International Journal of Clinical Oral and Maxillofacial Surgery
2016; 2(3): 12-18
http://www.sciencepublishinggroup.com/j/ijcoms
doi: 10.11648/j.ijcoms.20160203.11
ISSN: 2472-1336 (Print); ISSN: 2472-1344 (Online)

Effect of Temporomandibular Joint Bony Ankylosis on Location of the Mandibular Foramen

Dehis M.[1, *], Tantawi W.[2], Alnemer A.[1]

[1]Department of Oral and Maxillofacial Surgery, Faculty of Oral and Dental Medicine, Cairo University, Cairo, Egypt

[2]Department of Radiology, Faculty of Medicine, Ein Shams University, Cairo, Egypt

Email address:

mesd47@gmail.com (Dehis M.), tantawyw@yahoo.com (Tantawi W.), alnemrkhkh@gmail.com (Elnemr A.)

[*]Corresponding author

To cite this article:

Dehis M., Tantawi W., Elnemr A. Effect of Temporomandibular Joint Bony Ankylosis on Location of the Mandibular Foramen. *International Journal of Clinical Oral and Maxillofacial Surgery.* Vol. 2, No. 3, 2016, pp. 12-18. doi: 10.11648/j.ijcoms.20160203.11

Received: November 7, 2016; **Accepted**: November 24, 2016; **Published**: January 20, 2017

Abstract: Objective: The present research provides prediction for the possible changes of the location of the mandibular foramen in patients of TMJ ankylosis. Subjects and methods: Forty four subjects were included in this study; they were divided into two groups. Group I included 14 patients with TMJ bony ankylosis; they were selected from those attending the out patients clinics of Oral and Maxillofacial Department, Faculty of Oral and Dental medicine, Cairo University, Egypt. Group II included 30 normal subjects having same age range as group I. Certain measurements were selected on the medial side of mandible to locate the position of mandibular foramen in ankylosis group in comparison to normal subjects. Results: The lower half of mandibular ramus in ankylosis group was statistically significant shorter than normal group. The length of coronoid process in cases of long duration was significantly longer when compared with normal subjects and the cases below 10 year duration. Conclusions: The mandibular foramen exists in the lower half of mandibular ramus in position closer to the most inferior point of ankylosing bony mass. Also there is elongation of the distance between mandibular foramen and most superior point of the coronoid process.

Keywords: Temporomandibular Joint (TMJ) Ankylosis, Computerized Tomography, Mandibular Foramen (MF)

1. Introduction and Review of Literature

Localization of mandibular foramen is highly important in different aspects of oral and maxillofacial surgery. Management of post-ankylotic patients with distorted mandibular ramus necessitates study of these changes. The present investigation can provide prediction for possible changes of the location of the MF. The gained information will not only help in post-ankylosis orthognathic surgery, but will be of guidance in daily management of those patients in local anesthesia particularly inferior alveolar nerve (IAN) block. The aim of the present study is to analyze the position of mandibular foramen in patients of TMJ ankylosis. It was hoped to provide simple, reliable information about this important surgical landmark.

The location of the mandibular foramen constitutes a prime significance regarding, inferior alveolar nerve (IAN) block, dentoalveolar surgery planning, lesion diagnosis, spread of tumor and to determine a safe reference point for mandibular ramus osteotomy [1-6]. Successful IAN blocks necessitate knowledge of the exact location of the mandibular foramen, and this explains the failure in IAN anesthesia [4, 7-10]. Anatomically related complications in the local anesthesia delivery include perforation of the parotid gland capsule, blockage of the facial nerve and subsequent temporal palsy of some muscle, injuries to blood vessels, trauma to muscles (medial and lateral pterygoids in more superior injection) as well as injuries to nerves. It has been reported that detection of anatomical variation during local anesthesia injection usually minimizes temporary loss of vision, ophthalmoplegia, and ptosis of the eyelid as well as diplopia [9-11].

