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Age determination through gonial angle using OPG and lateral cephalogram in the general population of North Gujarat – A comparative study

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Abstract:

Age estimation is important in forensic and medico-legal investigations and the mandible is a key structure used for this purpose. Therefore, it is of interest to evaluate gonial angle measurements from orthopantomograms (OPG) and lateral cephalograms in 50 participants aged 10–40 years from the North Gujarat population to determine their usefulness in age assessment. The gonial angle increased with age and lateral cephalograms were found to predict age more effectively than orthopantomograms. Thus, data shows that both imaging methods can support age estimation, with lateral cephalograms offering greater predictive value.

Keywords: Age estimation, gonial angle, lateral cephalograms, orthopantomograms (OPG)

Background:

Forensic odontology has several applications including the identification of persons in crime scenes and/or mass tragedies and the evaluation of injuries to jaws, teeth and oral soft tissue. Recognition and evaluation of bite marks, common in cases of sexual assault, child abuse, self-defense, age estimation and gender determination. Forensic odontology involves a number of techniques like rugoscopy, cheiloscopy, radiography, photographic analysis and molecular techniques [1, 2]. How to estimate the age of a person should be very accurate and easy to use. Currently, most age estimation methods are invasive, require long processing times, expensive equipment and the assistance of a qualified pathologist to estimate the age of an individual [3, 4]. Length of the bones, secondary sexual characteristics, ossification of the bones *etc.*, is all useful in calculating the age. Ossification of the cartilages of the hyoid, larynx and ribs and obliteration of the skull sutures, are examples of parameters that may indicate aging but do not give specific proof [5]. Dentofacial radiography is now routinely used in dental, medical and hospital clinics [6]. Radiography is a non-invasive and less invasive technique, so it can be used on live and dead people. It is used in forensic dentistry to give information that cannot be retrieved by a physical examination. Some of the radiographic pictures that can be used to determine an individual's age are intraoral periapical radiographs, lateral oblique radiographs, cephalometric radiographs, panoramic

radiographs, digital imaging and sophisticated imaging technologies. The analysis of the digital pictures of available radiographs for age assessment has provided new insights into the field of age estimation [7]. Forensic radiology requires the determination of the real age of the patient. The stages of tooth growth can be used to determine the chronological age of a young person, provided a proper dental survey is made. Odontological age estimation is based on a triangle of subject for age estimation, suitable dental development assessment and legal considerations [6]. One of the first bones in the body to begin ossifying is the mandible, which is special because it has both intramembranous and endochondral ossification patterns. While the coronoid and condylar processes undergo endochondral ossification, the mandibular body undergoes intramembranous ossification. Up until the third decade of life, morphological and dental changes (such as the time and order of tooth eruption) can be used to estimate age [8]. The gonial angle is the most frequently used measurement in the mandible in various dental applications. It is about aesthetics, orthodontics, sleep disorders, angle fracture risk and forensics. It is used in forensic medicine to estimate age, to determine growth trends in individuals, to determine extraction patterns in class II patients and to decide whether to perform surgery on class III skeletal base patients. It is a dynamic anatomical landmark in the head and can be evaluated radiographically and clinically [9]. Recent studies have indicated that the gonial angle measured by

panoramic radiograph may be useful in cephalometric diagnosis. The measurement of the gonial angle measurement is difficult and inaccurate due to the superimposition on the right and left side of the lateral cephalometric radiograph. Also, the values of the gonial angle obtained from the dried human mandibles and panoramic radiographs are identical [1]. Therefore, it is of interest to assess the accuracy of age determination through gonial angle measured on panoramic radiographs and then compare this with the gonial angle measurements obtained from lateral cephalograms.

Materials and Methods:

