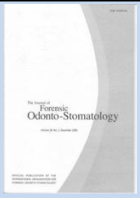

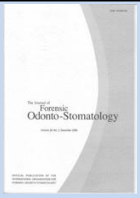

# JOURNAL of FORENSIC ODONTO-STOMATOLOGY

VOLUME 34 Number 2 December 2016


SECTION AGE ESTIMATION

# Assessing age-related change in Japanese mental foramen opening direction using multidetector computed tomography


Namiko Ishii[1, 2] *, Yohsuke Makino[1,3], Misuzu Fujita[4], Ayaka Sakuma[1], Suguru Torimitsu[1,3], Fumiko Chiba[1,3], Daisuke Yajima[1], Go Inokuchi[1], Ayumi Motomura[1], Hirotaro Iwase[1,3], Hisako Saitoh[1]

[1]*Department of Legal Medicine, Graduate School of Medicine, Chiba University, Japan*
[2]*Department of Forensic Dentistry, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University, Japan*
[3]*Department of Legal Medicine, Graduate School of Medicine, The University of Tokyo, Japan*
[4]*Department of Public Health, Graduate School of Medicine, Chiba University, Japan*
***Corresponding author:** acua2807@chiba-u.jp*


*The authors declare that they have no conflict of interest.*


***ABSTRACT***

***Objective:** The purpose of this study was to investigate how the opening direction of the mental foramen (MF) changes with age in a Japanese population using multi-detector computed tomography (MDCT). **Methods:** Post-mortem MDCT scans of 121 Japanese subjects (66 males and 55 females) were carried out where all subjects possessed at least twenty teeth, including molar teeth, in the upper and lower jaws. Two angles of the mental foramen opening were measured, namely the superior-inferior angle in the coronal plane and anterior-posterior angle in the transverse plane, on the CT reconstructed images. The associations between age and these two angles were evaluated using a multiple regression analysis. **Results:** For male subjects, the relationship between the superior-inferior angle and age was a quadratic curve (p<0.001). This angle increased until the subject reached their early 50s and then the angle decreased with age. In the transverse plane, there was a linear relation between the anterior-posterior angle and age (p=0.002).It was noted also that the angle decreased with age. By contrast, however, no significant associations between the two angles and age for either measurement were noted for female subjects. This study demonstrated that the opening direction of the mental foramen changes with age in Japanese male subjects. By contrast this change in the opening direction of the mental foramen was not demonstrated in Japanese female subjects. In male subjects, the opening direction moves superiorly until the individual reaches their early 50s, and then moves inferiorly with advancing age. It also shifts from a posterior to an anterior position with age. **Conclusion:** These observed change differ from the results of previous studies. The findings could be useful for forensic science as they demonstrate a change in the position of mental foramen in a sample of contemporaneous male Japanese subjects.*



**KEYWORDS:** forensic odontology, forensic anthropology, postmortem computed tomography imaging, aging, Japanese

JFOS.December 2016, Vol.34, No.2 Pag 11-20
ISSN :2219-6749

## *INTRODUCTION*

The mental foramen (MF) is located under the mandibular second premolar tooth and opens postero-superiorly. It is an exit of the mandibular canal, and the inferior alveolar nerve and blood vessels pass through it. Once they exit the MF, the nerve and vessels become MF vessels and nerves and conduct the distribution of the sensory nerve and vascular supply to the soft tissues of the chin, lower lip, and the posterior gingiva of the second mandibular molar region.[1,2] For this reason, the MF is an important landmark in clinical dentistry for the purposes of nerve block and dental implant or oral surgery.

In the forensic field, the MF is one of the anatomical landmarks to assist the identification of human remains, and various forensic anthropological studies of MF shape, size and position have been conducted. Amorim et al. and Apinhasmit et al. reported on the relationship between MF location and sex in dry mandibular bone.[3,4] Cutright et al. described racial trends in MF position by examining skulls.[5] With regard to changes in MF due to aging, Gershenson et al. evaluated the MF location in dry mandibles and reported that MF changed with age.[6] Kamijyo[7] and Takenoshita[8] measured Japanese dry mandibular bone to examine age-related changes of MF by performing macroscopic observations.

