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Gender and Age Differences in Mandibular Ramus and Body Measurements: 
A Radiographic Study

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Abstract: The dental panoramic radiographs (PR) and lateral cephalographs (LC) of 140 subjects in the age group between 5 and 24 years were examined to evaluate the mandibular morphology in relation to gender and age. The examined films were divided into seven age groups. The bigonal width (BW), mandibular body height (MBH) and length (MBL), mandibular ramus width (MRW), and gonial angle were recorded, measured and the data analyzed. Level of significance was set at 0.05. In our study the mean value of BW and MRW increased in both gender with increasing age up to age 17 years, then began decreasing. The anterior and posterior MBH and MBL increased with increasing age for both genders with statistically significant differences between the first and second groups (p < 0.05) and the fourth and fifth groups (p < 0.05). On the other hand, the gonial angle decreased with increasing age but without significant differences. Knowledge of mandibular growth is important factors for diagnosis and treatment planning in orthodontics as well as community medicine for monitoring the growth of children.

Key words: Cephalography, Mandibular morphology, Orthodontics, Panoramic radiograph

Introduction

The mandible is a paired bone that develops within the mandibular arch, embedding teeth and forming an articulation of the jaw with the cranium: the temporomandibular joint (TMJ). Morphological changes of the mandible are thought to be influenced by the occlusal status and age of the subject. Longitudinal studies have shown that remodeling of the mandibular bone occurs with age.

The skull is the most dimorphic and easily sexed portion of the skeleton after the pelvis. In cases where an intact skull is not found, the mandible can play a vital role in sex estimation because it is the most dimorphic, largest and strongest bone of the skull and is often recovered largely intact. Identification of gender based on dental anatomy and cephalometric radiography, as well as the determination of ethnic groups are described by other authors.

Panoramic radiography has become a commonly used imaging modality in dental practice and can be a valuable diagnostic tool for dentist’s. In the past few years, the need for involvement by the radiologist in jaw imaging has increased due to the development of dental implants. The knowledge of mandibular growth is also important to planning timely orthodontic treatment.

The aim of this study was to use dental panoramic radiographs (PR) and lateral cephalographs (LC) to clarify the differences in the morphologic mandibular parameters of young-to-aged dentate subjects, as well as between genders, since we have not found any report about mandibular morphology for our population.

Study identification

The study was reviewed and approved by the ethics committee, University Clinical Centre Maribor (No. 15-03/16) and conducted in accordance with the Declaration of Helsinki. Informed consent approval was obtained from each patients’ parents or patient.

Study design and samples

This retrospective study was conducted on digital dental panoramic radiographs and lateral cephalographs of 140 subjects (67 males and 73 females) in the age group between 5 and 24 years. The radiographs used in this study were acquired as part of these subjects’ diagnostic records. The sample was divided into seven age groups according to the subject’s age when the radiographs were taken:

- The first group consisted of 20 subjects (12 males and 8 females) under the age of six.
- The second group consisted of 20 subjects (8 males and 12 females) between six and eight years, inclusive.
- The third group consisted of 20 subjects (10 males and 10 females) between nine and 11 years, inclusive.
- The fourth group consisted of 20 subjects (10 males and 10 females) between 12 and 14 years, inclusive.
- The fifth group consisted of 20 subjects (10 males and 10 females) between 15 and 17 years, inclusive.
- The sixth group consisted of 20 subjects (10 males and 10 females) between 18 and 20 years, inclusive.
- The seventh group consisted of 20 subjects (10 males and 10 females) between 21 and 24 years, inclusive.

