Original Article

Influence of age on the radiomorphometric indices of the gonial region of mandible in North- Indian population

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ABSTRACT

Background: *The gonial region of mandible plays a significant role in the determination of mandibular basal bone morphology. Gonial Angle is important for maintenance of a harmonius facial profile whereas Gonial Index is an indicator of the bone quality of the mandibular gonial region.*

Objectives: *To examine the influence of age on two quantitative radiomorphometric indices of mandible, Gonial Angle (GA) and Gonial Index (GI) in a group of North-Indian population.*

Material and Methods: *60 adult human orthopantomographs were evaluated and divided into six age groups (35-65 years) with equal number of cases. Gonial Angle and Gonial Index were measured bilaterally on each radiograph. The measurements were analyzed for interactions with age and other inter-relationships between the indices. The data obtained was subjected to statistical analysis using SPSS (Statistical Package for Social Studies) software version No. 18 and Mann- Whitney tests were used for various comparisons.*

Results: *Gonial angle showed a significant positive correlation with age as the mean gonial angle values showed an increase with increasing age. Whereas in sharp contrast to this, gonial index showed no correlation with age as the mean gonial index values showed no pattern of either increase or decrease with increase in age. The correlation between gonial angle and gonial index was statistically insignificant (p>0.05).*

Conclusion: *Age had a significant influence on the angular radiomorphometric index i.e. gonial angle but the linear radiomorphometric index i.e. gonial index remained independent of age.*

Key Words: *Panoramic radiographs, gonial index, mandibular angle, mandibular remodeling, radiomorphometric, indices of mandible*

Introduction

The mandible undergoes constant remodeling and morphological alterations throughout an individual's lifetime in its various areas including the gonial region, antegonial region, condyle and the ramus. "Gonion" is the most inferior, posterior and lateral point on the external angle of the mandible. The word ''Gonion" is derived from the Greek word "ywvtx" meaning angle. The angular radiomorphometric measurement of the gonial region of mandible- gonial angle (mandibular angle/ angle of jaw) is the angle at which the lower border of the mandibular body meets the posterior border of the ramus of the mandible. Gonial Index is a linear radiomorphometric index of mandible devised by Bras et al. [1] It is the measurement of cortical thickness of inferior border of mandible at the gonial angle.

Dimensions of the facial skeleton are related to the contractile activity of the masticatory muscles. Electromyographic investigations have shown strong masseter and anterior temporal muscle activity to correlate with smaller gonial angles. [2] Also,

gonial angle plays an important role in ensuring a harmonius facial profile from an aesthethic point of view, so it is a representative of mandibular morphology and its increase or widening may cause the face to appear older. Thus the implication of gonial angle is of great importance to evaluate the mandibular basal bone morphology and to demonstrate the influence of aging process on the remodeling changes of the mandible.

It has been noted that the muscle insertion regions respond to the increased muscular activity with increased bone density. Fish [3] indicated that age and loss of teeth may effect change of gonial angle, but other factors are also influential. In recent study conducted by Xie et al, [4] the gonial angle size was widened in edentulous older women and also showed a significant negative correlation with cortical thickness at gonial angle, indicating a possible systemic effect such as osteoporosis or metabolic bone loss on the size of gonial angle. Bras et al [1] who first devised the Gonial Index, investigated the changes in the cortical thickness at gonial angle using panoramic radiographs in normal individuals of different ages and also in patients with chronic renal failure. They reported that after the fifteenth year of life, the cortical thickness at the gonial angle of the normal group is relatively constant except in postmenopausal women of 60 years and older, whereas loss of cortical bone was seen in the chronic renal failure patients. Kribbs et al [5] in their numerous studies have concluded that patients with systemic osteoporosis have a thinner cortex at gonion than normal population. Gonial Index of less than 1mm has been interpreted as radiographic evidence of metabolic bone loss. [6]

According to Weinmann and Sicher, [7] the consecutive atrophy of masticatory muscles with increasing age leads to changes in the region of mandibular angle. Resorption of the bone at the posterior or inferior border of this region i.e. in the area of insertion of masseter and medial pterygoid muscles leads to an increasing obtuseness of mandibular/gonial angle. Hence, gonial index, which is an indicator of bone density of the gonial region is expected to have an interaction/correlation with the gonial angle size. However, there is scarcity of literature establishing the interaction of gonial index with age in a normal population. Also, very few studies have investigated the relationship of gonial angle with gonial index.