Computed tomography (CT) is a suitable modality for observing hard tissue and has been widely used in the field of medicine, including clinical dentistry (e.g., dental implants and maxillofacial surgery). It has also been used to evaluate the mandibular canal after (??) the MF.[9] The use of CT is also becoming more common in the practice and study of forensic medicine.[10-13] Postmortem CT images taken in a forensic field are also applied to some anthropological studies.[11] However, no studies have focused on the change of the MF with age using MDCT. In the present study the opening direction of MF in Japanese subjects was evaluated using multi-detector raw computed tomography (MDCT) and assessed whether it changed with age.

## *MATERIALS AND METHODS*

Cadavers scheduled to undergo forensic autopsies were examined between January 2010 and February 2014 at the department of Legal Medicine of Chiba University. The cadavers used in this study were selected from Japanese subjects who had at least 20 remaining teeth including molar teeth in the upper and lower jaws. Edentulous cases and cases where the loss of [posterior teeth had led to occlusal collapse were excluded. The cadavers with mandibular asymmetries and fractures were also excluded. In total, MDCT was used to measure the angles of the opening direction of the MF in 121 cadavers (66 males and 55 females). The present study gained the approval of the ethics committee of Chiba University. The sex and age distributions are provided in Table 1.

Prior to forensic autopsy, postmortem MDCT scans (16-section MDCT scanner, Eclos, Hitachi Ltd, Tokyo, Japan) were carried out using the following protocol; 0.625 mm collimation, 0.63mm reconstruction interval, 120 kV tube voltage, 200 mA tube current, and 1 r/s rotation time. Image processing was performed on a radiological work-station (SYNAPSE VINCENT, Fujifilm, Tokyo, Japan). Firstly the mandibular plane was defined as a three-dimensional (3D) image on the work-station denoted by tangent lines drawn from the nadir of the mental region in the median sagittal plane (Me) to the right and left mandibular inferior margins (Fig. 1). The perpendicular and parallel planes were the reconstructed on the basis of this mandibular plane then the “coronal” and “transverse” planes were defined to observe and measure the MF. The coronal plane was defined as the plane that best describes the MF maximal opening of these perpendicular planes to the mandibular plane as shown in Fig. 2-A. The transverse plane was defined as the plane that best describes the MF maximal opening of these parallel planes to the mandibular plane as shown in Fig. 3-A. On each plane two parameters were measured of the MF opening direction as described below:

**I. Opening direction of the MF in the coronal plane (Angle θ1, Fig. 2)**

The superior-inferior angle was measured, indicating the MF opening direction based on the definition of Sasaki et al[9] (Fig. 2-A, B). On the coronal plane, two lines were drawn. One was Line a passing through each midpoint of the MF opening on the outside and inside of the cortical bone (Fig. 2-A, B), and the other was Line b parallel to the mandibular plane (Fig. 2-A). The angle consisting of these two lines was Angleθ1.

Table 1: Sex and age distribution

| | 10's | 20's | 30's | 40's | 50's | 60's | 70's | over80's | Total |
|---|---|---|---|---|---|---|---|---|---|
| Males | 8 | 9 | 10 | 10 | 10 | 9 | 8 | 2 | 66 |
| Females | 2 | 8 | 4 | 11 | 11 | 8 | 8 | 3 | 55 |

