Assessment of Effect of Age, Gender, and Dentoalveolar Changes on Mandibular Morphology: A Digital Panoramic Study

Abstract

Introduction: With progressive development in the growth and function of the jaws, changes are observed in size as well as shape of the mandible, which vary on the basis of age, gender, and dental status. The objective of this study was to evaluate and assess the morphological changes of the mandible, with varying age, gender, and dental status, using panoramic radiographs.

Materials and Methods: A retrospective study was conducted using digital panoramic radiographs taken by Kodak 8000c digital panoramic and cephalometric system on 150 patients, comprising fifty edentulous individuals (above 50 years of age), fifty old dentate individuals (above 50 years of age), and fifty young dentate individuals (below 25 years of age). All the mandibular measurements (gonial angle, ramus length, condylar length (CL), ramus notch depth, and cortical bone thickness) were carried out using RadiAnt DICOM VIEWER 2.2.9 (32-bit) software. The measurements were then subjected to paired t-test, Tukey’s multiple post hoc procedures, and multiple linear regression analysis. Results: Descriptive statistics for all the parameters on the right and left sides of the mandible in both males and females were analyzed. A statistical significance of P < 0.05 was observed for all the variables except one variable (CL). Conclusion: In the present study, all the variables showed increased measurements in males except gonial angle, which was found to be wider in females, indicating that women tend to get affected by varying dental statuses than men. Hence, the parameters used in this study may act as good indicators for the assessment of the effect of age, gender, and dental status on mandibular morphology.

Keywords: Condylar length, cortical bone thickness, dentulous, edentulous, gonial angle, ramus length, ramus notch depth

Introduction

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.[1] In general, at about the third decade of life, a decrease is seen not only in the quantity but also in the quality of the human bone. Resorption of this alveolar bone, caused by the loss of teeth, leads to remodeling that eventually leads to atrophy of edentulous ridges. In edentulous patients, reduction of the residual ridge profoundly affects the support, retention, stability, and masticatory function of the apparent denture.[2]

The present study aims at evaluating the morphological changes in the mandible with changes in age, gender, and dental status, by assessment of four linear measurements and one angular measurement along the body as well as ramus of the mandible. It also helps assess the variations that occur in the mandible with changes in the age group, gender, and dental status.

Materials and Methods

A retrospective study was conducted in the Department of Oral Medicine and Radiology, after sample size calculation was performed by power test. The sample size comprised of 150 panoramic radiographs taken using Kodak 8000C Digital Panoramic and Cephalometric System, under standard exposure conditions as recommended by the manufacturer.

The radiographs in our study were made with the same machine, in accordance with the same set protocol. It was mandatory for the selected radiographs to have good image quality with no gross distortion, magnification, or superimposition errors. The sample comprised of radiographs of old edentulous individuals and young

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dentate groups, whose complete set of medical records were available and in whom all the teeth were intact except the second and third molars (which were either present or absent). Previous denture wearers and patients with craniofacial syndromes, facial traumas, temporomandibular joint ankylosis/ hypoplasia/ hyperplasia, osteoporosis was measured as thickness, congenital abnormalities, or other lesions (cysts or tumors) were excluded from the study. The sample was divided into three groups of participants: Group I (completely edentulous group) with fifty individuals who were older than 50 years of age; Group II (old dentate group) with fifty individuals who were older than 50 years of age; and Group III (young dentate group) with fifty individuals (below 25 years of age) [Figures 1‑3], with equal number of males and females in all the three groups.

The mandibular measurements were carried out bilaterally using RadiAnt DICOM VIEWER software (Medixant, Poznan, Poland, Central Europe). The study was performed for 1 month.

The parameters measured were as follows [Figure 4]:

a. Gonial angle (GA): It was traced between the imaginary line along the posterior border of the mandibular ramus and the inferior border of the mandible

b. Ramus length (RL): Two lines were drawn, one perpendicular to the ramus tangent line at the level of the most lateral image of the condyle and the other perpendicular to the ramus tangent line at the level of the most lateral image of the ramus. RL was the distance between these two lines

c. Condylar length (CL): It was measured as the distance between the lines that pass tangentially to the superior most point on the condylar head and deepest point in the concavity of sigmoid notch

d. Ramal notch depth (RND): It was measured as the distance between the ramus tangent line and the deepest point of the ramus notch concavity

e. Cortical bone thickness: It was measured as thickness of radiopaque band from the point on the lower border of the mandibular body at the mesial starting point of the antegonial notch.

