CHAPTER II

REVIEW OF RELATED LITERATURE

1. The Mandibular Foramen

Boonpiruk [16] reported the location of mandibular foramen in Thai people. 290 Thai skulls of 14 to 82 years old were investigated. She measured the distance from the internal oblique ridge to the central point of the mandibular foramen. The mean value of the measurements was 1.43 cm and a probability of 95% of the confident interval was 1.41-1.45 cm.

In 1977, Hayward et al. [12] studied the anteroposterior position of the mandibular foramen by using 45 dry mandibles of Asiatic origin and 62 dry mandibles of American black or white origin. They found that the mean size of the anterior dimension was greater than the mean size of the posterior dimension of the ramus in all instance. The lingula was located just anterior to the mandibular foramen. There was no difference of the left or right side relative to the size of the foramen or the position of the foramen. No significant difference was noted in the anterior and posterior dimensions of the ramus in Asiatic and racially mixed groups.

In the study of Nicholson [17], the position of the mandibular foramen was examined. This study used 80 dry mandibles of East Indian ethnic origin. The vertical position of the foramen on the ramus was found to be on average halfway between the mandibular notch and the lower surface of the mandible. It was also noted that the foramen was about two-thirds of the way down a line joining the coronoid process and the angle of the mandible.

Hwang et al. [18] reported the position of the mandibular foramen with age in 112 patients. The subjects were divided into 6 age-groups; 3, 5, 7, 9, 11 and adult. They summarized that the mandibular foramen was located 4.12 mm below the occlusal plane at the age of 3. It subsequently moved upward with age. By the age of 9, it had reached approximately the same level as the occlusal plane. The foramen continued to move upward to 4.16 mm above the occlusal plane in the adult group.

Boonruangsri et al. [13] evaluated the position of the mandibular foramen in the adult mandibles of Northeastern Thai. They performed measurements in 49 mandibles of 16 to 55 years old. The mean lengths of the mandibular foramen to the internal oblique ridge of the right and left side were 13.15 $\pm$ 1.87 mm and 13.00 $\pm$ 1.82 mm, respectively. The mean lengths of the mandibular foramen to the anterior border of the mandibular ramus were 20.09 $\pm$ 1.77 mm on the right side and 20.17 $\pm$ 1.86 mm on the left side. In addition, the mean lengths of the mandibular foramen to the posterior border of the mandibular ramus were 20.46 $\pm$ 2.05 mm and 20.74 $\pm$ 1.79 mm on the right and left sides, respectively. On average, the width of the mandibular ramus was 40 mm. They reported that there was no significant difference between the lengths of both mandibular rami and the eruption of the third molar had no effect.

Fontoura et al. [19] compared the anatomic and radiographic localization of the mandibular foramen in 140 adult Brazilian mandibles. All specimens were dentulous mandibles. They concluded that the mandibular foramen was located approximately at the posterior third of the ramus, in both vertical and horizontal directions. There was no significant difference between the dry mandible and the radiographic localization of the mandibular foramen.

At the same year, Oquz and Bozkir [20] measured the location of mandibular foramen in 34 adult Turkish mandibles. The results of this experiment showed that the distance from the mandibular foramen to the angle was 16.90 mm on the right side and 16.78 mm on the left side. The distance to the posterior border of the ramus was 14.09 mm on the right side and 14.37 mm on the left side. The narrowest anteroposterior diameters were 32.80 mm on the right side and 32.05 mm on the left side. The distance of the lowest point of mandibular notch to the foramen was 22.37 mm on the right side and 22.17 mm on the left side. The distance from the mandibular foramen to the inferior border of the ramus in the mid position of the ramus was 30.97 mm on the right side and 29.75 mm on the left side.

In addition, Huang [21] reported the vertical dimension from the center of mandibular foramen to the lowest point of mandibular notch and the horizontal distance to the posterior margin of ramus in men and women were 24.50 mm, 16.75 mm and 23.13 mm, 16.08 mm, respectively.