**Fig.1:** The mandibular plane consists of the most inferior point of the chin and both mandibular inferior border.

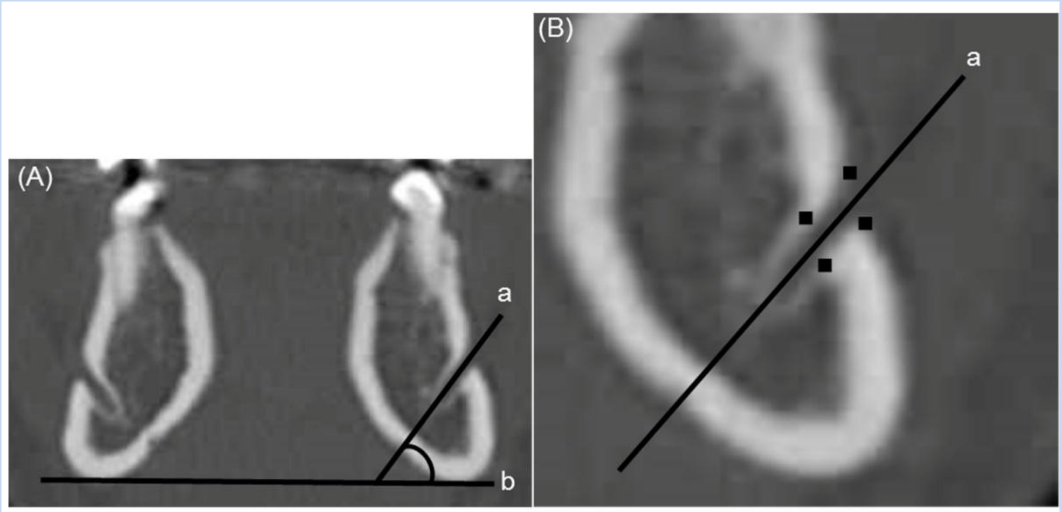


**Fig. 2:** Opening direction of the mental foramen (MF) in the coronal plane A. the superior-inferior angle in the coronal plane consists of Line a passing through the middle of the MF and Line b parallel to the mandibular plane B. the enlarged figure of the MF maximal opening.

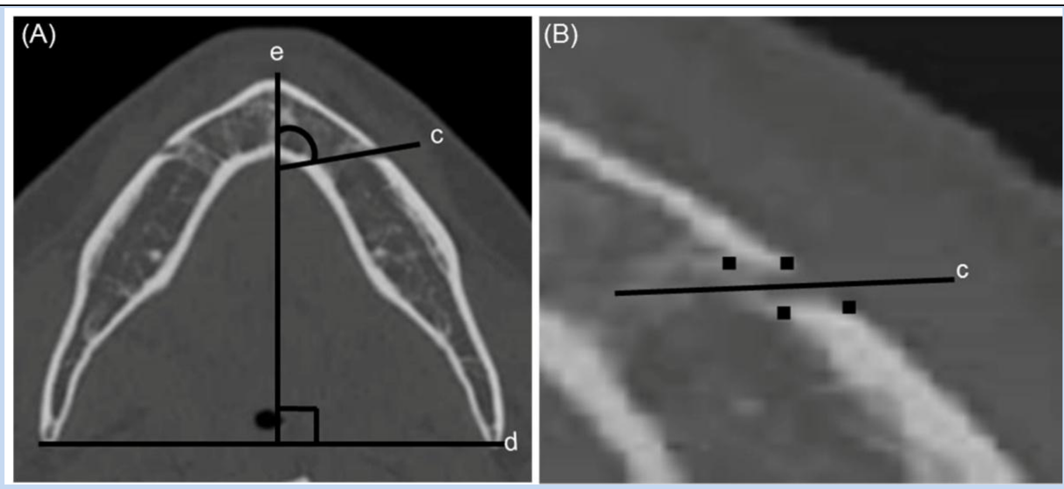


**Fig. 3:** Opening direction of the mental foramen (MF) in the transverse plane A. the anterior-posterior angle in the transverse plane consists of Line c passing through the middle of the MF and Line e perpendicular to Line d which links bilateral posterior margins of mandibular ramus. B. the enlarged figure of the MF maximal opening.