Descriptive statistics for each variable were calculated. A paired t-test was used to analyze both the difference in measurements between the left and right sides of the mandible and the statistical significance of intra-examiner difference. A linear regression analysis was performed to assess the association of the measurements and the factors (age, gender, and dental status) that showed statistical significance in the bivariate analysis. All values were considered statistically significant when \( P < 0.05 \).

**Results**

When both gender and edentulousness were assessed as a whole, a significant difference was noted on the left side for RL and both on the right and left sides for CL and cortical bone thickness. On sole assessment of the groups, a significant difference was observed for all the parameters, except CL, on both the right and left sides. When gender alone was assessed, a significant difference was noted for GA on the left side; RL, CL, and ramus notch depth on the right side; and both right and left sides for the cortical bone thickness. All the variables showed increased measurements in males except gonial angle, which was found to be higher in females [Table 1].

When variables were compared using Tukey’s multiple post hoc procedures, among the groups in males, between the right and left sides, a significant difference was observed between edentulous males and old dentate males in terms of cortical bone thickness, along both the right and left sides and between edentulous males and young dentate males in terms of RL, along both right and left sides; but no significant difference was assessed in any variable when...
comparison was done between old dentate males and young dentate males, along both right and left sides [Table 2].

Similar comparison made between the variables among the groups in females, between the right and left sides, showed a significant difference between edentulous females and old dentate females in terms of cortical bone thickness, along both right and left sides and CL on the left side; between edentulous females and young dentate females in terms of cortical bone thickness, along both right and left sides; and between old dentate females and young dentate females in terms of CL, along both right and left sides [Table 2].

On multiple regression analysis, GA showed that it had statistical significant correlation with ramus notch depth and cortical bone thickness on the right side [Table 3].

When an intraexaminer variability was assessed, a significant difference was noted along the CL and cortical bone thickness on both right and left sides [Table 4].

Discussion

Panoramic radiography is a widely used tool that is often used in routine dental examinations, especially for edentulous patients before the construction of a complete denture or selection of suitable implant for placement along the edentulous area. It is a convenient approach, which can be used to survey dental conditions by providing all the required information with only one panoramic film. Assessment of residual ridge resorption and positions of maxillary sinus, mandibular canal, and mental foramen with panoramic radiographs are practical for examination of large samples of patients.[1] Hence, panoramic radiograph has been used to measure the parameters in this study. Despite the unreliability of the horizontal measurements, angular measurements could be made with high reliability from the panoramic radiograph. Panoramic radiographs also have been demonstrated to be suitable for measuring vertical symmetry of the mandible, i.e. vertical dimensions of the ramus and condyle.[4]

In terms of relationship of GA with the dental status, in our study, GA was found to be wider in edentulous patients as compared to dentulous patients. These findings were found to be consistent with the studies performed by Joo et al. and Huumonen et al., who found that GA became larger with aging and advanced edentulism.[4,5] However, in contrast to our study, Oksayan et al., Raustia and Salonen, and Fish found that there was no significant difference in GA between the dentulous and edentulous states.[1,6,7]

When teeth are present, the muscular activity associated with the mastication preserves the angle from any change in size. However, with loss of teeth, there is loss of function, which leads to the bone undergoing remodeling, consequently leading to an increase in the size of the gonial angle.[8,9]

In the study performed, RL was seen to be higher in edentulous than dentulous patients whereas CL was found to be more in old dentulous as compared to edentulous subjects. These findings partly correlated with the study performed by Huumonen et al., where they found CL was more in dentulous subjects which correlated with the study performed, but the RL measured by them was found to be more in dentulous subjects which was contrary to our study.[5] Other studies performed by Joo et al., Raustia and Salonen, and Merrot et al. showed no significant difference in condylar and RL with age of the patients and/or edentulous period.[4,6,10]

In our study, the young dentate group showed lower mean values in ramus notch depth as compared to old dentate or edentulous group; these findings correlated with the findings of Oksayan et al., who found lower mean values in ramus notch depth in young dentate group.[1]

In the present study, the cortical bone thickness was smaller in edentulous patients than that in dentate ones and was larger in men than in women. Furthermore, the size of the GA was negatively correlated with the cortical bone thickness in men and women. These findings correlated with the study performed by Joo et al. and Xie and Ainamo, which showed similar findings as that of our study.[4,11] Edentulous mandibles had significantly thinner cortical bone than those of dentate mandibles.[12]