The location of Mandibular foramen (MF) in the mandibular ramus has been determined by taking a reference point which represents the MF, from this point to different mandibular rams landmarks, such as inferior, superior, anterior, posterior border of ramus, to the alveolar socket of second mandibular molar, and its location on the line joining the coronoid process to the angle of the mandible [12, 13]; to determine its anterior-posterior and superior-inferior locality. The following ways were used: direct osteometry of dry mandibles [9, 12, 14-28], panoramic and cephalometric radiographs [29-31], and distance measurement modality of three dimensional computed tomography (3D-CT) [32-35] as well as cone beam computed tomography (CBCT) [22, 36]. Many reference points have been used to represent the MF, such as tip of lingula [13, 15-17, 20, 23-26, 33, 36]; lowest point of MF [12, 18, 27, 33]; most superior-anterior and most posterior-inferior margins of MF [21, 28]; anterior, posterior, inferior margins as entrance of MF [9, 13-15, 24, 32, 36]; anterior border of MF [22]; mid-distance of anterior-posterior dimension of MF [19]; and circular radiolucency on panoramic radiograph [29, 30].

It has been reported that mandibular foramen (MF) has different positions; the most frequent location in the middle third of mandibular ramus both in anterior-posterior and superior-inferior directions [9, 12]. MF may be located posterior and superior to the middle point of mandibular ramus [4, 17, 37]; or in the third quadrant anterior-posteriorly [22]. MF is mostly located within 2 mm posterior of the mid middle point, whereas its location along the vertical plane to the mid waist point is highly variable [33].

Regarding the age, the MF is located in the third quarter anterior-posteriorly and moved anteriorly with age [19]; hence MF is located posterior-superior in adult and more posterior-inferior in children, this is due to the bone resorption at sigmoid notch and anterior border of ramus, and bone deposition at posterior and inferior border of ramus [25, 30, 38]. Kang et al. [32] reported that, the distance from MF to the anterior border of ramus is increased with age; however, the increase in the distance between anterior and posterior border of the rams did not correlate significantly with increase in age, this mean that the MF moved posteriorly as growth continued and the ramus grew in the posterior-superior direction.

2. Subjects and Methods

The present study comprised 44 persons. They were distributed into two groups; Group I: Ankylosed group comprised 14 patients suffering from temporomandibular joint (TMJ) bony ankylosis. They were selected from those attending the outpatient clinic of Oral and Maxillofacial Surgery Department, Faculty of Oral and Dental Medicine, Cairo University, Egypt. Diagnosis of the TMJ bony ankylosis was established on basis of careful history, clinical and radiographic examinations. Radiology included digital panoramic radiograph and computed tomography CT. Medically compromised patients were exempted according to clinical and laboratory investigations. The patient group included 9 females and 5 males, 9 bilateral cases and 5 unilateral, 6 recurrent and 8 non recurrent cases, with mean of age 21.57 year and median 10 years.

Group II: Normal group included 30 normal subjects. These subjects had the same age range mean and sex percentage. They were obtained from patients with other medical condition in whom no abnormalities of the mandible or maxilla were detected; so no extra radiation needed for them to be included in the study. The mean age of this group was 20.33 year. The condition was explained and their consents were signed. All subjects presenting mandibular ramus abnormalities (fracture, cysts, tumors or dysplastic) were excluded.

All patients were treated according to routine program for correction of TMJ bony ankylosis. Pre-operative investigations, hospital admission for general anesthesia, jaw mobilization after gap arthroplasty. Postoperative care was implemented from outpatient department to prevent recurrence.

2.1. Computerized Tomography Technique

The present study is based on examinations of the TMJ and location of mandibular foramen using helical computed tomography CT (Toshiba Aquilion 64). A slice thickness of 0.5×64 mm, distance field of view 240 mm collimation, (pitch= 41) at 120 kV and 400 mA/sec and 0.3 sec rotation time. Digital imaging and communications in medicine (DICOM) images were created and input into a personal computer. Images were reconstructed and analyzed on a MacBook Pro (13-inch, Mid 2012), 2.5 GHz Intel Core i5, 4 GB 1600 MHz DDR3 memory, Apple Computer running OS X Yosemite version 10.10.3 and OsiriX imaging software (OsiriX version 6.0 32-bit). The landmarks were determined on 3D with the help of 2D orthogonal Multiplanar reformations. Anterior nasal spine (ANS) and sella turcica (S) were used as a midsagittal line; right and left zygomaticofrontal suture were used as a horizontal line and was perpendicular to midsagittal line. The distance measurement modality of 3D-CT was used to study the position of mandibular foramen in horizontal and vertical dimensions in order to detect any possible changes that might be induced by TMJ bony ankylosis.