**II. Opening direction of MF in the transverse plane (Angle θ2, Fig. 3)**

The anterior-posterior angle was measured indicating the opening direction of the MF (Fig. 3-A, B). On the transverse plane, three lines were drawn. One was Line c passing through each midpoint of the MF opening on the outside and inside of the cortical bone (Fig. 3-A, B), another was Line d linking the right and left posterior margins of the mandibular ramus (Fig. 3-A), and the other was Line e perpendicular to line d (Fig. 3-A) . The angle consisting of Lines c and e was Angle θ2. Measurements of Angle θ1 and Angle θ2 were performed on each MF maximal opening, and by sex. In each measurement, measurements on both the left and right sides of the MF were taken, and the average of these two measurements was calculated. Two weeks later 20 MDCT images were randomly selected and MF was measured once again. The relative technical error of measurement (rTEM, %) and the coefficient of reliability (R) were calculated for estimation of the intra-observer error.[14-16] It was considered that rTEM (%) < 5% and R value > 0.75 was sufficiently precise.[15,16]

The associations between age and MF opening directions (Angles θ1 and θ2) were evaluated using multiple regression analyses. To confirm quadratic relationships age was entered into the model using a forced entry method and age square term using a forward elimination method with a threshold of $p < 0.05$. A $p$-value < 0.05 was considered statistically significant. All statistical analyses were performed using IBM SPSS Statistics software version 20.0 (IBM Corporation, Armonk, NY, USA).

## *RESULTS*

Using post-mortem MDCT images of 121 Japanese cadavers, age-related changes in the opening direction of the MF in the coronal plane (Angle θ1) and transverse plane (Angle θ2) were investigated. The intra-observer measurement error of Angle θ1 was expressed as rTEM =2.60% and R=0.99 (95% confidence interval 0.966~0.994). In Angle θ2, it was rTEM = 4.20% and R =0.97 (95% confidence interval 0.919~0.987). These results were within accepted standards.

In females, no significant association was demonstrated ($p = 0.709$) between age and Angle θ1 (Table 2). No significant association was demonstrated ($p = 0.392$) between age and Angle θ2 (Table 3).

However, when the association of age and the opening direction of MF in the coronal plane of male subjects was examined, the age-squared term was significant ($p < 0.001$) for the change of Angle θ1. Notably, the relationship between them was quadratic curvilinear (Fig. 4). The regression equation that explained the change of Angle θ1 with age was as follows: Angle θ1 = 24.06 – 0.01 × $(\text{age})^2$ + 1.04 × age, and the coefficient of determination (adjusted $R^2$) was 0.178 (Table 2). Based on the quadratic curve obtained from the regression equation, Angle θ1 increased until subjects reached their early 50s and thereafter decreased with age.

In the transverse plane, the age was significant ($p = 0.002$) for the change of Angle θ2. The relationship between age and the opening direction of the MF (Angle θ2) of males exhibited a linear relationship (Fig. 5). The regression equation of age-related change of Angle θ2 was as follows: Angle θ2 = 86.57 – 0.26 × age, and adjusted $R^2$ was 0.131 (Table 3). This regression equation demonstrated that Angle θ2 decreased with age.

## *DISCUSSION*

The purpose of the present study was to assess how the opening direction of the MF changed with age in a dentate Japanese population sample with no occlusal abnormalities as a result of the loss of posterior molar teeth using MDCT. The present study demonstrated age-related changes in MF opening directions in male subjects. By contrast no age-related changes were demonstrated in MF opening directions in female subjects.

Unlike the results for male subjects, no significant correlations between age and the opening direction of the MF in the coronal or transverse plane was detected for female subjects. In this present study it is recognized that only a limited number of young female subjects were included in the sample size. It is recognized that the muscles (including those responsible for occlusal force) are weaker in females than in males. Utsuno et al. reported that facial soft thickness differences were greater in females than that in the case of males.[17] It is considered that there is more variation in the individual cranial morphologies of female subjects compared to the individual cranial morphologies of male subjects. This may offer an explanation for the gender-based differences demonstrated in the present study.