The present cross sectional study was conducted on a sample of 300 individuals in the age group of 10-40 years who reported to the department of Oral Medicine and Radiology, Narsinhbhai Patel Dental College & Hospital, Visnagar, Gujarat. Selected participants were grouped based on gender (Male and Female) and age (10-20, 21-30 and 31-40 years). The data were obtained from digital panoramic and lateral cephalogram radiographs. The study was performed after approval of the Institutional Ethics Committee. Subjects aged 10 to 40 years with pre-orthodontic radiographs. Patients who declined or did not have error-free panoramic and cephalometric photographs were excluded. Those with a history of jaw injury or facial asymmetry were excluded. Based on the selection criteria, 300 patients/subjects who visited the Oral Medicine and Radiology outpatient department were chosen. A thorough clinical examination was conducted, and the results were entered into a pre-made or printed case history proforma. Before being included in the trial, each participant received study information and gave their informed consent. Using the Kodak 8000C Digital Panoramic and Cephalometric System, the chosen subjects underwent a series of digital extraoral radiographs that included lateral cephalograms and panoramic imaging (**Figure 1 and Figure 2**). Following picture acquisition, digital processing and enhancement were carried out and Kodak Imaging software 6.12.18.9 was used to produce bilateral linear measures. ImageJ v1.53 (NIH, USA) was used to measure the gonial angle. The gonial angle was measured using lateral cephalogram and panoramic imaging. Intersection of two lines, one tangential to the posterior border of the ramus and condyle and another tangential to the most inferior point at the angle and lower body of the mandibular body. Data were recorded in a table form in a Microsoft Excel sheet (linear measurements and patient demographics). Statistical analysis was carried out using SPSS software version 22. Group comparisons were made using the Z-test, unpaired and paired t-test and regression analysis was used for age estimations.

Results:

There were 157 (52.3%) patients in the 10-20 age group out of the three age groups that were included in the study. Out of the 157 patients, 98 patients were female and 59 were male. Patients were in the age group of 21 to 30 years (93 [31.0%]), of which 49 (52.7%) were females and 44 (47.3%) were males. We had 50 patients (16.7%) in the age group 31-40 years, females 28 and

males 22. Of 300 cases, 175 were females and 125.9 were men (**Table 1**). In the age range of 10 to 20 years, the mean gonial angle measured from the right side of the OPG was 123.03 ± 7.74 degrees, while the mean from the left side was 123.82 ± 7.58 degrees. The mean gonial angle values on the two sides of OPG were compared using the Z-test. The mean gonial angle acquired by OPG in this age group was shown to be statistically non-significantly different, with a p-value of 0.361. In the age range of 21 to 30 years, the mean gonial angle measured from the right side of the OPG was 123.8 ± 5.57 degrees, whereas the mean from the left side was 124.27 ± 5.75 degrees. The mean gonial angle values on the two sides of OPG were compared using the Z-test. The mean gonial angle acquired by OPG in this age group was shown to be statistically non-significantly different, with a p-value of 0.572. In the age range of 31 to 40 years, the mean gonial angle measured from the right side of the OPG was 126.2 ± 4.13 degrees, whereas the mean from the left side was 126.3 ± 4.86 degrees. The mean gonial angle values on the two sides of OPG were compared using the Z-test. The mean gonial angle acquired by OPG in this age group was found to be statistically non-significantly different, as indicated by the p-value of 0.91 (**Table 2**). The average gonial angle for the 10-20 age group was 122.35 ± 7.74 degrees. The average gonial angle for the 21-30 age group was 123.74 ± 5.49 degrees. In contrast, it was 126.74 ± 4.13 degrees in the 31-40 age group. It implies that the mean gonial angle values rise noticeably with aging. A statistically significant difference in the mean gonial angle derived from the lateral cephalogram between the various age groups was indicated by a p-value < 0.001 (**Table 3**). The correlation coefficient was found to be 0.79 (p-value < 0.05) in the 10-20 age group, 0.63 (p-value < 0.05) in the 21-30 age group and 0.46 (p-value < 0.05) in the 31-40 age group. The gonial angle measurements revealed the lowest correlation (0.46) in the 31-40 age group and the best correlation (0.79) in the 10-20 age group (**Table 4**). The lateral cephalogram yielded a sensitivity of 62.18 in the 10-20 age range, whereas the left OPG yielded a sensitivity of 65.00 and the right OPG a sensitivity of 63.10. Lateral cephalogram specificity was 0.00, whereas left OPG specificity was 45.95 and right OPG specificity was 40.20. The lateral cephalogram yielded a positive predictive value of 98.98, while the left and right OPGs yielded values of 79.59 and 72.09, respectively. Lateral cephalograms yielded a negative predictive value of 0.00, while left and right OPGs yielded values of 28.81 and 26.22, respectively. The lateral cephalogram's accuracy in predicting age was 41.32, while the left and right OPGs were 57.15 and 51.48, respectively. The lateral cephalogram yielded a sensitivity of 52.69 in the 21-30 age group, whereas the left OPG yielded a sensitivity of 49.28 and the right OPG a sensitivity of 46.20. The lateral cephalogram yielded a specificity of 0.00, while the left and right OPG yielded a specificity of 0.00. The lateral cephalogram yielded a positive predictive value of 100.00, while the left and right OPGs yielded values of 69.39 and 64.10, respectively. The lateral cephalogram yielded a negative predictive value of 0.00, while the left and right OPGs yielded values of 20.45 and 18.92, respectively. While the left OPG was 31.84 and the right OPG was 29.12, the lateral cephalogram was

