Original Article

Age Estimation Using Mandibular Ramus and Gonial Angle Using Digital Orthopantamogram

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Abstract

Introduction: Forensic age estimation of unidentified skeletons and corpses for the purpose of identification has been a conventional feature of forensic science. Age determination is of paramount importance in medicolegal issues. Mandible is a dimorphic bone of the skull which aids in determining the age of an individual.

Aim and Objectives: This study aimed to assess the efficacy of various mandibular ramus linear measurements (condylar ramus height and coronoid ramus height) and gonial angle measurements on digital panoramic images on the right side of the mandible for age determination.

Materials and Methods: Three hundred panoramic images were selected randomly and mandibular ramus linear measurements (condylar ramus height and coronoid ramus height) and gonial angle measurements were performed on the right side, tabulated, and evaluated statistically.

Results: Descriptive statistics for all the three parameters on the right side of the mandible were analyzed. No statistical significance was observed between the chronological age and estimated age using the above three parameters on the right side. However, the coronoid ramus height showed a statistically significant result between the chronological age and the estimated age ($P < 0.05$).

Conclusion: In the present study among the three mandibular parameters, coronoid ramus height proved to be a valuable indicator for age estimation.

Key Words: *Condylar ramus height, coronoid ramus height, digital orthopantamogram, gonial angle*

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Introduction

Skeleton has always aided in genetic, anthropological, odontological, and forensic investigation of living and nonliving individuals.[1] Skull bones and pelvis have been majorly used in sex and age determination.[2] Age is one of the essential factors of forensic odontology in establishing the identity of the person. Estimation of age at the time of death is an important step in identification of human remains. If the age is accurately estimated, it will significantly narrow the field of possible identities that will have to be compared to the remains during mass disasters, natural calamities to establish a positive identification, thus enabling a more efficient and time-saving approach.[3]

A number of methods for age determination have been proposed. These can be classified into four categories, namely clinical, radiological, histological, and chemical analysis. In living persons whose actual age is not known or is to be confirmed any or all the above methods can be used to determine the age. However in the dead, postmortem changes such as decomposition, mutilation or skeletonization may make identification progressively more difficult almost to the point of impossibility.[4]

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Mandible has been used in age and sex determination as it can retain its shape compared to any other bone in the forensic and physical anthropological field.[5] The mandible is among the first bones in the body to start ossifying and is unique in that it has both the patterns of ossification (endochondral and intramembranous). The body of the mandible is ossified intramembranously, whereas the ossification of the coronoid and condylar processes is endochondral. Morphological and dental changes (time and sequence of eruption of teeth) serve as an aid to estimate age until the third decade of life.[6] For ages above the third decade, the changes are subtle and have to be studied in greater detail.[7]

Radiograph is a less invasive method which can be employed in both living and dead individuals. Various radiographic images can be used in age identification which include intraoral periapical radiographs (IOPA), lateral oblique radiographs, lateral cephalogram, panoramic radiographs, digital imaging, and advanced imaging technologies. Dental

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orthopantomogram has been used as a valuable tool in forensic science and studies have been conducted to make a biometric system for human identification.[8]

The accuracy of digital panoramic radiography in providing anatomic measurements has been established. The principal advantages of digital panoramic images are interference of superimposed images that are not encountered, and contrast and brightness enhancement and enlargement of images provide an accurate and reproducible method of measuring the chosen points, broad coverage, low patient radiation dose, and the short time required for image acquisition.[9-12]

Hence, the present study was undertaken with an aim to estimate the age using condylar ramus height, coronoid ramus height, and gonial angle using digital orthopantamogram on the right side.

Materials and Methods

A set of 300 digital orthopantamograms within the age group of 8–20 years taken previously for various diagnostic purposes from the Department of Oral MEDICINE and Radiology, Mamata Dental College, Khammam, were selected and coded. The images were acquired using ORTHOPHOS XG5 of Sirona Dental Company, Germany. Exposure parameters were 66 kvp, 8 mA, and exposure time of 14.1 s according to the patient's age and size. SIDEXSIS radiographic dental diagnostic unit was used for imaging plate scanning. The digital orthopantamograms with good quality in regard to patient positioning, head alignment, film density, contrast, and clear visible lower border of the mandible, posterior border of the ramus, and condyle were selected.

The digital orthopantamograms were saved in a JPEG file format and exported to the Adobe Photoshop software where linear and angular measurements were performed on the right side.

For standardization, a horizontal orientation line was digitally traced passing through the summit of the gonial angle and used for the following measurements:

1. Condylar ramus height (AB): The distance from the condyle onto the intersection of the orientation line with the inferior border of the ramus [Figure 1]
2. Coronoid ramus height (AC): The distance between coronion and the intersection of the orientation line with the inferior border of the ramus [Figure 1]
3. Gonial angle (ABC): These were measured as the intersection between a digitally traced line tangential to the most inferior points at the angle and the lower border of the mandibular body and another line tangential to the posterior borders of the ramus and the condyle [Figure 2].