In male subjects, the opening direction of the MF moved superiorly part with age until the early 50s, after which time it moved inferiorly. The morphological changes in mandibular bone after middle age due to age-related periodontal disease,[18] may have some influence on the opening direction of the MF. Similarly, the decrease in mandibular mineral content as a result of ageing might also influence this variable.[19, 20]

Table 2: The relationship between age and MF opening direction in the coronal plane

| | Regression coefficient (95% confidence interval) | *p*-value | Adjusted $R^2$ |
|---|---|---|---|
| Males | | | |
| Age | 1.044(0.513, 1.576) | < 0.001 | 0.178 |
| $(Age)^2$ | -0.010(-0.016, -0.005) | < 0.001 | |
| Females | | | |
| Age | -0.032(-0.201, 0.137) | 0.709 | -0.016 |

Age was entered in the model using a forced entry method and an age squared term was entered using a forward elimination method with a threshold of $p < 0.05$.

Table 3: The relationship between age and MF opening direction in the transverse plane

| | Regression coefficient (95% confidence interval) | *p*-value | Adjusted $R^2$ |
|---|---|---|---|
| Males | | | |
| Age | -0.262(-0.422, -0.103) | 0.002 | 0.131 |
| Females | | | |
| Age | -0.082(-0.273, 0.109) | 0.392 | -0.005 |

The opening direction of the MF tended to move anteriorly with age in males, and this finding was different from the results of previous research studies. Al-Khateeb et al. reported that the MF position of subjects in northern Jordan increased with advancing age using panoramic radiographs; specifically, there was a greater frequency of more posterior and inferior positioning.[21] Santini et al. also reported that the MF in mandibles of Chinese and British skulls became more distal with age.[22] In Japanese subjects, Kamijyo[7] and Takenoshita[8] performed mandibular macroscopic observations. Specifically Takenoshita[8] inserted needles into the MF of 40 dry mandibles from Japanese subjects to investigate the MF opening direction. Kamijyo[7] and Takenoshita[8] reported that the MF opening moved from the anterior to posterior direction with age. The use of differing measuring methods is likely to account for discrepancies in their findings. Cutlight et al. reported that the MF of Negroid subjects were posterior compared with those in Caucasoid subjects[5] and that racial differences may be a factor affecting the position of the MF . It is recognized that bone formation can be influenced by dietary habits, environmental influences, and socioeconomic factors.[23]