Narayana and Prashanthi [22] observed the incidence of large accessory mandibular foramen in 335 dry human mandibles of south Indian origin. Only one mandible (0.3%) showed the large accessory mandibular foramen on the left side. This additional foramen was present posterosuperior to the normal foramen. The normal mandibular foramen was 7 mm in antero-posterior diameter and 5 mm in vertical diameter, whereas the additional foramen was 10 mm antero-posteriorly and 5 mm vertically. The distance between these two foramina was 11 mm. It was located 4 mm posterior to the apex of the lingula at the level of the root of third molar. Its posterior limit was 18 mm anterior to the posterior border of the ramus. The distance from the mandibular angle to the foramen was 52 mm.

Kilarkaje et al. [23] measured the location of the mandibular foramen and found that absolute bilateral symmetry was maintained in 132 mandibles of different age-groups: 8 children, 93 adults, and 31 elderly. Results of this study indicated that the distance between the mandibular foramen and other landmarks were gradually increased with age with significant intergroup differences.

Captier et al. [24] published their research in 2006. They studied neural symmetry and functional asymmetry of the mandible. 83 adult dry mandibles with unknown sex and age were divided into 2 groups: dentulous mandibles (n=60) and edentulous mandibles (n=23). They confirmed that the position of the mandibular foramen was symmetric. The position of the mandibular foramen in relation to the mandibular notch in the edentulous group was asymmetric.

2. The Mental Foramen

During 1986 to 2005, there were several authors studied the position of mental foramen. In 1986, Wang et al. [25] observed the location of the mental foramen in 100 mandibles of adult Chinese cadavers of both sexes without missing teeth, alveolar bone resorption and malposition of teeth. They found that the most common location of the mental foramen was below the apex of the lower second premolar (58.98%). On average, the distance from the most anterior portion of the anterior border of the mental foramen to the symphysis menti was 28.06 mm. The distance from the most anterior portion of the anterior border of the mental foramen to the posterior border of the ramus was 74.10 mm. The distance from the inferior border of the mental foramen to the lower border of the mandibular body was

14.70 mm. The distance from the superior border of the mental foramen to the bottom of the second premolar socket was 2.50 mm. The distance across the mental foramen between the alveolar crest and the lower border of the mandibular body was 30.29 mm.

Sawyer et al. [26] investigated the frequency of "accessory mental foramina (AMT)" in four ethnic groups. Including, 234 dry adult Indian mandibles, 50 dry adult Nazca mandibles (100 B.C.-A.D.800), 166 dry adult African American and 255 dry adult American White mandibles. AMT was found less frequent in the American White and Asian Indian populations than in the other groups (American White, 1.4%; Asian Indian, 1.5%; African American, 5.7% and Nazca, 9.0%). The incidence of AMTs did not differ significantly between sides.

Moiseiwitsch [15] studied the position of the mental foramen from 51 males and 54 females, 60 whites and 45 African-Americans. He reported that the majority of mental foramina were located between the first and second premolars.

In 2002, Oquz and Bozkir [20] evaluated the location of the mental foramen in 34 adult Turkish mandibles. The distance of the mental foramen to the inferior border of the mandible was 14.61 mm on the right side and 14.29 mm on the left side. Its distance to the superior border was 13.62 mm on the right side and 14.62 mm on the left side. Moreover, they found that the mental foramen was located below the root of the second premolar in 21 cases (61.76%) of the right side and 17 cases (50%) of the left side. The other position was between the roots of the first and second premolars in 13 cases (38.2%) of the right side and in 17 cases (50%) on the left side.

Cutright et al. [27] studied the location of important maxillofacial foramina relative to frequently encountered surgical landmarks. Measurements were made on 80 cadaver heads of known race and gender. The mental foramen was an average of 2.2 cm lateral to the mandibular skeletal midline. The average position of the mental foramen, relative to adjacent teeth, was between the first and second premolars for whites and just posterior to the second premolar in blacks.

In Thailand, Agthong et al. [28] observed the position of the mental foramen. They used 110 adult Asian skulls. They reported the distances from the center of the mental foramen to the midline which was 2.80 $\pm$ 0.02 cm on the right side and 2.78 $\pm$ 0.02 cm on the left side. The distances from the center of mental foramen to the inferior rim of the mandible on the right and left sides were 1.45 $\pm$ 0.02 cm and 1.44 $\pm$ 0.01 cm, respectively. No significant difference between sides was found in these 2 measurements.