Therefore, the present study was conducted with the aim of measuring Gonial Angle (GA) and Gonial Index (GI) in a group of North-Indian population of Haryana (a state of India) and studying the influence of age on these radiomorphometric indices. This study also explored the interaction of these indices with each other. According to the best of our knowledge, this is the first study to consider the interactions of both these indices with each other in an Indian population.

Material and Methods

The study sample and design

This study was conducted in the department of Anatomy, Pt. B. D. Sharma Post Graduate Institute of Medical Sciences, Rohtak (Haryana, India) in collaboration with the department of Periodontology using 60 adult dental panoramic radiographs i.e. orthopantomographs of routine patients visiting dental clinics for various indications like periodontal diseases, implantations, cosmetic treatment

etc. The radiographic machine used was Kodak 8000 (Kodak Eastman Company, France). Name, age and C.R. No. of the patient were recorded for each radiograph from the records of the radiography department.

The following radiographs were excluded from the study:

1. Poor quality images.
2. Radiographs with distorted images of the mandible.
3. Radiographs in which the gonion points of both sides were not clearly visible.
4. Radiographs where either the gonial angles of both sides were not visualized completely or where lower border of mandible, posterior border of the ramus or the condyle were not readable to allow proper measurements of the angle on both sides.
5. Radiographs in which the inferior cortical borders of mandible were not clearly identified.
6. Radiographs which showed any obvious gross distortion of the normal anatomical landmarks, for example, presence of a cyst, destructive lesions of mandible- which interfere with measurements.

The whole sample size of 60 orthopantomographs was divided into six age-groups of five-year age interval with equal no. of cases as follows:

Table 1: Age wise distribution of number of cases

GROUP NUMBER	AGE (in years)	Total number (n) of radiographs used
1	35-40	10
2	41-45	10
3	46-50	10
4	51-55	10
5	56-60	10
6	61-65	10

Radiographic Measurements:

The digitalized radiographs were printed on special photographic papers. Linear measurements were carried out using a vernier caliper whereas angular measurements were made with a protractor to obtain the following radiomorphometric indices:

GONIAL ANGLE (GA): was assessed by tracing one line tangent to the lower border of mandible and another line tangent to the posterior border of the ramus of mandible. The intersection of these lines forms the gonial angle. (Fig. 1, 2)

GONIAL INDEX (GI): was measured as the mandibular cortical width on the bisectrix of the angle between the two tangent lines forming gonial angle (as described above); according to the technique devised by Bras et al. [1] (Fig. 1, 2)

GA and GI were measured bilaterally on all radiographs and the mean of right and left sided measurements was calculated for each index in every radiograph.

Statistical Analysis:

Comparisons of the mean values of gonial angle and gonial index were made between different age groups. The data obtained from comparisons was subjected to statistical analysis using SPSS (Statistical package for social studies) software version no. 18. Mann-Whitney test was used for inter- age-group comparisons.

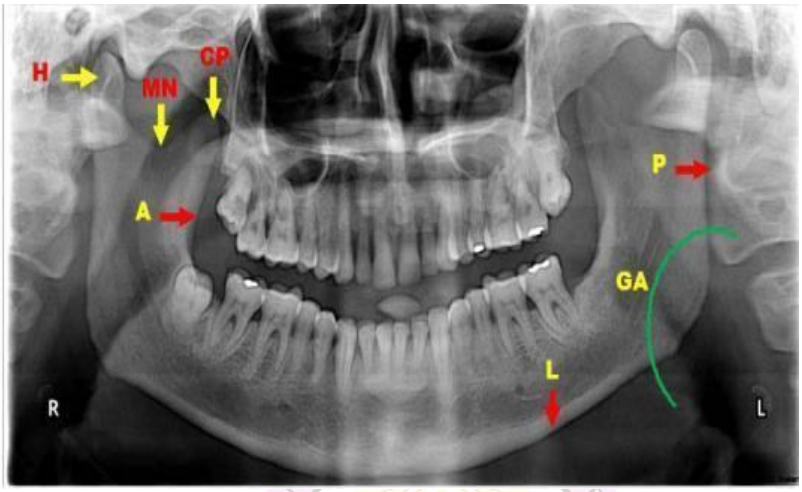

Fig. 1 Orthopantomograph used in the study showing various anatomic landmarks of mandible:- **L**-Inferior border of mandible, **P**-Posterior border of ramus, **GA**-Gonial/mandibular angle, **H**-Head of mandible, **A**-Anterior border of ramus, **MN**-Mandibular Notch, **CP**-Coronoid Process