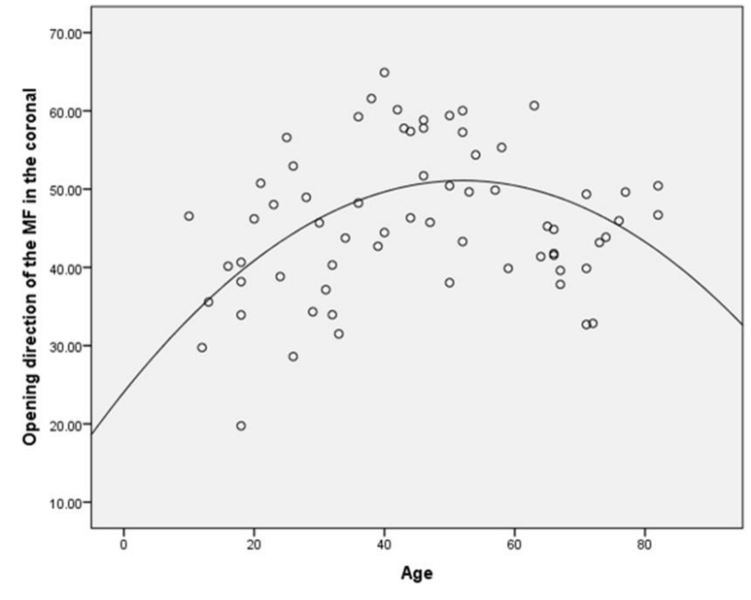


**Fig. 4:** Age-related change in the mental foramen (MF) opening direction in the coronal plane.

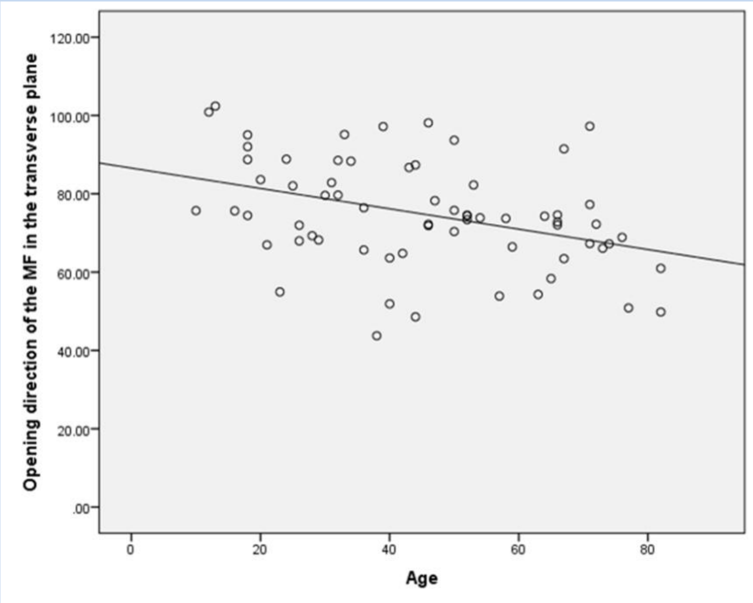


**Fig. 5:** Age-related change in the mental foramen (MF) opening direction in the transverse plane.

With regard to the findings of Kamijyo[7] and Takenoshita,[8] both reports were published more than 30 years ago, and it is possible that their results were different from that of the current Japanese MF cohort for the following reason. Their studies included both dentate and edentate mandibles and did not take any account of the effects of teeth being present. We consider this as an important consideration, in that resorption of the alveolar bone following tooth loss has a major influence on the MF opening. [6] The loss of teeth depends largely on personal circumstances such as, for example, the oral environment of the individual. As a consequence, it is difficult to consider that their results were solely age dependent. The present study was limited to subjects with at least 20 remaining teeth, including posterior molar teeth and, by inference, the results would not be seen to be affected by alveolar bone resorption. For this reason, it is considered that the results of this present study are more indicative of actual age-related changes in MF position.

Several different methods have been used to assess MF position and the location of the mandibular canal in MF, including dry mandibular macroscopic observation, panoramic tomography,[24-26] and cone-beam CT (CBCT).[27-29] However for assessment of the age-related change of the MF opening direction, it was considered that the use of MDCT would be the most appropriate methodology. Using macroscopic observation of MF it is necessary to dissect out the mandible. Not only is this an invasive procedure but it also time intense. Additionally the MF must be identified blindly on the inside of the cortical bone. It is difficult to decide the measurement point and this is likely to increase the error between measurements. By contrast, MDCT is a non-invasive procedure. 3D-CT images are as accurate as direct observation for purposes of measurement,[30] and obviate the necessity for blind searching of the opening direction of the MF. Using panoramic tomography, it is not possible to obtain 3D information, and the MF cannot be viewed from different angles. Ngeow et al.[25] reported a weakness using dental panoramic radiographs in that the visibility of the anterior loop of the mental nerve becomes difficult to visualize due to the decreased calcification of the bone around the MF in older subjects. As a consequence, these panoramic images could not be used in the present study which involved measurement of the two angles of opening of MF in the coronal and transverse planes.