3. The Mandibular Dimensions

Mbajiorgu et al. [29] measured the mandibular angle in black Zimbabweans in 32 dry adult mandibles (23 males and 9 females). They found that the mean mandibular angle and height were greater in females (128 degrees and 6.13 cm) than in males (123.06 degrees and 5.98 cm) while the mean mandibular length was greater in males (7.78 cm) than in females (7.23 cm). There was a statistically significant sex difference in the mandibular angle and length.

Ceylan et al. [30] studied the mean measurements of the mandibular angle of the 134 radiographs. 49 of them were unilaterally and posteriorly partially edentulous adults and 85 were totally edentulous adults. Changes in the mandibular angle between denture wearers and nondenture wearers in each group were also compared. There were no significant differences between the angles measured in the groups.

In 1999, Eisenburger et al. [31] reported the human mandibular intercondylar angle measured by computed tomography. Participants were divided into three groups: (1) patients with functional disorders of temporomandibular joint; (2) healthy adults who acted as a control group; (3) children. They concluded that the intercondylar angle has a similar variation in patients with temporomandibular joint dysfunction as in controls. A relation to age and sex is not evident.

In the study of John et al. [32], the anthropometric of mandibular asymmetry in infants with deformational posterior plagiocephaly was analyzed. 27 infants (16 boys and 11 girls) with the mean age of 6.2 months (range, 3 to 12 months). Auricular (temporomandibular joint) displacement also resulted in an apparent mandibular asymmetry with rotation of the jaw to the affected side. Mean mandibular measurements on the affected and unaffected side were ramus height of 35.2 and

36.4 mm, body length 59.0 and 60.3 mm, gonial angle of 127.1^{O} and 126.8^{O}, respectively. Comparison of the affected with the unaffected sides, using a paired samples *t* test, was not statistically significant.

In 2002, Mbajiorgu and Ekanem [33] presented their results of the mandibular angles in 60 dry adult mandibles from the North Eastern arid zone of Nigeria. The mean mandibular angle (118.75 $\pm$ 0.395, mean $\pm$ SEM) was smaller than those of other African populations but was wider than that of the Neanderthals and similar to those of the Chinese and Peruvians.

Xie and Ainamo [34] reported the correlations of gonial angle size with cortical thickness, height of the mandibular residual body and duration of edentulism. A total of 356 panoramic radiographs were divided into 3 groups according to age: the young dentulous group (131); the older dentulous group (97); and the elderly edentulous group (128). They concluded that elderly edentulous subjects had larger gonial angles than dentulous subjects. The angle size was negatively related to the cortical thickness at the gonial angle in edentulous women and was associated with the average height of the mandibular residual body in the edentulous men and women; it was also related to average height of the mandibular residual body of elderly edentulous men. The gonial angle size was not correlated with the duration of mandibular edentulism.

In 2004, Merrot et al. [35] investigated changes in the edentulous mandible in the elderly. This study was done with antero-posterior and lateral teleradiographs carried out in a systematic fashion in 110 elderly subjects older than 70 years, who were free of any pathology in the oral facial region. Two series were compared: the first was of 67 completely edentulous subjects (maxilla and mandible) and the second was 43 dentulous subjects. The edentulous mandibles showed a diminution in the height of the symphysis and increase in the height of the mandibular incisure. A diminution in the height of the body and an increase in the gonial angle in the significant manner. No significant difference was seen for the height of the ramus and the length of the mandible, the minimum width of the ramus and the bigonial width. The diminution in the height of the mandibular symphysis and of the body is explained by the resorption of the alveoli part of the mandible. The increase in the mandibular angle and the diminution in the height of the mandibular incisure may be explained by disequilibrium between the elevator and depressor muscles of the mandible.

