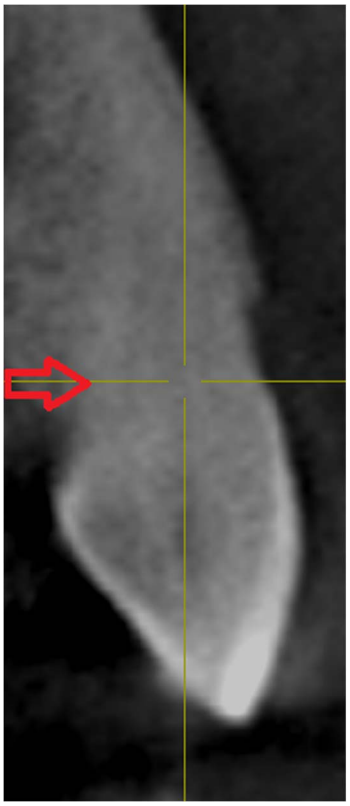

Fig. 1. The level of the axial section in the left maxillary canine.

2.3. Methods

After opening the appropriate image acquisition using "Galileos viewer software", the axial section for the left maxillary canine, then the left mandibular second premolar were chosen. After a corono-radicular scanning with 0.3 mm slice thickness, the first axial section without enamel was selected and the maximum zooming was used (Fig. 1).

Following Cameriere et al. [24], each section image was saved as a high-resolution JPEG file on a desktop computer and imported to the Adobe Photoshop CC later. The image file was opened and zoomed in. Brightness/contrast and sharpness, if needed, were adjusted.

The magnetic lasso tool provided in this program was selected from the tool bar. The outline of the root was traced (Fig. 2). After completion of the tracing, the number of pixels in the entire root was shown in the histogram palette.

The number of pixels contained in the entire root (RP: root pixels) represented the first required variable. Next, the outline of the pulp chamber was traced and the pixels number shown. It is our second required variable (PP: pulp pixels).

The same procedure was done for the entire sample. After that, the physiological ratio, pulp/dentin area ratio (R) = PP/RP-PP, was derived. We can note the presence of a very thin layer of cementum surrounding the dentin that varies very little with age.

2.4. Statistical analysis

For each case, the physiological ratios, pulp/dentin area ratio (R) = PP/RP-PP, were measured on the left maxillary canines (R1), left mandibular second premolars (R2), then ratios were multiplied (Product: R1*R2).

All the measurements were carried out by the same observer. To test the intra-observer reproducibility, a random sample of 32 CBCT was re-examined after an interval of one month. After that, the same slice data