CBCT is commonly used in the field of clinical dentistry and is usually performed with the subject in a sitting position. This can present practical difficulties in research involving cadavers. However MDCT can be performed with the subject in a supine position. Compared to CBCT, MDCT is able to obtain data with less image noise and is suitable for observation of the mandibular bone.[31,32]

In the present study accurate and objective data using MDCT was obtained regarding the position of MF in Japanese subjects. It is accepted that there were limitations to the scope of the study. All of the subjects were Japanese, and the number of cases was small. Further studies with larger numbers of cases, including other races, are needed to clarify the relationship between age and the position of MF.

## *CONCLUSION*

The present study demonstrated that there are age-related changes apparent in MF opening direction of Japanese males. By contrast the present study demonstrated that there are no age-related changes apparent in MF opening direction of Japanese females. In the coronal plane, the opening direction of the MF moves superiorly until the early 50s, after which point, it moves inferiorly. In the transverse plane, it moves anteriorly with age. These observations differ from the results of previous studies. The findings of this present study could be relevant in the field of forensic anthropology as they indicate changes of the position of MF in contemporary Japanese males that may be helpful in the identification of human remains.

## *REFERENCES*


*1. Phillips JL, Weller N, Klild JC. The mental foramen: Part I. Size, orientation, and positional relationship to the mandibular second premolar. J Endod 1990;16:221–3.*

*2. Chrcanovic BR, Abreu MH, Custódio AL. Morphological variation in dentate and edentulous human mandibles. Surg Radiol Anat 2011;33:203–13.*

*3. Amorim MM, Prado FB, Borini CB, Bittar TO, Volpato MC, Groppo FC, et.al. The Mental Foramen Position in Dentate and Edentulous Brazilian's Mandible. Int J Morphol 2008;26:981–7.*

*4. Apinhasmit W, Methathrathip D, Chompoopong S, Sangvichien S. Mental foramen in Thais: an anatomical variation related to gender and side. Surg Radiol Anat 2006;28:529–33.*

*5. Cutright B, Quillopa N, Schubert W. An anthropometric analysis of the key foramina for maxillofacial surgery. J Oral Maxillofac Surg 2003;61:354–7.*

*6. Gershenson A, Nathan H, Luchansky E. Mental foramen and mental nerve: changes with age. Acta Anat (Basel) 1986;126:21–8.*

*7. Kamijyo Y. The anthropological and anatomical studies on the mental foramen in mandible of Japanese in Kyushu. In: Yamamoto K (ed.). Forensic dental medicine, 6th ed. Tokyo. Ishiyaku publishers Inc; 1993, p 177–8.*

*8. Takenoshita Y. Developmental and age changes of mental foramen. Jpn J Oral Maxillofac Surg 1978;24:481–7.*

*9. Sasaki K, Furuya J. Relationship between ACP classification and the opening position, direction of the mental foramen and anterior loop in edentulous patients. Dent J Iwate Med Univ 2012;37:1–13.*

*10. Levy AD, Harcke HT, Getz JM, Mallak CT. Multidetector computed tomography findings in deaths with severe burns. Am J Forensic Med Pathol 2009;30:137–41.*

*11. Torimitsu S, Makino Y, Saitoh H, Ishii N, Hayakawa M, Yajima D, et al. Stature estimation in Japanese cadavers using the sacral and coccygeal length measured with multidetector computed tomography. Leg Med (Tokyo) 2014;16:14–9.*

*12. Inokuchi G, Yajima D, Hayakawa M, Motomura A, Chiba F, Torimitsu S, et al. The utility of postmortem computed tomography selective coronary angiography in parallel with autopsy. Forensic Sci Med Pathol 2013;9:506–14.*

*13. Sakuma A, Saitoh H, Makino Y, Inokuchi G, Hayakawa M, Yajima D, et al. Three-dimensional visualization of composite fillings for dental identification using CT images. Dentomaxillofac Radiol 2012;41:515–9.*

*14. Ward RE, Jamison PL. Measurement precision and reliability in craniofacial anthropometry: implications and suggestions for clinical applications. J Craniofac Genet Dev Biol 1991;11:156–64.*