2.2. Location of Mandibular Foramen (MF)

The following reference lines were used to localize the position of the mandibular foramen (MF) starting from the most inferior point of its margin, in ankylosed (A) and normal (N) subjects by the use of 3D-CT (Table 1-Figure. 1):

Table 1. *Reference lines to localize the position of the mandibular foramen (MF) in ankylosed (A) and normal (N) subjects.*

Ankylosis group	Control group	Represent	Distance to the most
Aa	Na	Lower half of mandibular ramus	Inferior point of the mandibular angle
AA	NA	Height to ankylosed bony mass	Superior point of the ankylosing bony mass and condyle in normal subject
AC	NC	Height to most inferior point of ankylosed bony mass (Most constricted part in normal)	Constricted part of the ankylosed bony mass and most constricted part of neck of condyle in normal subject
Aaa	Naa	Upper half of mandibular ramus	Superior point of the ankylosing bony mass at the sigmoid notch and most inferior point of the sigmoid notch in normal subject.
Ab	Nb	Anterior horizontal half of mandibular ramus	Anterior point of the anterior border of the ramus in the level of coronoid notch
Abb	Nbb	Posterior horizontal half of mandibular ramus	Posterior point of the posterior border of the ramus in the level of coronoid notch
AB	NB	Height to most superior point of the coronoid process	Superior point of the coronoid process.

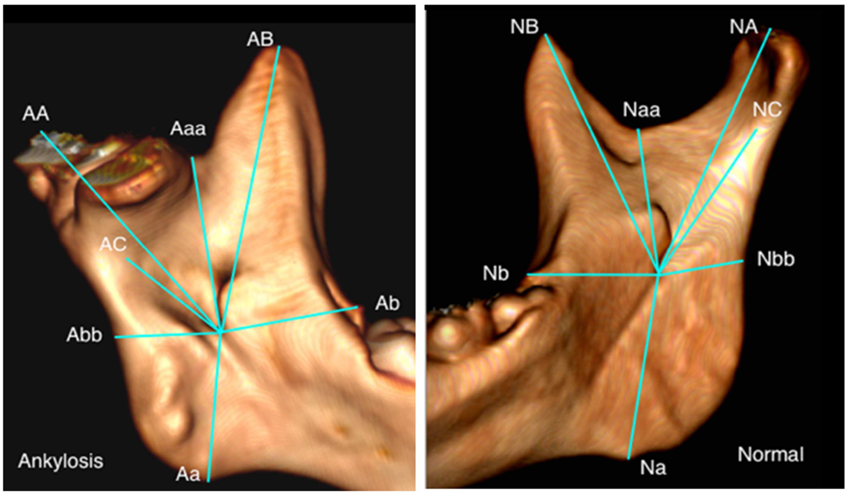

Figure 1. *The reference lines from the most inferior point of the mandibular foramen (MF) in ankylosed (A) and normal (N) subjects.*

I. Comparison was done between the ankylosed and normal subjects.

II. Comparison of Sub-groups of ankylosis

The median of duration of ankylosis (10 years) in ankylosed group was used to divide the group into two subgroups; below and above 10 years.

Effect of Recurrence of ankylosis into two sub-groups: Recurrent and non-recurrent cases.

The collected data were tabulated and statistically analyzed by the use of Statistical Package for Social Sciences (SPSS) version 21, 2013.

3. Results

3.1. Comparison of the Location of Mandibular Foramen (MF) Between Ankylosed and Normal Subjects

On comparison between the means of the ankylosed group (A) and normal group (N) concerning MF location in relation to the predetermined reference lines (Table 2) (Figure. 1, 2) revealed that the lower half of mandibular ramus in ankylosis group (Aa), Height to ankylosed bony mass (AA) and Height to most inferior point of ankylosed bony mass (Most constricted part, (AC) was shorter than control group (Na), (NA) and (NC) respectively and the difference was statistically significant. The other reference lines showed insignificant changes. However, the height of coronoid process (AB) of cases of long duration was increased when compared with cases with shorter duration and this difference was statistically significant. (Table 3)

Table 2. *Statistical comparison between the means of the ankylosis (22 sides) and normal (60 sides) concerning the location of mandibular foramen (MF) in relation to the predetermined.*