Data of 300 samples were then entered into the Microsoft 2010 Excel spreadsheet and subjected to statistical analysis.

Age calculation

Age estimation formula was derived for each parameter by simple linear regression analysis. Estimated age for each parameter was calculated by substituting the obtained values in the derived equation and compared with chronological age. The radiographs were then decoded and actual age was ascertained by subtracting the date of radiographs from the date of birth of the patient. All measurements were carried out by the same observer.

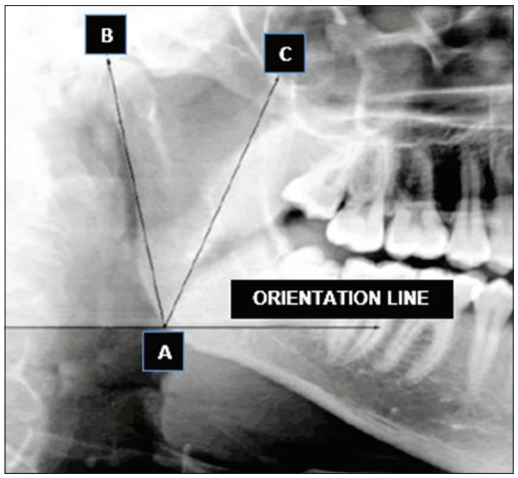

Figure 1: The two linear ramus measurements performed on the digital panoramic image (AB: Condylar ramus height, AC: Coronoid ramus height)

Statistical analysis was performed with a statistical package for the social sciences software (SPSS version 20.00) (IBM Corporation, Bangalore, Karnataka, India).

Results

In the present study, 300 samples within the age range of 8–20 years were included. Age was estimated in the total sample for each variable on the right side independently using formulae derived by multiple regression analysis. Paired *t*-test was done to compare chronological age with estimated age by all the variables (condylar ramus height, coronoid ramus height, and gonial angle) and the correlation between chronological and estimated age was done with the Kearl Pearson Coefficient test.

Table 1 shows that the mean chronological age of all parameters was 14.48, whereas the mean of estimated age by condylar ramus height, coronoid ramus height, and gonial angle was 14.48 years. This suggests that estimated age by condylar ramus height, coronoid ramus height, and gonial angle was comparable to that of chronological age.

Table 2 shows correlations between chronological age with estimated age using coronoid ramus height, condylar ramus height, and gonial angle. Among the three parameters, coronoid ramus height showed a statistically significant difference indicating that it is a reliable indicator of age estimation.

Discussion

Age estimation is an important part of personalization, especially when information regarding the deceased is unavailable,[13] and is an essential basic biological parameter that facilitates the identification of human remains in both forensic and archaeological contexts.[14]

The need to estimate the age of living individuals is becoming increasingly important in forensic odontology. There are

Table 1: Comparison of chronological age and estimated age by condylar ramus height, coronoid ramus height, and gonial angle

Parameters	Age	Mean	SD	Mean difference (absolute error)	SD difference	Paired *t*	*P*
Condylar ramus height	Chronological	14.48	4.17	0.00	4.17	0.000	1.000
	Estimated	14.48	0.15				
Coronoid ramus height	Chronological	14.48	4.17	0.00	3.99	0.000	1.000
	Estimated	14.48	1.22				
Gonial angle	Chronological	14.48	4.17	0.00	4.15	0.000	1.000
	Estimated	14.48	0.46				

Paired *t*-test, *P*=1.000, nonsignificant. SD: Standard deviation

Table 2: Correlations between chronological age and estimated age using condylar ramus height, coronoid ramus height, and gonial angle

Techniques	Variables	Correlations between chronological age with		
		r	*t*	*P*
Orthopantamogram	Condylar ramus height	−0.0370	−0.6388	0.5235
	Coronoid ramus height	−0.2918	−5.2661	0.0001*
	Gonial angle	−0.1101	−1.9117	0.0569

*Significant. Karl Pearson coefficient test, *P*=0.0001

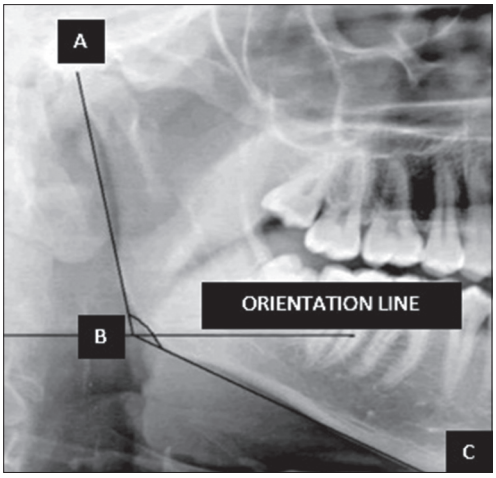

Figure 2: Measurement of the Gonial angle on the digital panoramic image

increasing numbers of immigrants who arrive in a country without acceptable identification papers and more generally individuals with missing or uncertain birth data, thus giving importance to forensic odontologists.[15] Age estimation also helps in differentiating juvenile from adult status in both civil and criminal cases such as kidnapping, rape, marriage, employment, identification, and in question of age fitness or unfitness.[16]