35.13 in terms of age prediction. The lateral cephalogram yielded a sensitivity of 56.00 in the 31–40 age range, while the left and right OPGs yielded sensitivity values of 56.41 and 54.12, respectively. The lateral cephalogram yielded a specificity of 0.00, while the left and right OPG yielded a specificity of 0.00. The lateral cephalogram yielded a positive predictive value of 100.00, while the left and right OPGs yielded values of 78.57 and 76.01, respectively. The lateral cephalogram yielded a negative predictive value of 0.00, while the left and right OPGs yielded values of 22.73 and 21.11, respectively. While the left OPG was 36.80 and the right OPG was 31.01, the lateral cephalogram was 37.33 in terms of age prediction (Table 5).

Table 1: Distribution of patients according to age group

Age group (in years)	Females	Males	Total
10-20	98	59	157 (52.3%)
21-30	49	44	93 (31.0%)
31-40	28	22	50 (16.7%)
Total	175	125	300

Table 2: Age wise Mean gonial angle value by OPG (Z test for significance of means)

Age group (in years)	Mean Gonial angle in OPG Right side	Mean Gonial angle in OPG Left side	p-value
10-20	123.03 ± 7.74	123.82 ± 7.58	0.361
21-30	123.8 ± 5.57	124.27 ± 5.75	0.572
31-40	126.2 ± 4.13	126.3 ± 4.86	0.91

Table 3: Age wise Mean gonial angle value by lateral cephalogram

Age group (in years)	Mean Gonial angle in lateral cephalogram	p-value
10-20	122.35 ± 7.74	p < 0.001
21-30	123.74 ± 5.49	
31-40	126.74 ± 4.13	

Table 4: Age wise correlation of gonial angle measurements obtained from lateral cephalogram and OPG

Age group	Correlation coefficient	P-value
10-20	0.79	<0.05 significant
21-30	0.63	<0.05 significant
31-40	0.46	<0.05 significant

Table 5: Sensitivity and specificity of OPG and lateral cephalogram in predicting gender by age groups

Age group: 10-20 years	Lateral cephalogram	OPG
Sensitivity	62.18	65.00
Specificity	0.00	45.95
Positive predictive value	98.98	79.59
Negative predictive value	0.00	28.81
Efficacy	41.32	57.15
Age group: 21-30 years		
Sensitivity	52.69	49.28
Specificity	0.00	0.00
Positive predictive value	100.00	69.39
Negative predictive value	0.00	20.45
Efficacy	35.13	31.84
Age group: 31-40 years		
Sensitivity	56.00	56.41
Specificity	0.00	0.00
Positive predictive value	100.00	78.57
Negative predictive value	0.00	22.73
Efficacy	37.33	36.80

