ORIGINAL ARTICLE

Radiographic evaluation of remodeling of mandible in adult South Indian population: Implications in forensic science

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Abstract

Introduction: Panoramic X-ray is an imagiological examination produced by a technique that exhibits images of the facial structure present in the upper and lower dental arches, as well as the support structures in the diagnosis of problems that require a broad view of the oral–maxillofacial complex, such as the assessment of traumatisms, extensive lesions, dental development, tooth retention, and growth anomalies. Many morphological and anatomical changes are exhibited by the mandible with the advancement of age and changes in gender, as well as dentoalveolar condition of the patient, and it can be assessed with the help of such radiograph, thus playing an important role in personal identification in forensic dentistry. **Aims:** This study aimed to evaluate the changes in gonial angle (GA), antegonial angle (AGA), and antegonial depth (AGD) in adult mandible with regard to age, gender, and dental status using panoramic radiographs. **Settings and Design:** This cross-sectional retrospective study was done using hospital records. **Subjects and Methods:** A total of 100 panoramic radiographs were evaluated. The images were grouped into three age groups (40–70) of 10 years each. GA, AGA, and AGD were digitally measured from the radiographs. **Statistical Analysis Used:** Descriptive statistics of the variables were expressed in percentage, frequencies, mean, and standard deviations. Statistical differences between the variables were explored using independent sample *t*-test and one-way ANOVA. The significant level was set as 0.05. **Results:** There were no significant changes in GA, AGA, and AGD with age and dental status of the patients. Males had significantly smaller GA and AGA than females. Understandably, AGD was significantly greater in males than females. **Conclusions:** Remodeling changes of the mandible with respect to the age groups and dental status studied were minimal. However, gender-related differences in ante AGA, depth, and GA were significant, which can be used as a tool in forensic identification.

Key words: Antegonial angle, antegonial depth, forensic dentistry, gender, gonial angle, panoramic radiograph

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Introduction

Mandible is one of the important maxillofacial bones which enable several functions such as mastication, deglutition, and phonation. In addition, it is one of the key bones which determine the morphology of the human face and facial profile. From the developmental stage onward, the mandible undergoes several subsequent morphological changes, which is prominent in the first two decades of life. Understandably, several studies evaluating the growth pattern in the first and second decades of life are available, but little is known regarding the remodeling of mandible in adult South Indian population.[1-6] Panoramic radiograph is the easiest and reliable modality for the determination of morphological changes of mandible in living individuals. Hence, this study was planned aiming to evaluate three morphometric parameters of mandible, namely gonial angle (GA), ante GA AGA, and antegonial depth (AGD) with regard to age, gender, and dental status using panoramic radiographs.

Subjects and Methods

A total of 100 panoramic radiographs (54 males and 46 females) of patients, age ranging from 40 to 70 years, were selected from the digital archives of the department of oral medicine and radiology [Graph 1]. All the panoramic images were made using Carestream KODAK 8000C (Rege Imaging and Cine Films Pvt. limited, Patel Nagar, New Delhi) Digital Cephalometric and Panoramic X-ray system during the period of January 2018 to December 2018. Only high-quality radiographs with minimal artifacts and correct patient positioning were selected for evaluation. Patients with fractures, temporomandibular joint disorders, facial asymmetry, skeletal deformity, postorthognathic surgery, and those undergoing/undergone head-and-neck radiotherapy/surgery were excluded from the study. The radiographs were grouped into three 10-year span age groups as 40–50 (Group 1), 50–60 (Group 2), and 60–70 (Group 3) years. Gender, age, and dental status were also recorded.

Radiographic measurements

The measurements were made using Trophy Dicom Inc. 6.4 software (Trophypan smart SC, Kodak). A single observer performed all the measurements. The following measurements were made:

1. GA
2. AGA
3. AGD.

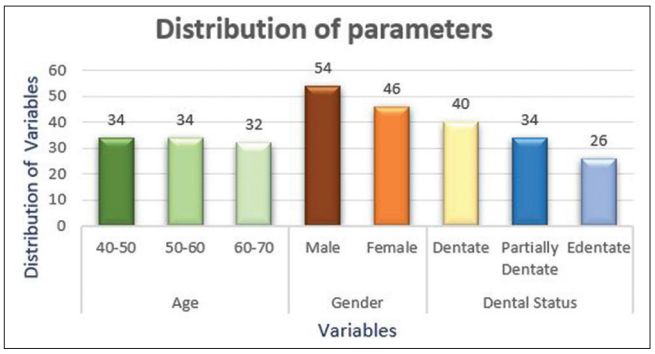
GA was measured by drawing two tangents, one along the distal border of the ramus and the other along the inferior border of the body of mandible. The intersection of these lines represented the angle [Figure 1]. AGA was estimated by tracing two lines along the slopes of the antegonial region that will intersect at the deepest point of the antegonial notch. AGD was measured by drawing a perpendicular from the deepest point of the notch concavity to a tangent that is drawn along the interior border of the mandible [Figure 2]. Measurements of all angles and distances were made on both sides.

Dental status was divided into dentate, partially dentate, and edentate. Those with all the mandibular molars missing were considered as partially dentate, those with all the teeth missing as edentate, and those with the entire teeth present were considered as dentate.

Intraobserver reliability was estimated by repeating the measurements performed 4 weeks apart in 25 radiographs selected randomly from the sample and were statistically tested using concordance correlation coefficient (CCC).

Statistical analysis

All the collected data were analyzed using the Statistical Package for the Social Sciences Software for Windows



Graph 1: Distribution of age, gender, and dental status in the study

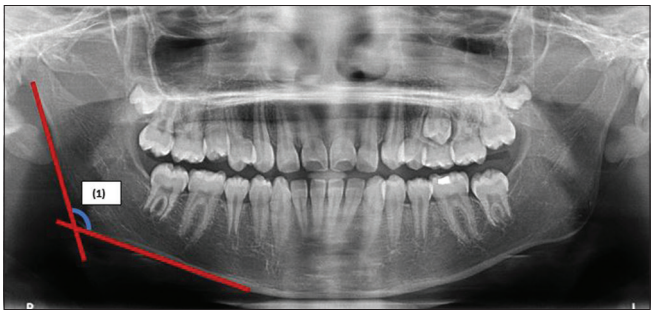


Figure 1: Measurement of (1) gonial angle

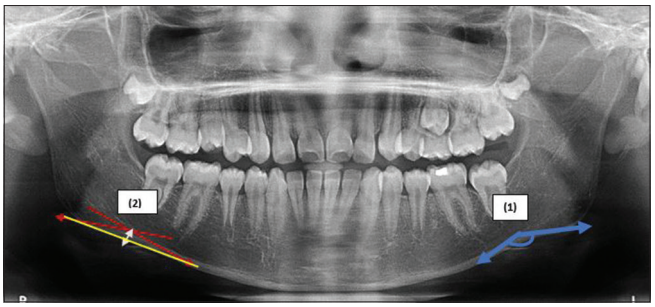


Figure 2: Measurement of (1) antegonial angle and (2) antegonial depth

version 17 (IBM Corp, Armonk, NY, USA). Descriptive statistics of the variables were expressed in percentage, frequencies, mean, and standard deviations. Statistical differences between the variables were explored using independent sample *t*-test and one-way ANOVA. The significant level was set as 0.05.

Results

All possible observations were readable and were included in the present analysis. Measurements of all angles and distances were made on both sides.

Results of angles and distances are presented in Table 1. Values of the right and left sides showed minimal variation in all measurements and were statistically insignificant. In males and females, both side values of AGA, AGD, and GA were more or less similar and did not show statistically significant changes with age. However, a trend of marginal increase in GA with age was observed.

The mean GA and AGA values in males were 124.1° ± 5.2 and 163.9° ± 5.5, respectively, which were lesser compared to that of females (126.2° ± 5.2 and 166.4° ± 5.1, respectively) [Graph 2a]. The difference was statistically significant ($P < 0.05$) and was irrespective of the dental status. AGD was significantly higher for males (0.22 ± 0.06 mm) than females (0.19 ± 0.07 mm) [Graph 2b and Tables 2 and 3].

Only AGD showed statistically significant association with dental status of the individuals out of the three parameters studied. The AGD was significantly greater in edentate (0.23 ± 0.08 mm individuals compared to the dentate (0.19 ± 0.05 mm) and partially dentate groups (0.20 ± 0.06 mm) [Table 2].