Reference line		Ankylosis (A) mean ± SD	Normal (N) mean ± SD	P value
Aa	Na	21.03 ± 4.50	23.89 ± 4.51	< 0.013
AA	NA	31.50 ± 5.70	40.38 ± 4.40	< 0.000
AC	NC	14.80 ± 4.11	27.82 ± 3.30	< 0.000
Aaa	Naa	23.76 ± 4.93	22.37 ± 3.26	> 0.05
Ab	Nb	19.11 ± 2.50	18.98 ± 2.12	> 0.05
Abb	Nbb	11.63 ± 1.72	12.63 ± 2.61	> 0.05
AB	NB	37.79 ± 7.03	37.15 ± 4.74	> 0.05

The left side in case no 11 (bilateral ankylosis) were excluded from the study as there is sever deformity of the ramus

Aa, Na: Lower half of mandibular ramus,

AA: Height to ankylosed bony mass (Ankylosis),

NA: height to most superior point of the condyle (Normal),

AC: Height to most inferior point of ankylosed bony mass (Most constricted part) (Ankylosis),

NC: height to most constricted part of the neck of the condyle (Normal),

Aaa, Naa: Upper half of mandibular ramus,

Ab, Nb: Anterior horizontal half of mandibular ramus,

Abb, Nbb: Posterior horizontal half of mandibular ramus,

AB, NB: Height to most superior point of the coronoid process.

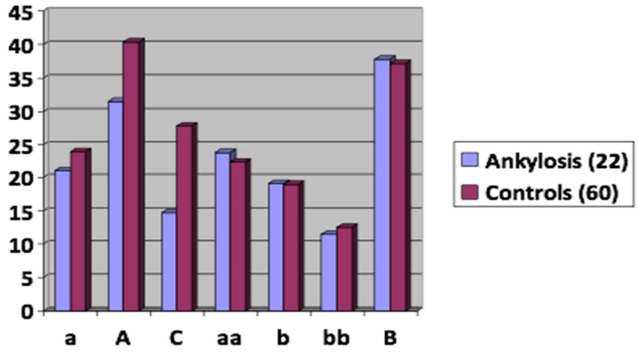

Figure 2. *The mean value of the ankylosis (A) and normal (N) concerning the location of mandibular foramen (MF) in relation to the predetermined reference lines.*

3.2. Comparison of Sub-groups of Ankylosis

A. Effect of Duration of ankylosis on position of mandibular foramen

The difference between the means of (below and above 10 years) was increased and this change was statistically significant for the height to ankylosed bony mass and height to most superior point of the coronoid process (AA, AB lines), respectively (Table 3) (Figure. 1, 3).

Table 3. *Statistical comparison between the means of (below 10 years, 11 sides) and (Above 10 years 11 side) duration, concerning the effect of duration on position of mandibular foramen.*

Reference line	Below 10 y mean ± SD	Above 10 y mean ± SD	P value
Aa	19.61 ± 5.03	22.45 ± 3.56	> 0.05
AA	29.17 ± 5.02	33.82 ± 5.58	< 0.054
AC	15.76 ± 3.14	13.84 ± 4.86	> 0.05
Aaa	22.14 ± 5.40	25.37 ± 4.02	> 0.05
Ab	20.00 ± 2.61	18.23 ± 2.14	> 0.05
Abb	11.04 ± 1.24	12.21 ± 1.99	> 0.05
AB	34.47 ± 4.54	41.10 ± 7.68	< 0.0230

Aa: Lower half of mandibular ramus,
AA: Height to ankylosed bony mass,
AC: Height to most inferior point of ankylosed bony mass (Most constricted part),
Aaa: Upper half of mandibular ramus,
Ab: Anterior horizontal half of mandibular ramus,
Abb: Posterior horizontal half of mandibular ramus,
AB: Height to most superior point of the coronoid process.

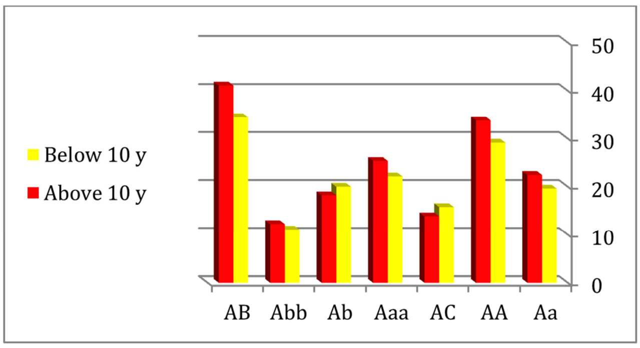

Figure 3. *Mean value of (Up to 10 years) and (Above 10 years), concerning the effect of duration on position of mandibular foramen.*

B. Effect of Recurrence of ankylosis on position of mandibular foramen

The distance between the Mandibular foramen to the anterior horizontal half of the ramus (Ab line) and to the height of the most inferior point of the ankylosed bony mass (AC line) was increased in non-recurrent cases and this changes was statistically significant, (Table 4) (Figure. 4).