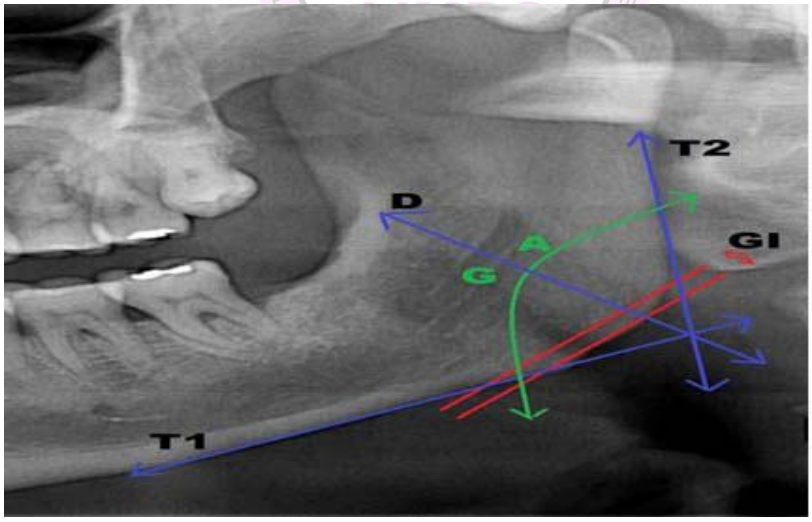

Fig. 2 Magnified view of a part of an orthopantomograph depicting the method of measuring Gonial Angle **(GA)** and Gonial index **(GI)**: **T1** – Line tangent to the lower border of the mandible. **T2** – Line tangent to the posterior border of ramus of the mandible. **D** – Bisectrix of the angle formed between **T1** and **T2** i.e. **GA** or Gonial Angle. **GI** – Mandibular cortical thickness measured on **D**.

Results

The range of gonial angle values recorded by the present study is shown in table no.2. The mean gonial angle values ranged from 114.85º ± 4.346 to 122.475º ± 6.846. The highest mean gonial angle was found in group 6 (61-65 years) whereas group 2 (41-45 years) showed lowest values. A trend of increase in the mean gonial angle values with increase in age was observed from Group 2 to Group 6 (Fig. 3). However, Group 1 (35-40 years) did not conform to this trend as the mean gonial angle value for Group 1 was higher than those observed for Groups 2(41-45 years) & 3(46-50 years).

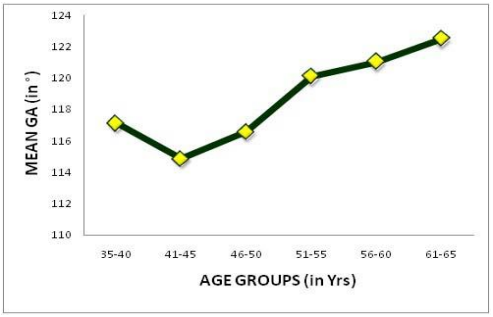

Fig. 3 Graph depicting the trend of Gonial Angle (GA) with increasing age

Table 2: Gonial Angle (GA) values in different age-groups

AGE GROUP		RANGE (In °)	MEAN GA (In °) ± SD
NO.	IN YRS		
1	35-40	108.5 – 127	117.1 ± 6.569
2	41-45	110.5 - 123.5	114.85 ± 4.346
3	46-50	109.5 - 124.5	116.55 ± 4.355
4	51-55	110 – 131	120.075 ± 8.541
5	56-60	106 – 126	121 ± 5.954
6	61-65	114 - 131.5	122.475 ± 6.846

Table No. 3: Gonial Index (GI) values in different age-groups

AGE GROUP		RANGE (In mm)	MEAN GI (In mm) ± SD
NO.	IN YRS		
1	35-40	1.4 - 2.5	1.91 ± 0.348
2	41-45	1.4 - 2.5	1.92 ± 0.341
3	46-50	1.75 – 3	2.255 ± 0.409
4	51-55	1.75 - 2.65	2.105 ± 0.335
5	56-60	1.65 – 3	2.175 ± 0.413
6	61-65	1.3- 3	2.135 ± 0.492

The range of gonial index values recorded by the present study is shown in table no.3. The mean gonial index values ranged from 1.91 mm ± 0.348 to 2.255 mm ± 0.409. The highest value for mean gonial index was recorded for Group 3 (46-50 years) while the lowest value of mean gonial index value was recorded in group 1 (35-40 years). In sharp contrast to gonial angle, there was no uniform trend of either an increase or decrease in the mean gonial index values observed with increase in age (Fig.4).