The observer showed high intraobserver reproducibility, and the CCC ranged between 0.90 and 0.96 for the angles and distances [Table 4].

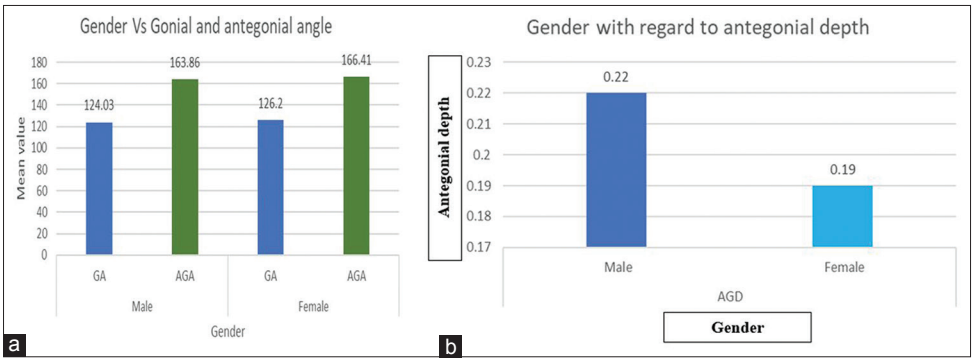
Discussion

Although several researchers had analyzed the gonial–antegonial region in the early decades of life for the assessment and prediction of mandibular growth, little is known regarding the remodeling of mandible in the process of aging and with different dental status. Furthermore, assessing the forensic scope of these findings in predicting the age and sex of the individual and thus shedding light on the personal identification of skeletal remains has not been much discussed in literature.

Panoramic radiographs have been proven to be an important tool for the estimation of different morphological parameters of the mandible. According to Larheim *et al*.,[5] these radiographs have acceptable reproducibility for the measurement of vertical and angular variables for group comparisons, provided the head positioning is standard and kept constant. In addition, superimposition of anatomical landmarks as in lateral cephalogram and increased radiation exposure as in computed tomography and cone-beam computed tomography are relatively less in this modality.

Common remodeling fields in the mandible which undergo changes with advancing age include the gonial region, antegonial region, condyle, and ramus.[7] According to Enlow *et al*.,[8] the morphological changes undergone by the mandible are thought to be influenced by the dental status and the age of the patient in both genders. In the present study, three parameters from the aforementioned areas were included, and panoramic radiograph was used to measure these variables.[4,9]

There were no significant changes in the mean values of GA, AGA, and AGD in the age groups studied. However, the mean AGA slightly decreased and mean GA slightly increased with age. The lack of significant variations of the morphometric parameters with age in the current study may be related to the relatively higher age groups selected. The results were consistent with the study conducted by Dutra *et al*. on Philippine population. They did not find any significant correlation of age to AGA and AGD. However, the results of the present study were not in agreement with the studies of Saini *et al*.[10] and Ghosh *et al*.[7] where an increase in values was obtained with increase in the age of the individual.



Graph 2: Relationship of gender with regard to (a) gonial angle and antegonial angle, (b) antegonial depth

Table 1: Demographic distribution of samples

	n	Mean±SD
Gonial angle	100	125.03±5.3
Antegonial angle	100	165.03±5.1
Antegonial depth	100	0.21±0.07

SD: Standard deviation

Table 2: Parameter relationship with regard to gender

	Gender	Mean	*P*
Gonial angle	Male	124.03	0.041*
	Female	126.20	
Antegonial angle	Male	163.85	0.019*
	Female	166.41	
Antegonial depth	Male	0.22	0.021*
	Female	0.18	

*Significance level $P<0.05$

Table 3: Group statistics: The standard deviation and *P* values have been determined in relation to each parameter with gender

	Gender	Mean (angles and inches)±SD	*P*
Gonial angle	Male	124.03±5.20	0.041*
	Female	126.20±5.23	
Antegonial angle	Male	163.86±5.49	0.019*
	Female	166.41±5.19	
Antegonial depth	Male	0.22±0.076	0.021*
	Female	0.19±0.068	

*Significance level $P<0.05$. All the *P* values were found to be <0.05 and were significant. They were found to have statistically significant relation with both the genders and each parameter. SD: Standard deviation

Table 4: Concordance correlation coefficient

	Gonial angle	Antegonial angle	Antegonial depth
Intraobserver	0.96	0.92	0.89

There was no significant difference between right- and left-side measurements, which was in agreement with the studies of Preston *et al*.[11] and Chole *et al*.[12] However, measurements of the antegonial region on the left side were marginally higher, which was probably due to the inherent asymmetry of human mandible[7,8] or increased function,[10,13] and further studies are needed to prove such assumptions.