Table 4. *Statistical comparison between the mean of Recurrence (10 sides) and Non recurrence (12 sides), concerning the effect of recurrence of ankylosis on position of mandibular foramen.*

Reference line	Recurrence mean ± SD	Non recurrence mean ± SD	P value
Aa	20.34 ± 4.01	21.60 ± 4.96	> 0.05
AA	31.62 ± 6.61	31.39 ± 5.12	> 0.05
AC	12.64 ± 4.21	16.60 ± 3.15	< 0.020
Aaa	24.48 ± 4.70	23.16 ± 5.24	> 0.05
Ab	17.81 ± 2.27	20.20 ± 2.22	< 0.022
Abb	11.76 ± 2.17	11.51 ± 1.34	> 0.05
AB	39.95 ± 8.51	35.99 ± 5.23	> 0.05

Aa: Lower half of mandibular ramus,
AA: Height to ankylosed bony mass,
AC: Height to most inferior point of ankylosed bony mass (Most constricted part),
Aaa: Upper half of mandibular ramus,
Ab: Anterior horizontal half of mandibular ramus,
Abb: Posterior horizontal half of mandibular ramus,
AB: Height to most superior point of the coronoid process.

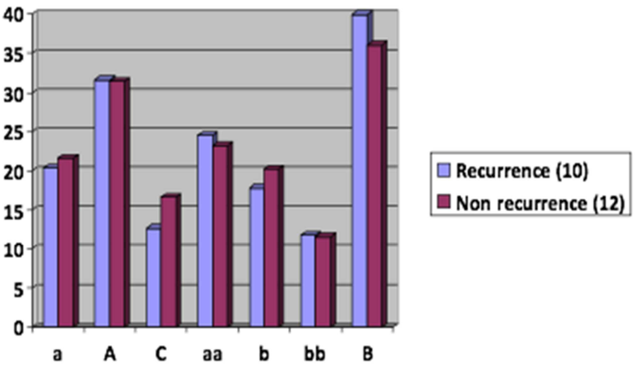

Figure 4. *Mean value of Recurrence and Non recurrence, concerning the effect of recurrence of ankylosis on position of mandibular foramen.*

4. Discussion

Location of the mandibular foramen (MF) in patients with TMJ bony ankylosis has not received awareness in medical and dental literature. The position of mandibular foramen at the medial aspect of mandibular ramus is variable in normal subjects. Localization of mandibular foramen is highly important in different aspects of oral and maxillofacial surgery. Management of post-ankylotic patients with distorted mandibular rami necessitates study of changes, which is possibly induced in MF area. The present investigation provides information, which can assist oral and maxillofacial surgeon in preoperative evaluation and surgical planning in management of such cases.

This study intended to utilize the versatility of computed tomography CT to depict accurately the changes expected in the location of the mandibular foramen. In addition to the well-known multiple advantages of CT, 3D reconstruction and anatomical landmark can be well defined by CT, it is a reliable and accurate caliper for the assessment in this study and its measurements are matching that of osteometry, this opinion is supported by several authors [35, 39-46].

The most inferior margin of the mandibular foramen was utilized as a reference point in ankylosed patients and normal subjects, being stable and not affected by limitation of jaw movement induced by ankylosis, this opinion is concordant with findings of Alves et al. [27], Valente et al. [18], Yu et al. [35] and Nicholson [12]. In other study the tip of lingula was used as a reference point for location of MF. This view has its limitations; it was not used in the present study, as the shape and size of lingula is affected by limitation of jaw movement. The alternative is the use of the inferior margin of the mandibular foramen, where no muscle attachment or tendon exists, so it will be more reliable than the tip of the lingula.

The current research support the view of shortening of mandibular ramus in TMJ ankylosis (particularly in its lower half) i.e. from mandibular foramen towards the lower border of the ramus [47-50]. The downward translation of the mandible is prohibited by prolonged isometric contraction of pterygomasseteric sling. This continuous contraction impedes bone formation in the lower portion of ramus. The temporalis muscle also had spastic contraction that lead to pulling of the coronoid process bone formation and consequently lead to elongation (elongation of the distance between the MF and coronoid process). These changes could be responsible for translocation of mandibular foramen.