In our study, when angular measurements were compared in terms of gender, females showed greater GA as compared to males, this supported the study performed by Jeong Ki Joo et al and Chole RH et al who found similar result.[4,13] On assessment of linear measurements in terms of gender, we found that all the linear measurements (RL, CL, RND, and cortical bone thickness) were more in males as compared to females. These findings correlated
Table 1: Comparison of three Groups (Group 1, Group 2, Group 3) and sex (male and female) with mean values and standard deviation of gonial angle (°), ramus height (mm), condylar length (mm), ramus notch depth and cortical bone thickness (mm)

| Variables          | Sides               | Edentulous male | Old dentate male | Young dentate male | Significance between sex | Significance between groups | Significance between interactions |
|--------------------|---------------------|-----------------|------------------|--------------------|-------------------------|----------------------------|---------------------------------|
|                    |                     | Mean  SD        | Mean  SD         | Mean  SD           | F   P                    | F   P                        | F   P                           |
| Gonial angle       | Right side          | Male            | 121.29 6.76      | 119.49 6.12        | 119.22 7.48             | 1.8366 0.1631               | 13.4197 0.0003* 0.4730 0.6241 |
|                    |                     | Female          | 125.32 7.58      | 122.10 6.32        | 124.39 4.88             |                            |                                 |
|                    | Left side           | Male            | 122.84 7.30      | 118.55 5.67        | 119.64 7.55             | 5.6049 0.0045* 13.4192 0.0003* | 0.0029 0.9971                   |
|                    |                     | Female          | 126.63 6.83      | 122.54 5.81        | 123.55 5.63             |                            |                                 |
|                    | Paired r-(between right vs. left) |               | −1.5651 1.089    | −0.7634            | 0.1307 0.2784            |                            |                                 |
| Ramus length       | Right side          | Male            | 35.60 4.34       | 33.64 4.13         | 31.56 3.61              | 6.6942 0.0017* 22.1074 0.0001* | 1.9709 0.1431                   |
|                    |                     | Female          | 31.62 3.09       | 30.44 2.93         | 30.38 3.47              |                            |                                 |
|                    | Left side           | Male            | 35.52 4.22       | 33.40 3.67         | 32.08 3.92              | 1.7778 0.1727 28.8317 0.0001* | 4.5380 0.0123*                   |
|                    |                     | Female          | 30.09 3.59       | 30.71 2.90         | 30.86 2.78              |                            |                                 |
|                    | Paired r-(between right vs. left) |               | 0.1311 0.4719    | −1.0737            | 0.8968 0.6413            |                            |                                 |
| Condylar length    | Right side          | Male            | 7.23 1.26        | 7.32 1.24          | 6.51 1.50               | 4.9552 0.0083* 43.6929 0.0000 | 13.4154 0.0001*                  |
|                    |                     | Female          | 6.20 1.23        | 4.54 0.90          | 6.26 1.28               |                            |                                 |
|                    | Left side           | Male            | 6.78 1.86        | 7.08 1.42          | 6.32 1.50               | 1.5465 0.2165 27.0689 0.0000 | 8.1698 0.0004*                  |
|                    |                     | Female          | 5.82 1.18        | 4.55 1.02          | 6.10 1.63               |                            |                                 |
|                    | Paired r-(between right vs. left) |               | 1.7261 0.8522    | 0.6617             | 0.0972 0.4025            |                            |                                 |
| Ramus notch depth  | Right side          | Male            | 2.35 0.86        | 2.41 0.82          | 2.16 0.70               | 3.3814 0.0367* 6.0362 0.0152* | 0.3527 0.7034                   |
|                    |                     | Female          | 2.07 0.69        | 2.23 0.73          | 1.73 0.64               |                            |                                 |
|                    | Left side           | Male            | 2.43 0.68        | 2.38 0.74          | 2.29 0.86               | 2.3450 0.0995 8.2891 0.0046* | 0.6680 0.5143                   |
|                    |                     | Female          | 2.20 0.61        | 2.14 0.64          | 1.78 0.60               |                            |                                 |
|                    | Paired r-(between right vs. left) |               | −0.5088 0.2157   | −0.8109            | 0.6155 0.8310            |                            |                                 |
| Cortical bone thickness | Right side         | Male            | 2.95 0.55        | 3.50 0.67          | 3.19 0.45               | 20.5136 0.0001* 27.4880 0.0001* | 4.1285 0.0181*                  |
|                    |                     | Female          | 2.24 0.54        | 2.96 0.61          | 3.07 0.33               |                            |                                 |
|                    | Left side           | Male            | 3.14 0.43        | 3.57 0.59          | 3.38 0.51               | 21.2291 0.0001* 45.0530 0.0001* | 4.5468 0.0122*                  |
|                    |                     | Female          | 2.25 0.63        | 3.04 0.50          | 3.11 0.41               |                            |                                 |
|                    | Paired r-(between right vs. left) |               | −2.0680 −0.4817  | −2.4794            | 0.0496 0.6343            |                            | 0.0206*                         |