Various parameters help in age estimation up to 25 years of age such as length of femur, secondary sexual characteristics, and ossification of bones. Parameters such as ossification of cartilages in the hyoid, larynx, ribs, and obliteration of the skull sutures may be suggestive of advancing age but give no precise evidence.[6]

A number of techniques based on tooth wear, root dentine translucency, tooth cementum annulations, and racemization of aspartic acid in dentin or tooth enamel have been developed and they rely upon the correlation between age and dental structures. However, these methods are invasive and require manipulation or extraction of a tooth, which may not be tolerable for ethical, cultural, and scientific reasons.[17,18]

Dental radiography is a nondestructive and simple technique, routinely employed in methods of age estimation.[9] It also plays a vital role in forensic dentistry to uncover the hidden facts which cannot be seen by means of physical examination.[3] Various radiographic images which can be used in age identification include IOPA, lateral oblique radiographs, cephalometric radiographs, panoramic radiographs, and hand–wrist radiographs.[10]

Among several maturational indicators, bones form a reliable source of information regarding growth and growth changes. Considerable attention has been paid to mandibular growth because it has been reported that this bone enlarges the most during adolescence.[11] The mandible acts as an important tool for radiological identification because of ease of imaging and no overlying bony structures. Morphological changes of the mandible are thought to be influenced by the occlusal status and age of the subject.[19,20] Mandibular ramus and gonial angle, in particular, are the sites associated with the greatest morphological changes in size and remodeling during growth.[21-23] Hence, in the present study, the mandibular ramus and gonial angle were selected for age estimation.

In the present study, 300 subjects within the age group of 8–20 years' OPG were included. Formulae were derived for condylar ramus height, coronoid ramus height, and gonial angle on the right side, and the estimated age for each parameter was calculated by substituting the obtained values in the derived equation. Then, statistical analysis was performed.

In the present study, the mean estimated age of condylar ramus height, coronoid ramus height, and gonial on the right side was 14.48 years, suggesting that all the three parameters were comparable to that of chronological age [Table 1]. The results were in accordance with the study conducted by Abu-Taleb

and El Beshlawy[21] who found that there is no statistical significance on comparing the chronological age and estimated age using condylar ramus height, coronoid ramus height, and gonial angle on both right and left sides.

In view of individual parameters when condylar ramus height was considered in the present study, there was a correlation between this parameter and age. This was in accordance with a study conducted by Kedarisetty *et al*.[12] where they observed that condylar ramus can also be used for age estimation but has less reliability than the length of the mandibular body. In contrast to the present study, Raustia and Salonen[22] found no correlation between age and ramus height on complete denture wearers. We observed that as age increased, condylar ramus height decreased in the present study and similar observations were seen in a study conducted by Leversha *et al*.[23]

When gonial angle was investigated for age estimation, there was a correlation between gonial angle and age, and as the age increased, the gonial angle decreased. This finding was in accordance with the study conducted by Upadhyay *et al*.[24] who found decreased gonial angle as age increased, whereas in studies conducted by Chole *et al*.[25] and Dutra *et al*,[26] gonial angle was not influenced by the age or by dental status. On the other hand, some researchers found that gonial angle increased with age[23,25] and others found that gonial angle decreased with age.[24] The different results of the correlation between gonial angle and age observed among various studies may be attributed to the different age ranges and different dental statuses selected among those studies [Table 2].

In the present study, when the three parameters such as condylar ramus height, coronoid ramus height, and gonial angle on the right side were compared between each other for the accuracy of age estimation, coronoid ramus height showed a statistically significant difference among the three parameters, thus stating that coronoid ramus height is a most reliable indicator for age estimation compared to condylar ramus height and gonial angle of mandible [Table 2]. This was in accordance with the study conducted by Abu-Taleb and El Beshlawy[21] The coronoid process of the mandible effectively extends upward and backward into the tendon of the temporalis muscle and is presumably influenced by it. Few studies have hypothesized that there is a clear considerable interplay between the variation of masticatory function, muscle microstructure, and mandibular morphology.[26]

The results of the present study indicate that all the three parameters such as condylar ramus height, coronoid ramus height, and gonial angle can be used as reliable indicators for age estimation. Among the three parameters, coronoid ramus height was the most significant predictor for age estimation in a selected population.

However, further studies using a larger sample size from diverse regions and different imaging modalities are recommended to set our population standards for age estimation.

Conclusion

Our results showed that all the three parameters can be used for age estimation, and among them, coronoid ramus height is the best indicator. The limitations of the study are to consider a large proportion of samples with different age groups to reduce standard errors, achieve maximum reproducibility, and derive a universal formula.

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Conflicts of interest

There are no conflicts of interest.

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