The present study showed that, the lower half of ramus was shorter by 2.86 mm (11.97%) in ankylosed patients when compared with normal subjects. Upper half of ramus of ankylosed patients was longer when compared with normal subjects due to extension of ankylosing bony mass to the sigmoid notch, but the difference was statistically insignificant. So the mandibular foramen (MF) in ankylosed patient dose not occupy mid-vertical distance as normal subject, this could be explained on the light of marked significant decrease in the height of lower portion of ramus below mandibular foramen. This means that mandibular foramen moves toward the lower portion in case of TMJ ankylosis.

The results of this study direct the attention towards increased difficulty in creating gap at the most constricted point of ankylosing bony mass. This fact represented by significant decrease of AC line (height to most inferior point of ankylosed bony mass) in recurrent ankylosis. In such cases there is increasing risk of endangering of the neurovascular bundle related to mandibular foramen. While creating a gap at higher level may carry the risk of jeopardizing the major vessels closely related to the base of temporal bone. So it is recommended in such cases where mandibular foramen gets very close to ankylosing bony mass to release the jaw by inter-positional arthroplasty instead of gap arthroplasty.

Length of coronoid process (AB line) in cases of longer duration was significantly increased when compared with normal subjects and cases below 10 years duration. This means that there is elongation of coronoid process in cases only with longer duration. The elongated coronoid process was a radiographic characteristic of ankylosis previously discussed by many authors [47-50]. The result of the present study will help in surgical management of TMJ ankylosis as indicate coronoidectomy or coronoidetomy in all cases of longer duration.

References

[1] Lipski M, Tomaszewska IM, Lipska W, Lis GJ, & Tomaszewski KA.: The mandible and its foramen: anatomy, anthropology, embryology and resulting clinical implications. Folia Morphol (Warsz). 2013; 72: 285-92.

[2] Khoury JN, Mihailidis S, Ghabriel M, & Townsend G.: Applied anatomy of the pterygomandibular space: improving the success of inferior alveolar nerve blocks. Aust Dent J. 2011; 56: 112-21.

[3] Fabian FM.: Observation of the position of the lingula in relation to the mandibular foramen and the mylohyoid groove. Ital J Anat Embryol. 2006; 111: 151-8.

[4] Thangavelu K, Kannan R, Kumar NS, Rethish E, Sabitha S, & Sayeeganesh N.: Significance of localization of mandibular foramen in an inferior alveolar nerve block. J Nat Sci Biol Med. 2012; 3: 156-60.

[5] Kota G, Gupta P, & Mintz A.: PET/CT illustration of metastatic breast cancer to the left mandibular foramen. Clin Nucl Med. 2013; 38: 385-6.

[6] Choi YY, & Han SS.: Double mandibular foramen leading to the accessory canal on the mandibular ramus. Surg Radiol Anat. 2014; 36: 851-5.

[7] Jerolimov V, Kobler P, Keros J, Stanicić T, & Bagić I.: Assessment of position of foramen mandible in recent adult population. Coll Antropol. 1998; 22: 169-77.

[8] Epars JF, Mavropoulos A, & Kiliaridis S.: Influence of age and vertical facial type on the location of the mandibular foramen. Pediatr Dent. 2013; 35: 369-73.

[9] Ennes J, Medeiros R, & Grant J.: Localization of mandibular foramen and clinical implications. Int J Morphol. 2009; 27: 1305-1311.

[10] Tsai HH.: Panoramic radiographic findings of the mandibular foramen from deciduous to early permanent dentition. J Clin Pediatr Dent. 2004; 28: 215-9.

[11] Cvetko E.: Bilateral anomalous high position of the mandibular foramen: a case report. Surg Radiol Anat. 2014; 36: 613-6.

[12] Nicholson ML.: A study of the position of the mandibular foramen in the adult human mandible. Anat Rec. 1985; 212: 110-2.

[13] Sekerci AE, & Sisman Y.: Cone-beam computed tomography analysis of the shape, height, and location of the mandibular lingula. Surg Radiol Anat. 2014; 36: 155-62.

[14] Shenoy V, Vijayalakshmi S, & Saraswathi P.: Osteometric analysis of the mandibular foramen in dry human mandibles. JCDR. 2012; 6: 557-560.