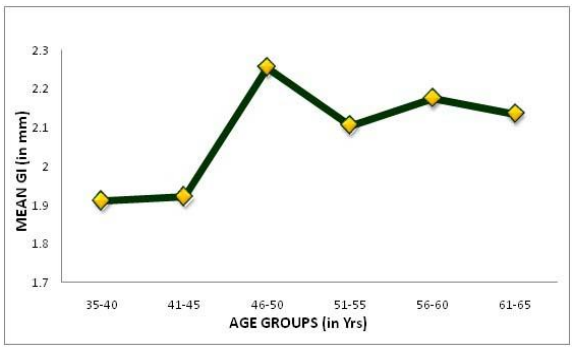

Fig. 4 Graph depicting the trend of Gonial Index (GI) with increasing age

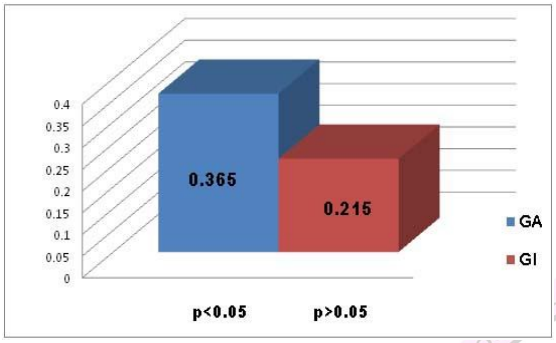

Fig. 5 Correlation-coefficient (r value) between age and radiomorphometric indices

A positive correlation coefficient was calculated between age and mean gonial angle; r = 0.365, which was statistically significant ($p<0.05$). On the other hand, there was no significant correlation between age and mean gonial angle (r = 0.215, $p>0.05$) (Fig.5).

However, the inter-age-group comparisons showed statistically insignificant differences for both the indices when the mean gonial angle and gonial index values were compared separately for successive age groups, using Mann-Whitney tests (Tables No. 4 & 5).

Lastly, the correlation coefficient calculated between gonial angle and gonial index, r = -0.154 was statistically insignificant ($p>0.05$).

Table 4: Comparison of Mean GA between different age groups (Mann-Whitney Test)

Age groups compared		p-value
Group No.	**In yrs**	
1&2	35-40 & 41-45	p > 0.05
2&3	41-45 & 46-50	p > 0.05
3&4	46-50 & 51-55	p > 0.05
4&5	51-55 & 56-60	p > 0.05
5&6	56-60 & 61-65	p > 0.05
1&6	35-40 & 61-65	p > 0.05

Table 5: Comparison of Mean GI between different age groups (Mann-WhitneyTest)

Age groups compared		P-value
Group No.	**In yrs**	
1&2	35-40 & 41-45	p > 0.05
2&3	41-45 & 46-50	p > 0.05
3&4	46-50 & 51-55	p > 0.05
4&5	51-55 & 56-60	p > 0.05
5&6	56-60 & 61-65	p > 0.05
1&6	35-40 & 61-65	p > 0.05

Discussion

This study was carried out to examine the influence of age on the two radiomorphometric indices of the gonial region of mandible i.e. Gonial Angle (GA) and Gonial Index (GI) in a group of North-Indian population and also to classify their interactions with each other. The study group was not selected on the basis of any radiographic or medical criteria that would define an individual as normal or osteoporotic. It represented patients undergoing normal physiologic bone changes with age who had radiographic examination done as a part of their routine dental treatment. A Comparative study of the results of our study with those of various other authors across the globe is presented in Tables No. 6 & 7.

Table 6: Comparison of Gonial Angle (GA) in various studies

Author	Population	Age-group	Range Of Mean Gonial Angle (In °)	Correlation Between Gonial Angle And Age	Inter age-group comparisons
CASEY et al [11]	American	-	123.9°±7.3 to 126.3°±7.3	Increase with age	p>0.05
OHM et al [10]	Norwegian	18-86 yrs	-	Increase with age	-
XIE et al [4]	Finnish	18-81 yrs	122.4°±6.6 to 122.8°±6.6	-	p>0.05
FATTAH et al [9]	Iraqi	20-85 yrs	-	Increase with age, significant correlation	-
SHAMOUT et al [8]	Jordanian	11-69 yrs	122.23° to 127.537°	Increase with age	-
PRESENT STUDY	North Indian	35-65 yrs	114.85°±4.346 to 122.475°±6.846	Increase with age (except gp.1>gp.2,3) significant correlation	p>0.05