*15. Weinberg SM, Scott NM, Neiswanger K, Marazita ML. Intraobserver error associated with measurements of the hand. Am J Hum Biol 2005;17:368–71.*

*16. Torimitsu S, Makino Y, Saitoh H, Sakuma A, Ishii N, Hayakawa M, et al. Stature estimation in Japanese cadavers based on the second cervical vertebra measured using multidetector computed tomography. Leg Med (Tokyo) 2015;17:145–9.*

*17. Utsuno H, Kageyama T, Uchida K, Kibayashi K. Facial soft tissue thickness differences among three skeletal classes in Japanese population. Forensic Sci Int 2014:236:175-80.*

*18. Suresh R. Prevention and Treatment of Age-related Diseases. In: Rattan S, Kassem M (eds.). Aging and Periodontal Disease, New York. Springer; 2006. p 193–200.*

*19. Choël L, Duboeuf F, Bourgeois D, Briguet A, Lissac M. Trabecular alveolar bone in the human mandible: a dual-energy x-ray absorptiometry study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2003;95:364–70.*

*20. von Wowern N. In vivo measurement of bone mineral content of mandibles by dual-photon absorptiometry. Scand J Dent Res 1985;93:162–8.*

*21. Al-Khateeb T, Al-Hadi Hamasha A, Ababneh KT. Position of the mental foramen in a northern regional Jordanian population. Surg Radiol Anat 2007;29:231–7.*

*22. Santini A, Land M. A comparison of the position of the mental foramen in Chinese and British mandibles. Acta Anat (Basel) 1990;137:208–12.*

*23. Bogin B, Rios L. Rapid morphological change in living humans: implications for modern human origins. Comp Biochem Physiol A Mol Integr Physiol 2003;136:71–84.*

*24. Yosue T, Brooks SL. The appearance of mental foramina on panoramic radiographs. I. Evaluation of patients. Oral Surg Oral Med Oral Pathol 1989;68:360–4.*

*25. Ngeow WC, Dionysius DD, Ishak H, Nambiar P. A radiographic study on the visualization of the anterior loop in dentate subjects of different age groups. J Oral Sci 2009;51:231–7.*

*26. Kasat V, Karjodkar F, Vaz W. Age estimation in 25-45 yrs. old females by physical and radiological methods. J Forensic Dent Sci 2010;2:91–5.*

*27. von Arx T, Friedli M, Sendi P, Lozanoff S, Bornstein MM. Location and Dimensions of the Mental Foramen. A Radiographic Analysis by Using Cone-beam Computed Tomography. J Ended 2013;39:1522–8.*

*28. Ritter L, Neugebauer J, Mischkowski RA, Dreiseidler T, Rothamel D, Richter U, et al. Evaluation of the course of the inferior alveolar nerve in the mental foramen by cone beam computed tomography. Int J Oral Maxillofac Implants 2012;27:1014–21.*

*29. Angel JS, Mincer HH, Chaudhry J, Scarbecz M. Cone-beam computed tomography for analyzing variations in inferior alveolar canal location in adults in relation to age and sex. J Forensic Sci 2011;56:216–9.*

*30. Sakuma A, Ishii M, Yamamoto S, Shimofusa R, Kobayashi K, Motani H, et al. Application of postmortem 3D-CT facial reconstruction for personal identification. J Forensic Sci 2010;55:1624–9.*

*31. Haktanir A, Ilgaz K, Turhan-Haktanir N.Evaluation of mental foramina in adult living crania with MDCT. Surg Radiol Anat 2010;32:351-6.*

*32. Liang X, Jacobs R, Hassan B, Li L, Pauwels R, Corpas L, et al. A comparative evaluation of Cone Beam Computed Tomography (CBCT) and Multi-Slice CT (MSCT) Part I. On subjective image quality. Eur J Radiol 2010;75:265-9.*


*****