The sample was divided into seven age groups according to the subject’s age when the radiographs were taken:
Methods and equipment

All radiographs were taken using the same equipment (Planmeca ProMax® 2D, Finland) by an experienced dental radiology engineer under standard conditions, subjects were in standing position and adequately protected. The LC were taken with the Frankfort horizontal plane parallel to the floor, with the teeth in the maximal intercuspation (centric occlusion), relaxed lips and tongue and with identical distances between the condylion (Co) and the orientation line. All radiographs fulfilled the inclusion criteria of standard images of good quality, without any grade of exposure or positioning errors. Morphological mandibular characteristics were evaluated from the digital PR and LC by one orthodontist examiner (AF) using the Planmeca Romexis software program, for each patient twice at different times to eliminate errors, and the mean was calculated. The linear and angular measurements were measured to the nearest 0.1 mm and 0.1 degree, respectively. From the digital PR, the following mandibular measurements were performed (Fig. 1):

1. Bigonial width (BW) – distance between right and left gonion (Go).
2. Mandibular body height (MBH) – anterior mandibular body height (AMBH) – distance from infraental anterior (Ida) to gnathion (Gn)
3. Mandibular ramus height (MRH):
   - anterior mandibular ramus height (AMRH) – distance from infraental anterior (Ida) to gnathion (Gn)
   - posterior mandibular body height on right (PMBHr) and left (PMBHl) side – perpendicular distance from infraental posterior (Idp) to lower border of corpus
   - posterior mandibular body height on right (PMBHr) and left (PMBHl) side – perpendicular distance from infraental posterior (Idp) to lower border of corpus
4. Mandibular ramus height (MRH):
   - projective condylar ramus height (RH1) – the projective distance between the condylion (Co) and the orientation line
   - projective incisura ramus height (RH2) – the projective distance between the deepest point of incisura mandibulare (sigmoid notch) and the orientation line.
5. Projective coronoides ramus height (RH3) – the projective distance between the coronoides (Cr) and the orientation line.
6. Go – the most anterior inferior point on the bony chin in the midsagittal plane
7. Mandibular body height (MBH)
   - anterior mandibular body height (AMBH) – distance from infraental anterior (Ida) to gnathion (Gn)
8. Mandibular ramus height (MRH)
   - anterior mandibular ramus height (AMRH) – distance from infraental anterior (Ida) to gnathion (Gn)
9. Mandibular ramus width (MRW):
   - upper mandibular ramus width (UMRW) – horizontal distance between anterior and posterior margins of the ramus passing through the sigmoid notch along the line parallel to the orientation line
   - lower ramus width (LMRW) – horizontal distance between anterior and posterior margins of the ramus passing through the mandibular foramen along the line parallel to the orientation line

Table 1. Age and gender distribution of subjects

| Group (age category) | 1     | 2     | 3     | 4     | 5     | 6     | 7     |
|---------------------|-------|-------|-------|-------|-------|-------|-------|
| Gender              | mean±SD | mean±SD | mean±SD | mean±SD | mean±SD | mean±SD | mean±SD |
| Males               | 5.56±0.28 | 7.52±0.95 | 10.24±0.98 | 13.51±0.76 | 15.83±0.51 | 19.71±2.94 | 23.61±2.30 |
| Females             | 5.13±0.39 | 7.20±1.13 | 9.86±0.76 | 13.53±0.76 | 15.73±1.05 | 19.32±2.75 | 23.20±3.22 |

SD: standard deviation
Ar – the point of intersection of the radiographic images of the posterior margin of the mandibular ramus and the inferior margin of the cranial base.

Me – the most inferior point of the mandibular symphysis, in the midsagittal plane

2. Mandibular ramus length (MRL) – distance between condylion (Co) and gonion (Go)

3. Mandibular body length (MBL) – distance between gonion (Go) and pogonion (Pg)

Pg – the most anterior point of the contour of the bony chin, in the midsagittal plane.

Statistical analysis

The recorded data were entered into a spreadsheet in Microsoft Office Excel 2007. The computer program SPSS 10.0 (SPSS, Chicago, IL, USA) was used for the statistical analysis. A descriptive approach was used for all parameters (mean and standard deviation (SD)). An independent sample 2-tailed t-test was used to compare the means of the parameters between different age groups and to compare the right and left side measurements. The Mann-Whitney U-test was used to compare the mean values of the parameters between male and female subjects. The significance level was set at \( P \leq 0.05 \).

Results

The mean age of the male and female subjects is presented in Table 1. Although the mean age of males was slightly higher (in all groups except the fourth) than that of females, the differences were not statistically significant.