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Table No. 7: Comparison of Gonial Index (GI) in various studies

Author	Population	Age-group	Range Of Mean Gonial Index (In mm)	Correlation Between Gonial Index And Age	Inter age-group comparisons
BRAS et al [1]	Netherlands	0-69 yrs	1mm To 2.5mm	Relatively constant with age, decrease in females in 60-69 yrs	$p > 0.05$
KNEZOVIC et al [16]	Croatian	48-86 yrs	-	Decrease with age	-
FATTAH et al [9]	Iraqi	20-85 yrs	-	Decrease with age, significant correlation	-
PRESENT STUDY	North Indian	35-65 yrs	1.91mm±0.348 to 2.25mm±0.409	No uniform trend, insignificant correlation	$p > 0.05$

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The mean gonial angle values recorded in the present study showed a trend of increase with increasing age with the exception of group 1 and a significant positive correlation was calculated between age and gonial angle. This result is supported by the studies of Shamout et al, [8] Fattah et al, [9] Ohm et al [10] and Casey et al. [11] The explanation for this trend is the combined effect of the altered mandibular basal bone morphology and the decreased density and activity of masticatory muscles due to aging. With advancing age, the mandibular process and reinforcing bone are removed by osteoclastic activity leaving behind a silhouette that resembles more easily the growth path taken by the condyle during earlier life. Due to this remodeling, the angle again opens out as in childhood. Also, the decreasing contractile power of masticatory muscles inserting in the mandibular angle region (masseter and medial pterygoid) has a widening effect on the gonial angle. [12,7] Contrary to these results, Raustia et al [13] (Finnish population) have reported that there was no correlation between age and gonial angle. Similarly, in the study conducted by Dutra et al [14] (British population), the correlation between age and gonial angle was statistically insignificant. The only explanation offered by these authors was that according to their respective studies, the gonial angle was not influenced by bone status.

In sharp contrast to gonial angle, the correlation coefficient between age and gonial index was statistically insignificant and there was no uniform trend observed in mean gonial index values with increasing age, in the present study. There is controversy in literature regarding the interaction of gonial index with age. These results imply that cortical thickness in the gonial region is unaffected by both the bone status as well as by senile remodeling of the mandibular base. But authors like Fattah et al [9], Kim et al [15] (Korean population) and Knezovic et al [16] have reported a significant negative correlation between age and gonial index; conforming to the general consensus that bone mass decreases with increasing age owing to decreased osteoblastic activity.

Statistically, no significant differences ($p>0.05$) were recorded when mean gonial angle values were compared separately for successive age groups, using Mann Whitney test. These results are supported in literature by Xie et al [4] and Casey et al.[11] Similarly for gonial index, on inter-age group analysis between successive age groups, none of the differences were found to be statistically significant ($p>0.05$). Bras et al [1] have also reported similar results.

The mean gonial angle values of our study were comparable to those reported by Xie et al. [4] Values reported by Shamout et al [8] and Casey et al [11] were higher than our results. Mean gonial index values of the present study were comparable to those presented by Bras et al. [1] These variations in the values of both the indices reported by different authors are attributed mainly to the racial or ethnic differences which exist in various populations of the world for any morphometric measurement. Besides that, the other factors which are responsible are the non-uniformity of the sample size used in independent studies, different radiographic machines with inherent magnifications unique to each one, different morphometric techniques used and specific aspects such as the biomechanics and physiology characterizing and differentiating the groups of people studied. Therefore direct comparison between results of various authors across the globe is a difficult task.

In the present study, the correlation coefficient between gonial index and gonial angle was statistically insignificant. Contrary to this, Fattah et al [9] have reported a statistically significant negative correlation between these two indices. In a study conducted by Xie et al, [4] gonial angle size had a significant negative correlation with cortical thickness at gonion i.e. gonial index only in elderly edentulous women. According to the best of our knowledge, this is the first study to consider the interactions of both these indices with each other in an Indian population.

Within its limitations i.e. sample size, magnification inherent in panoramic radiography and non-availability of information such as tooth to tooth contact and chewing habits, the present study concluded that the angular and linear radiomorphometric indices of the gonial region of mandible had contrasting interactions with age. Age had a significant influence on gonial angle but gonial index remained unaffected by age. Also, the correlation between these two indices was statistically insignificant. Therefore, in conclusion, the present study suggests a multi-factorial model of structural variation involved in mandibular remodeling leading to altered basal bone morphological characters.

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