*P<0.05 significance at 5% level of significance. The difference between the left and right sides and the effect of edentulousness and gender on each variable. SD: Standard deviation

with the study performed by Abu-Taleb and El Beshlawy who found that males had statistically significant higher mean values regarding all the mandibular ramus linear measurements as compared to females. [14]

This study has limitations, in terms of nonobservance of skeletal classifications of the participants and nonrecordance of the period of tooth loss in partially dentate and edentulous patients.

**Conclusion**

Edentulousness not only affects the alveolar part but also the basal part of the mandible, leading to residual ridge
Table 2: Pair wise comparison of three Groups (Groups 1, Groups 2, Groups 3) and sex (male and female) with mean values and standard deviation of gonial angle (°), ramus height (mm), condylar length (mm), ramus notch depth and cortical bone thickness (mm)

| Variable               | Sides          | EM versus ODM (P) | EM versus YDM (P) | ODM versus YDM (P) | ODF versus YDF (P) | EF versus ODF (P) | EF versus YDF (P) |
|------------------------|----------------|-------------------|-------------------|--------------------|--------------------|-------------------|-------------------|
| Gonial angle           | Right side     | 0.9291            | 0.8782            | 0.9999             | 0.8229             | 0.5124            | 0.9662            |
|                        | Left side      | 0.1825            | 0.5066            | 0.9917             | 0.9939             | 0.2274            | 0.5515            |
| Ramus length           | Right side     | 0.3963            | 0.0012*           | 0.3295             | 0.9999             | 0.8588            | 0.8313            |
|                        | Left side      | 0.2835            | 0.0080*           | 0.7727             | 0.9999             | 0.9895            | 0.9728            |
| Condylar length        | Right side     | 0.9998            | 0.3216            | 0.1953             | 0.0001*            | 0.0001*           | 0.9999            |
|                        | Left side      | 0.9761            | 0.8836            | 0.4392             | 0.0024             | 0.0252            | 0.9854            |
| Ramus notch depth      | Right side     | 0.9997            | 0.9436            | 0.8386             | 0.1651             | 0.9768            | 0.5760            |
|                        | Left side      | 0.9999            | 0.9805            | 0.9966             | 0.4192             | 0.9997            | 0.2579            |
| Cortical bone thickness| Right side     | 0.0033*           | 0.6093            | 0.2948             | 0.9732             | 0.0001*           | 0.0001*           |
|                        | Left side      | 0.0401*           | 0.5710            | 0.7931             | 0.9980             | 0.0001*           | 0.0001*           |

*P<0.05 significance at 5% level of significance. The difference between the right and left sides as per tukeys multiple posthoc procedure (method used for statistics). EM: Edentulous male; EF: Edentulous female; YDM: Young dentate male; YDF: Young dentate female; ODM: Old dentate male; ODF: Old dentate female

Table 3: Multiple linear regression of gonial angle by other variables in male, female and as a whole samples

| Independent variables      | Total samples right side | Total samples left side |
|---------------------------|--------------------------|-------------------------|
|                           | Estimates                | SE of estimates | t    | P    | Estimates | SE of estimates | t    | P    |
| Intercept                 | 140.6190                 | 5.1122               | 27.5064 | 0.0001* | 131.4301 | 5.1219    | 25.6603 | 0.0001* |
| Ramus length              | −0.2144                  | 0.1351               | −1.5869 | 0.1147 | −0.0755 | 0.1422 | −0.5311 | 0.5962 |
| Condylar length           | −0.2134                  | 0.3520               | −0.6064 | 0.5452 | 0.7350  | 0.3496 | 2.1024 | 0.0372 |
| Ramus notch depth         | −1.6655                  | 0.7103               | −2.3448 | 0.0204* | −1.4173 | 0.7921 | −1.7894 | 0.0756 |
| Cortical bone thickness   | −2.2762                  | 0.8323               | −2.7347 | 0.0070* | −2.6205 | 0.8907 | −2.9422 | 0.0038 |