The bigonial width increased in both genders with increasing age up to age 17 years, then slowly decreased. Statistically significant differences in bigonial width were recorded between age groups three and four (Fig. 3). In addition, males had higher mean values of bigonial width compared to females in all age groups. Significant gender differences were noted in the second (\( p < 0.05 \)) and third age groups (Fig. 4).

The Fig. 5 shows that the mean values of the AMBH and the PMBH increased with increasing age for both genders. The differences were statistically significant between the first and second groups and the
fourth and fifth groups for AMBH, and between the third and fourth groups for PMBH. The mean values in males were higher than in females with statistically significant differences between gender in fifth group (Fig. 6) for AMBH. The differences between the mean values of the PMBH on the right and left sides were not statistically significant.

The mean values of the MRW increased with increasing age for both genders on both sides of the mandible up to age group five, then decreased (Fig. 7). Comparisons between right and left sides were performed and no statistically significant difference was found between the two sides. The mean values of MRW in males were slightly higher than those in females, but without statistically significant differences.

The mean values of the MRH on both sides for both genders increased with increasing age but without statistically significant differences between sides. Statistically significant differences in mandibular ramus height (Fig. 8) were recorded between two age groups: age group three and four, and age groups four and five.

The mean values of MRL and MBL increased with increasing age (Fig. 9). The results were statistically significant between the fourth and fifth age groups and the fifth and sixth age groups for MRL and between the third and fourth age groups for MBL. The mean measurements in our female subjects were smaller than male subjects with statistically significant differences in the fifth age groups for ramus length (Fig. 10).

The mean values of gonial angle (Fig. 11) decreased with increasing age.

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![Figure 6](image6.png)  
**Figure 6.** Anterior mandibular body height (AMBH) and posterior mandibular body height (PMBH) among gender. *P < 0.05*

![Figure 7](image7.png)  
**Figure 7.** Lower mandibular ramus width (LMRW) and upper mandibular ramus width (UMRW) for both genders and on both sides.

![Figure 8](image8.png)  
**Figure 8.** Mandibular ramus height (MRH) for both genders on both sides. *P < 0.05*

![Figure 9](image9.png)  
**Figure 9.** Mandibular ramus length (MRL) and mandibular body length (MBL) for both genders. *P < 0.05*

![Figure 10](image10.png)  
**Figure 10.** Mandibular ramus length (MRL) among gender. *P < 0.05*

![Figure 11](image11.png)  
**Figure 11.** Mandibular gonial angle for both genders.
age but without significant differences. The mean values of gonial angle for females was larger than males in all age groups except in the fourth group (Fig. 12) but without statistically significant differences.

**Discussion**

The knowledge of mandibular morphology is important for several dental and medical procedures. There are heritable differences in the morphology of different populations. Therefore, it is important to have knowledge of mandibular morphology for a given population. This is the first study that appears to have investigated the mandibular morphology in our population. To analyze mandibular morphology according to age and gender, the dental panoramic radiographs and cephalographs of 140 subjects were analyzed.

Previous studies have demonstrated that the growth changes of facial tissues, although not completed, occurred predominantly before the age of 18 years\(^{10,12}\).

In the current study, the mean value of bigonial width increased with increasing age up to the age of 17 years and the difference was significant between age groups three (9-11 years) and four (12-15 years). Al-Shamout et al. also reported that bigonial widths increased with increasing age\(^{15}\). Leversha et al. measured and analyzed panoramic radiographs of patients between the ages of 19-69 years and reported that bigonial width decreases with age which is in agreement with our study\(^{16}\). We also found that bigonial width decreased after age 17. Males had higher values of bigonial width compared to their females counterparts. These results are in agreement with previous studies\(^{13,14}\).

Tooth eruption and masticatory function acts as a “functional matrix” by determining the extent of mandible growth\(^{11}\). The alveolar processes grow at a rapid rate during the periods of tooth eruption. This means that bone deposition contributes to the growth of height of the body of the mandible. In our study, we measured AMBH and PMBH and found that mandibular body height increased with increasing age. The differences were statistically significant between the first and second, and the fourth and fifth age groups for AMBH, and between the third and fourth age groups for PMBH. This difference in magnitude might be associated with eruption of the mandibular incisors and eruption of the mandibular premolars, respectively. These changes are also confirmed by the study by Saglam who evaluated significant reductions in the height of the edentulous mandible\(^{19}\). The results of our study were not in agreement with other authors who reported that mandibular body height decreased with age for both genders, but the result was not statistically significant\(^{16,17}\). We also found that mandibular body dimensions were higher for males compared to females, with statistically significant differences in fifth age group Saglam also reported that height of the mandible body was significantly higher in men than in women\(^{15}\).