[15] Chenna D, & Hosapatna M.: Lingula and antilingula as anatomic reference points for ramus osteotomies. J Dent. 2015; 3: 1-3.

[16] Samanta PP, & Kharb P.: Morphological analysis of the lingula in dry adult human mandibles of north Indian population. J Cranio-Maxillary Dis. 2012; 1: 7-11.

[17] Lee S-W, Jeong H, Seo Y-K, Jeon SK, Kim S-Y, Jang M, & Paik D-J.: A Morphometric Study on the Mandibular Foramen and the Lingula in Korean. Korean J Phys Anthropol. 2012; 25: 153-166.

[18] Valente V, & Arita W.: Location of the mandibular foramen according to the amount of dental alveoli. Int J Morphol. 2012; 30: 77-81.

[19] Ashkenazi M, Taubman L, & Gavish A.: Age-associated changes of the mandibular foramen position in anteroposterior dimension and of the mandibular angle in dry human mandibles. Anat Rec (Hoboken). 2011; 294: 1319-25.

[20] Apinhasmit W, Chompoopong S, Jansisyanont P, Supachutikul K, Rattanathamsakul N, Ruangves S, & Sangvichien S.: The study of position of antilingula, midwaist of mandibular ramus and midpoint between coronoid process and gonion in relation to lingula of 92 Thai dried mandibles as potential surgical landmarks for vertical ramus osteotomy. Surg Radiol Anat. 2011; 33: 337-43.

[21] Kositbowornchai S, Siritapetawee M, Damrongrungruang T, Khongkankong W, Chatrchaiwiwatana S, Khamanarong K, & Chanthaooplee T.: Shape of the lingula and its localization by panoramic radiograph versus dry mandibular measurement. Surg Radiol Anat. 2007; 29: 689-94.

[22] Hayward J, Richardson ER, & Malhotra SK.: The mandibular foramen: its anteroposterior position. Oral Surg Oral Med Oral Pathol. 1977; 44: 837-43.

[23] Balcioglu HA, Kilic C, Varol A, Ozan H, Kocabiyik N, & Yildirim M.: A Morphometric Study of the Maxillary Artery and Lingula in Relation to Mandibular Ramus Osteotomies and TMJ Surgery. Eur J Dent. 2010; 4: 166-70.

[24] Monnazzi MS, Passeri LA, Gabrielli MF, Bolini PD, de Carvalho WR, & da Costa Machado H.: Anatomic study of the mandibular foramen, lingula and antilingula in dry mandibles, and its statistical relationship between the true lingula and the antilingula. Int J Oral Maxillofac Surg. 2012; 41: 74-8.

[25] Kim HJ, Lee HY, Chung IH, Cha IH, & Yi CK.: Mandibular anatomy related to sagittal split ramus osteotomy in Koreans. Yonsei Med J. 1997; 38: 19-25.

[26] Jansisyanont P, Apinhasmit W, & Chompoopong S.: Shape, height, and location of the lingula for sagittal ramus osteotomy in Thais. Clin Anat. 2009; 22: 787-93.

[27] Alves N, & Deana NF.: Morphometric study of mandibular foramen in macerated skulls to contribute to the development of sagittal split ramus osteotomy (SSRO) technique. Surg Radiol Anat. 2014; 36: 839-45.

[28] Moudi E, & Mehdizadeh M.: Accuracy of panoramic radiograph in determining the location of the lingula. Caspian J Dent Res. 2013; 2: 48-54.

[29] Afsar A, Haas DA, Rossouw PE, & Wood RE.: Radiographic localization of mandibular anesthesia landmarks. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1998; 86: 234-41.

[30] Poonacha KS, Shigli AL, & Indushekar KR.: Relative position of the mandibular foramen in different age groups of children: a radiographic study. J Indian Soc Pedod Prev Dent. 2010; 28: 173-8.

[31] Patil K, Guledgud MV, & Bhattacharya PT.: Reliability of Panoramic Radiographs in the Localization of Mandibular Foramen. J Clin Diagn Res. 2015; 9: 35-8.

[32] Kang SH, Byun IY, Kim JH, Park HK, & Kim MK.: Three-dimensional anatomic analysis of mandibular foramen with mandibular anatomic landmarks for inferior alveolar nerve block anesthesia. Oral Surg Oral Med Oral Pathol Oral Radiol. 2013; 115: 17-23.