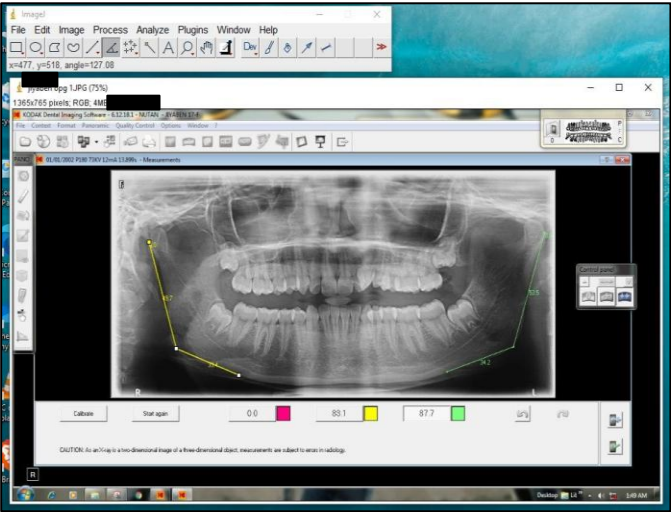


Figure 1: Measurement of gonial angle on OPG image using ImageJ software

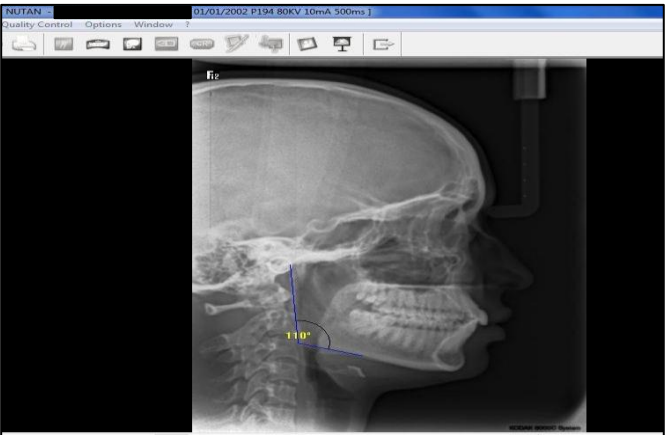


Figure 2: Measurement of gonial angle on lateral cephalometric image

Discussion:
The study of sex estimate is crucial for population history, geographical differences and forensic purposes [10]. Furthermore, given the rise in a variety of crimes, one of the crucial responsibilities of medicolegal officials in the modern era is age estimation. Because they are linked to the greatest morphological changes in size during the growing phase, the mandibular condyle, ramus and gonial angle in particular are typically the most sexually dimorphic [11]. Therefore, the gonial angle was chosen for age estimation in the current investigation. The study of age estimate is crucial for population history, geographical differences and forensic purposes. Furthermore, given the rise in a variety of crimes, one of the crucial responsibilities of medicolegal officials in the modern era is age estimation. Because they are linked to the greatest morphological changes in size during the growing phase, the mandibular condyle, ramus and gonial angle in particular are typically the most sexually dimorphic [11]. For the purpose of estimating age in the current study, the gonial angle was selected. The mean

gonial angle for males in the current investigation, as determined by OPG, was 122.98 ± 6.36 degrees on the right side and 122.94 ± 6.08 degrees on the left. With a p-value of 0.88, this difference was not statistically significant. According to Al-Shamout *et al.* (2012), there was no statistically significant difference in males. The mean gonial angle in females, as determined by OPG, was 124.38 ± 6.89 degrees on the right side and 125.40 ± 6.94 degrees on the left [12]. This difference was statistically highly significant, with a p-value of less than 0.001. Shahab *et al.* (2015) reported a statistically significant difference between the two sides of OPG, which was consistent with this [13]. We found in our study that the gonial angle rises with age. In line with our work, Dhaka *et al.* [14] also reported a similar finding. Our research did not support the findings of Behl *et al.* [1], who said that gonial angle diminishes with age. In contrast, Srii *et al.* [9] found that the gonial angle decreases with age. Therefore, our study differs from existing investigations. According to both writers, as people age, their gonial angle decreases due to a decrease in the masticatory muscles' contractile activity and muscular density. In contrast to our work, Matilla *et al.* [15] also found that the gonial angle decreased with aging. OPG was used in the current investigation to predict age. For both males and females, our model significantly predicted age. The results of our investigation were consistent with those of Bhardwaj *et al.* [16]. In the current investigation, a regression equation was used to predict the participants' ages based on their lateral cephalograms. Age was highly significantly predicted by our model. Rai *et al.* [17] observed that gonial angle had a similar capacity to predict age using a comparable regression equation. The ability of the lateral cephalogram and both sides of the OPG to predict age was compared in this study. We found that an individual's age may be ascertained using both the lateral cephalogram and OPG methods. The left side of OPG showed the lowest accuracy in estimating a subject's age, whereas the lateral cephalogram had the highest accuracy. The study by Pillai *et al.* [18], which found that OPG can be used to estimate age, was comparable to this.

Conclusion:

The lateral cephalogram and OPG were the radiological methods utilized in this investigation to assess gonial angles in

order to predict age and gender. Among these, lateral cephalograms were the most accurate in determining a subject's age. Gonial angle is a crucial factor in determining age. The ease of access to lateral cephalograms and panoramic radiographs can play a significant role in determining whether or not they are an appropriate method for this kind of prediction.

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