In present study, the mean of MBL increased with increasing age, with statistically significant differences between the third and fourth age group which is important for the formation of additional space for eruption of the second mandibular molars. Shaw et al and Ghaffari et al. reported a significant decrease with increasing age\(^{16,17}\).

The MRW measured at the level of the sigmoid notch and at the level of the mandibular foramen were found to be increased with increasing age up to age 17. The mean values of the ramus width were larger in males than in females, indicating that bone remodeling of ramus width is more active in males. This is in agreement with Saglam and Ali et al. who noted that the masseter muscles and temporal muscles are thicker in males than in females\(^{15,16}\). No significant sexual dichotomy was found, in line with Indira et al.\(^{19}\).

In present study, the mean of MRH increased with increasing age up to age 17, with a steady decline in next years. Increasing ramus height was significantly different between the third and fourth, and fourth and fifth age groups, which might be due to growth spurts\(^{13,11}\). Al-Shamout et al. and Leversha et al. also reported that ramus height increased from 11-29 years, then decreased with increasing age, and in line with Shaw et al. and Ghaffari et al. who reported that ramus height decreased after age 20 and 21 years, respectively\(^{13,14,16,17}\).

In agreement with the findings of other authors males were found to have a higher MRH than their female counterparts\(^{13,17,19-22}\). Significant sexual dichotomy was found in the fifth age group. Another significant difference was found in MRL between fourth and fifth, and fifth and sixth age groups. The evaluated mandibular morphology is associated with the changes in size due to remodeling during growth in terms of bone apposition at the condyle, coronoid process, alveolar process and posterior aspect of the ramus, and bone resorption at the anterior aspect of the ramus with previous finding by Bjork and Skiller and Humphrey et al.\(^{12,21}\). The high growth rate of the mandible ramus in the fifth group suggested that this is a critical period in which the disruption of the developmental process may have long-lasting or permanent effects on the morphology of the mandible with a prognostically unfavourable effect on later growth and occlusion and facial morphology\(^9\).

We found no significant difference when comparing measurements of left and right sides of MRH, MRW and PMBH regardless of gender, what is in agreement with Laversha et al.\(^{14}\). A large number of studies about cranial asymmetries have been published in recent years, but without information about the symmetry of the mandible in healthy samples, meaning there are no standard definitions of normal baseline mandible symmetry and normal variances. Moreover, the ideal mandible shape is not yet known. The two-dimensional symmetry-related parameters in this study revealed close to symmetrical shape in healthy samples.

In this study, gonial angle decreased with increasing age, but without significant difference. This trend was not noted by other authors who concluded that the gonial angle increased with increasing age\(^{13,14,17,23}\). We also found that females have a higher value of gonial angle than their male counterparts which was analogous to the results obtained by other authors\(^{13,14,17,20,22}\). However, these results were not in agreement with Al-Shamout et al. who reported larger gonial angle in men than in women\(^13\).

The knowledge of mandibular growth is important factors for diagnosis and treatment planning in orthodontics therefore, it is important to have knowledge of mandibular morphology for a given population. This is the first study that appears to have investigated the mandibular morphology in our population.

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Figure 12. Mandibular gonial angle among genders
A limitation of the current study was that data in subjects younger than five years were not analysed. This is due to the small number of radiographs taken in the first years of life. Therefore, our reported findings should provide valuable information on mandibular morphology between the ages of five and twenty-five in our population.

In the present study, the sample size was insufficient. It is the first to have studied mandibular morphology in our population. It is believed that the results are valuable for the design of future research with larger sample sizes, as well as for the elderly population.

Conflicts of Interest
The authors have declared that no Conflicts of Interest exists.

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