R, R²: 0.35318667, 0.12474082
F (4, 145), P, SE of estimate: 5.1663, <0.05 (S), 6.5116, <0.05 (S), 6.6537

P<0.05 significance at 5% level of significance. SE: Standard error; S: Significant

Table 4: Intra examiner calibration in gonial angle (°), ramus height (mm), condylar length (mm), ramus notch depth and cortical bone thickness (mm) in right and left sides in total samples (1, 2, 3 together) by paired t-test

| Sides      | Variables               | Assessment | Mean    | SD      | Mean difference | SD difference | Paired t | P    |
|------------|-------------------------|------------|---------|---------|-----------------|---------------|----------|------|
| Right side | Gonial angle            | 1<sup>st</sup> | 120.63  | 7.49    | −0.05           | 5.46          | −0.0535  | 0.9577|
|            | 2<sup>nd</sup>          | 120.69     | 7.16    |         |                 |               |          |      |
|            | Ramus length            | 1<sup>st</sup> | 33.52   | 4.73    | 0.30            | 3.76          | 0.4376   | 0.6649|
|            | 2<sup>nd</sup>          | 33.22      | 5.08    |         |                 |               |          |      |
|            | Condylar length         | 1<sup>st</sup> | 5.86    | 1.42    | −0.58           | 1.11          | −2.8772  | 0.0075*|
|            | 2<sup>nd</sup>          | 6.45       | 1.74    |         |                 |               |          |      |
|            | Ramus notch depth       | 1<sup>st</sup> | 2.33    | 0.75    | −0.05           | 0.66          | −0.4129  | 0.6827|
|            | 2<sup>nd</sup>          | 2.38       | 0.70    |         |                 |               |          |      |
|            | Cortical bone thickness | 1<sup>st</sup> | 2.78    | 0.66    | −0.23           | 0.56          | −2.2658  | 0.0311*|
|            | 2<sup>nd</sup>          | 3.01       | 0.73    |         |                 |               |          |      |
| Left side  | Gonial angle            | 1<sup>st</sup> | 122.35  | 7.82    | 0.22            | 6.37          | 0.1891   | 0.8514|
|            | 2<sup>nd</sup>          | 122.13     | 7.77    |         |                 |               |          |      |
|            | Ramus length            | 1<sup>st</sup> | 34.06   | 4.00    | 0.44            | 4.24          | 0.5731   | 0.5710|
|            | 2<sup>nd</sup>          | 33.62      | 4.57    |         |                 |               |          |      |
|            | Condylar length         | 1<sup>st</sup> | 5.40    | 1.35    | −0.73           | 1.26          | −3.1568  | 0.0037*|
|            | 2<sup>nd</sup>          | 6.12       | 1.57    |         |                 |               |          |      |
|            | Ramus notch depth       | 1<sup>st</sup> | 2.24    | 0.68    | −0.05           | 0.42          | −0.7025  | 0.4880|
|            | 2<sup>nd</sup>          | 2.30       | 0.73    |         |                 |               |          |      |
|            | Cortical bone thickness | 1<sup>st</sup> | 2.95    | 0.63    | −0.19           | 0.51          | −2.0536  | 0.0491*|
|            | 2<sup>nd</sup>          | 3.14       | 0.69    |         |                 |               |          |      |

*P<0.05. SD: Standard deviation
resorption. Over a period of time, this may have a profound effect on both the esthetics and the function of the jaws in an individual.

Although a lot of studies have emphasized the importance of gonial angle, very few studies have recorded the effects of linear measurements on mandibular morphology. In our study, we observed both widening of GA and decrease in linear measurements with advancing age. When we assessed gender as a separate entity we found that women showed lower mean values in terms of all linear mandibular measurements, along with relatively wider GA as compared to men, indicating that women tend to get affected by varying dental statuses more than men.

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Conflicts of interest
There are no conflicts of interest.

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