[33] Park KR, Kim SY, Kim GJ, Park HS, & Jung YS.: Anatomic study to determine a safe surgical reference point for mandibular ramus osteotomy. J Craniomaxillofac Surg. 2014; 42: 22-7.

[34] Findik Y, Yildirim D, & Baykul T.: Three-dimensional anatomic analysis of the lingula and mandibular foramen: a cone beam computed tomography study. J Craniofac Surg. 2014; 25: 607-10.

[35] Yu IH, & Wong YK.: Evaluation of mandibular anatomy related to sagittal split ramus osteotomy using 3-dimensional computed tomography scan images. Int J Oral Maxillofac Surg. 2008; 37: 521-8.

[36] Sekerci AE, Cantekin K, & Aydinbelge M.: Cone beam computed tomographic analysis of the shape, height, and location of the mandibular lingula in a population of children. Biomed Res Int. 2013; 2013: 825453.

[37] Mbajiorgu EF.: A study of the position of the mandibular foramen in adult black Zimbabwean mandibles. Cent Afr J Med. 2000; 46: 184-90.

[38] Lim MY, Lim WW, Rajan S, Nambiar P, & Ngeow WC.: Age-related changes in the location of the mandibular and mental foramen in children with Mongoloid skeletal pattern. Eur Arch Paediatr Dent. 2015; 16: 397-407.

[39] Stull KE, Tise ML, Ali Z, & Fowler DR.: Accuracy and reliability of measurements obtained from computed tomography 3D volume rendered images. Forensic Sci Int. 2014; 238: 133-40.

[40] Noleto JW, Marchiori E, & Da Silveira HM.: Evaluation of mandibular ramus morphology using computed tomography in patients with mandibular prognathism and retrognathia: Relevance to the sagittal split ramus osteotomy. J Oral Maxillofac Surg. 2010; 68: 1788-94.

[41] Kim G, Jung HJ, Lee HJ, Lee JS, Koo S, & Chang SH.: Accuracy and reliability of length measurements on three-dimensional computed tomography using open-source OsiriX software. J Digit Imaging. 2012; 25: 486-91.

[42] Katsumata A, Fujishita M, Maeda M, Ariji Y, Ariji E, & Langlais RP.: 3D-CT evaluation of facial asymmetry. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2005; 99: 212-20.

[43] Cavalcanti MG, V&annier MW.: Quantitative analysis of spiral computed tomography for craniofacial clinical applications. Dentomaxillofac Radiol. 1998; 27: 344-50.

[44] Cavalcanti MG, Haller JW, & Vannier MW.: Three-dimensional computed tomography landmark measurement in craniofacial surgical planning: experimental validation in vitro. J Oral Maxillofac Surg. 1999; 57: 690-4.

[45] Wang J, Ye M, Liu Z, & Wang C.: Precision of cortical bone reconstruction based on 3D CT scans. Comput Med Imaging Graph. 2009; 33: 235-41.

[46] De Wilde L, Defoort S, Verstraeten TR, Speeckaert W, & Debeer P.: A 3D-CT scan study of the humeral and glenoid planes in 150 normal shoulders. Surg Radiol Anat. 2012; 34: 743-50.

[47] Walford LM, Fonseca RJ, Scully JR, & Costello BJ.: Facial asymmetry. Diagnosis and treatment considerations. Oral and Maxillofacial Surgery. 2nd Ed. New York: Elsevier 2009. p. 272-315.

[48] Priya Shetty, Ann Thomas, & B Sowmya: Diagnosis of temporomandibular joint (TMJ) ankylosis in children 2014: 32, 266-270. Journal of Indian Society of Pedodontics and Preventive Dentistry

[49] Hemant Gupta, Parul Tandon, Deepak Kumar, Vijay Prakash Sinha, Sumit Gupta, Hemant Mehra, & Jasmeet Singh.: Role of coronoidectomy in increasing mouth opening. Natl J Maxillofac Surg. 2014; 5: 23–30.

[50] Arvind Agarwal, Brijesh Ruparelia, Ajay Kubawat, Sandeep Patel, & Shalini Gupta: Modified Gap Arthroplasty and Myrhaug's Incision as a Treatment Option in Management of Temporomandibular Joint Ankylosis: A Study of 10 Cases. The Journal of Contemporary Dental Practice. 2011; 12: 295-300.