The intra-observer agreement was very high for all the indices ranging from 0.92 (for AGA) to 0.96 (for GA) for angles and distances, further confirming the reliability of the assessment.

Differences in the three morphometric parameters with regard to gender have been assessed, and it was found that females had higher values of GA and AGA, but lower values of AGD compared to males. The results were compared with that of Humonen *et al*.[14,15] who also observed significantly higher values of GA in females. A 3°–5° higher mean GA values in females were observed in studies of Casey and Emrich,[13] which was in line with our study. The downward and backward growth of female mandible and the difference in the action of masticatory muscles bring out such a difference between genders. However, the results of our study were not in agreement with the studies of Dutra *et al*.[13] and Upadhyay *et al*.,[16] who observed similar values of GA in males and females. Dutra *et al*. noticed higher values of AGA in females (165° ±0.58) and significantly higher values of AGD in males. Similar trend was observed in the present study, and the mean values of antegonial parameters of both the studies were almost within the same range. The difference in AGD in males and females is thought to be due to the differences in gender-related bone metabolism and the action of muscle mass attached to this region.[13,17]

Dentition status with regard to GA, AGA, and AGD was evaluated, which revealed that only AGD depicted a statistically significant increase from dentate to edentate group regardless of gender. A mild but statistically insignificant increase in GA and decrease in AGA were also observed in edentate group compared to the other two. Chole *et al*.[12] in their studies on Indian population and Dutra *et al*. on Philippine population showcased similar results. Muscle function tends to preserve the bone at its point of insertion, therefore the architecture of the gonial region will be maintained by the insertion of medial pterygoid and masseter muscles.[7,13,16] The antegonial region undergoes resorption in the edentulous mandible, perhaps due to the reduced muscle function in this region, thereby increasing the AGD.

When the remodeling changes at the gonial and antegonial regions were studied, Enlow *et al*.[8] stated that bone deposition occurs throughout the inferior border of the mandible except at the antegonial region where resorption predominates, causing a decrease in the AGA and an increase in the AGD. Similarly, when the teeth are present, the muscle activity associated with mastication preserves the angle from any change in the size, but as the tooth is lost, the bone will undergo remodeling, causing an increase in AGD.[12,18,19] Various factors other than age, gender, and dental status have their role in remodeling of gonial–antegonial region in adult mandible such as occupation, social status, and postural and functional interrelationship of cheek, lips, and tongue.[20-22] Hence, further studies including such aspects are needed.

The result of the present study has many important implications. The study highlighted that gonial and antegonial regions have high potential to be used as a tool for gender determination, further expanding the amour of forensic tools. In this digital era, a large part of the population has access to these kinds of radiographs and would have taken such radiographs at some point of their lifetime, which further enhances the availability of the antemortem data that can serve as a good indicator for personal identification in mass disasters. Moreover, those

performing osteotomies and orthognathic surgeries in the antegonial region should have a thorough knowledge regarding the resorptive pattern of antegonial region, especially in edentulous patients. When prediction of osteoporosis is made by measuring the cortical width at the antegonial region, one should also consider the other factors which affect the resorption in the region.

The major limitation of this study was that the remodeling pattern was assessed by one-time measurement. Instead of a cross-sectional study design, there is a need for a large longitudinal study to ascertain a definitive conclusion regarding remodeling changes of mandible and to estimate the impact of age, gender, and dental status on GA, AGA, and AGD. Mandible is a bone which shows sexual dimorphism both morphologically and morphometrically. Here, we used orthopantomograms to take measurements and did not rule out these dimorphic features. Mandibular index, which was a better indicator to distinguish between male and female sexes, was not added to this study, which is another limitation.

Conclusion

Remodeling changes of the mandible with respect to the age groups and dental status were found to be minimal. Significant gender related difference was noted Furteher research are necessary to confirm the results of the present study wth a large sample size and considering other confounding factors.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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