Later, Lazic and et al. [36] measured the intercondylar distances of the human temporomandibular joint by using 101 subjects of both sexes ranging in age from 20 to 80 years. They found that the intercondylar distance between the two temporomandibular joints was within the range of 110 and 145 mm, with the mean of 126 mm. In men the intercondylar distance was within the range of 116 and 145 mm, with the mean of 130.2 mm. In women the intercondylar distance was within the range of 110 and 138 mm, with the mean of 123.5 mm. There was a significant different between the two sexes.

Captier et al. [24] described the neural symmetry and functional asymmetry of the mandible. They categorized the mandibles into 2 groups: dentulous (n=60) and edentulous mandibles (n=23). They found that the total lengths of the mandible and the ramus were significantly greater on the left side, whereas the width and the height of the ramus were symmetric. The angle between the corpus and ramus and the total length of the corpus were symmetric. The mandibular notch was always asymmetric and its height was greater in the dentulous group. The condylar process was the most asymmetric structure in each group.

A recent study carried out by Puisoru et al. [37] analyzed the mandibular variability in different geographic areas (Europe, Middle Orient, Asia and Africa). A total number of 45 dry mandibles from the dissection of 45 human cadavers (18 females and 27 males) have been studied. According to the dentition status, they were classified as follows: non-edentulous, partially edentulous and completely edentulous. The aim of their experiment was to evaluate the opening of the mandibular angle, ramal length and width, condylar diameters and the gonion-menton distance. They concluded that the mandibular parameters had a significant ethnic variability. The opening of gonion angle correlates to the length of mandibular body and the height of mandibular ramus. Partial and complete tooth loss results in changes in the mandibular body length and height, as well as in gonion opening and condylar diameters.

Ogura et al. [38] were studied by Forty-four women's crania, with intact faces, cranial bases, and mandibles, were selected for this analysis. The relationship between anteroposterior cranial vault deformation and mandibular morphology in pre-Columbian population. The crania were divided into anteroposterior deformation (AP) and undeformed (U) groups according to frontal, parietal and occipital curvatures. They found that cranial base angle, bizygomatic breadth, and upper facial height, bicondylar breadth, anterior breadth and mandibular body length were significantly larger, and the mandibular angle was significantly smaller, in the AP group than in the U group.

4. Predictive accuracy of sexing the mandible

Kemkes-Grottenthaler et al. [39] used the mandibular ramus flexure and gonial eversion as morphologic indicators of sex. Two samples, one of forensic (n=153) and one of archaeological provenance (n=80), were examined. Instructions in how to evaluate both traits derived from Loth and Henneberg [40-41]. For ramus flexure, male accuracy was only 66%, while female accuracy was even lower (32%). Overall accuracy was 59%. For gonial eversion, a similar picture emerged (75.4% for males, 45.2% for females and 69.3% overall accuracy).

Balci et al. [42] examined predictive accuracy of sexing the mandible by ramus flexure. The sample consisted of 120 mandibles (95 males, 25 females) randomly selected from individuals of known sex and age. The posterior mandibular ramus flexure noted at the level of the occlusal surface of the molars was scored as +1, a straight border or flexure other than at the occlusal plan was scored as -1, while ambiguous borders were scored as 0. The scores of both left and right rami were then added to yield a total score of +2, +1, 0, -1, and -2. They assigned the mandibles with a total score of +2 as male, score of -2 as female and scores of -1, 0 and +1 as a "sex indeterminate" group. Whereas Loth and Henneberg's classification (where +2, +1 and 0 were male, and -1, -2 female), It is also known that there is no single trait or method for the sex assessment from the skeleton with 100% accuracy.

5. Torus mandibularis

Torus mandibularis is a rounded body protuberance on the lingual surface of the mandible and usually found above the myohyoid line, medial to the molar roots. It is also know to be due to an exostosis by hypertrophy of the compact bone and sometimes of the spongy bone [1]. In 2006, Ihunwo and Phukubye [43] studied the frequency and anatomical features of torus mandibularis in 284 mandibles from Black South African population. The anatomical features included the shape (round or elongated), torus type (solitary or multiple) and the location (bilateral, right or left) were examined in each mandible. Torus mandibularis was found in 61 (21.5%) cases in which 37 (61.7%) cases were bilateral, 42 (70%) cases were solitary type and 31 (51.7%) cases were round shape.