GENDER AND AGE DETERMINATION OF DENTULOUS PATIENTS - A RADIOGRAPHIC STUDY

DISSERTATION

Submitted to

BABU BANARASI DAS UNIVERSITY,
LUCKNOW, UTTAR PRADESH

In partial fulfilment of the requirement for the degree of

MASTER OF DENTAL SURGERY

In

ORAL MEDICINE AND RADIOLOGY

By

Dr. ABHISHEK BANERJEE

Under the guidance of

Dr. Shiva Kumar. G.C

Professor

DEPARTMENT OF ORAL MEDICINE & RADIOLOGY

BABU BANARASI DAS COLLEGE OF DENTAL SCIENCES,
LUCKNOW

YEAR OF SUBMISSION: 2018

ACADEMIC BATCH: 2016-2019

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation entitled **"Gender and Age Determination of Dentulous Patients- A Radiographic Study"** is a bonafide and genuine research work carried out by me under the guidance of **Dr. Shiva Kumar. G.C**, Professor, Department of Oral Medicine and Radiology, Babu Banarasi Das College Of Dental Sciences, Babu Banarasi Das University, Lucknow, Uttar Pradesh.

Date:	Signature of the candidate
Place: Lucknow	**Dr. Abhishek Banerjee**

CERTIFICATE BY THE GUIDE/CO-GUIDE

This is to certify that the dissertation entitled "**Gender and Age Determination of Dentulous Patients- A Radiographic Study"** is a bonafide work done by **Dr. Abhishek Banerjee,** under our direct supervision and guidance in partial fulfilment of the requirement for the Degree of Master of Dental Surgery in Oral Medicine and Radiology.

GUIDE
Dr. Shiva Kumar. G.C
Professor
Dept. of Oral Medicine and Radiology
B.B.D.C.O.D.S.
BBDU, Lucknow (U.P.)

CO-GUIDE
Dr. Neeta Misra
Professor and Head
Department of Oral Medicine and Radiology
B.B.D.C.O.D.S
BBDU, Lucknow (U.P.)

Dr. Deepak U
Professor
Department of Oral Medicine and Radiology
B.B.D.C.O.D.S
BBDU, Lucknow (U.P.)

Dr. Puja Rai
Senior Lecturer
Department of Oral Medicine and Radiology
B.B.D.C.O.D.S
BBDU, Lucknow (U.P.)

ENDORSEMENT BY THE HEAD OF DEPARTMENT

This is to certify that the dissertation entitled **"Gender and Age Determination of Dentulous Patients- A Radiographic Study"** is a bonafide work done by **Dr. Abhishek Banerjee,** under direct supervision and guidance of **Dr. Shiva Kumar. G.C,** Professor, Department of Oral Medicine and Radiology, Babu Banarasi Das College Of Dental Sciences, Babu Banarasi Das University, Lucknow, Uttar Pradesh.

Seal and signature of the HOD

Dr. Neeta Misra
Professor & Head
Department of Oral Medicine and Radiology
B.B.D.C.O.D.S
BBDU, Lucknow (U.P.)

ENDORSEMENT BY THE HEAD OF THE INSTITUTION

This is to certify that the dissertation entitled **"Gender and Age Determination of Dentulous Patients- A Radiographic Study"** is a bonafide work done by **Dr. Abhishek Banerjee,** under direct supervision and guidance of **Dr. Shiva Kumar. G.C,** Professor, Department of Oral Medicine and Radiology, Babu Banarasi Das College Of Dental Sciences, Babu Banarasi Das University, Lucknow, Uttar Pradesh.

Seal and signature of the Principal

Dr. B. Rajkumar

Principal

B.B.D.C.O.D.S

BBDU, Lucknow (U.P.)

COPYRIGHT

I hereby declare that the **Babu Banarasi Das University** shall have the right to preserve, use and disseminate this dissertation in print or electronic format for academic / research purpose.

Date: Signature of the candidate

Place: Lucknow **Dr. Abhishek Banerjee**

INTRODUCTION

Remains of human skeleton identification are an important part in forensic science. Gender determination using the remains of human skeleton is the first step which is followed by estimation of age and stature which is dependent on gender. [1]

The reliability of gender determination depends on the completeness of the remains and the degree of sexual dimorphism inherent in the population. When the entire adult skeleton is available for analysis, gender can be determined up to 100% accuracy, but in cases of mass disasters where usually fragmented bones are found, sex determination with 100% accuracy is not possible and it depends largely on the available parts of skeleton. Skull is the most dimorphic and easily sexed portion of skeleton after pelvis, providing accuracy up to 92%. But in cases where intact skull is not found, mandible may play a vital role in sex determination as it is the most dimorphic, largest, and strongest bone of skull. Presence of a dense layer of compact bone makes it very durable, and hence remains well preserved than many other bones. Dimorphism in mandible is reflected in its shape and size. Male bones are generally bigger and more robust than female bones. [2]

Distinguishing males from females and the differences in ethnic groups by analyzing the morphological characteristics of bone is important in the field of physical and forensic anthropology. Gender determination is done by analyzing the morphological characteristics of bone. Mandible being the strongest bone in the human body remains in a preserved state longer than other bones in the human body. [3]

The forensic age estimation of unidentified skeletons and corpses for the purpose of identification has been a conventional feature of forensic science. Determining the identity of a person is of considerable significance from the ethical, legal, and criminal perspectives; not only is it the prerequisite for officially declaring an individual dead but it is also the basis for dealing with mass disasters, crimes, and war crimes.[4]

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. [5]

The Mental Foramen (MF) is an important anatomical structure located in the body of mandible. It represents the termination of mental canal which opens onto the surface in oblique direction. The mental bundle passes through MF and supplies sensory innervations and nutrition to the chin, lower lip and gingiva on the ipsilateral side of the mandible. As there are no absolute anatomical landmarks for reference and the foramen cannot be directly visualized or palpated, radiographic evaluation of the position of MF becomes an obligation for accurate diagnosis. [6]

Mental foramen is one such landmark on the mandible which is stable. The mental foramen morphology, in terms of position, varies not only according to age, gender and ethnicity but even within the same race, in different geographic regions and within the inhabitants of the same geographic area. The digital panoramic radiography provides the actual location of the mental foramen in both vertical and horizontal planes and the body of the mandible for measuring the vertical height of the mandible. [7]

The radiographs are indispensable tools that are used in forensic anthropology. The radiographic method is simplest and cheapest method for age estimation and gender determination when compared to the histological and biochemical methods. Among radiographic methods Panoramic radiography is the most preferred diagnostic modality as it allows a more accurate localization of mental foramen. [8]

A through radiographic assessment is paramount for evaluating bone volume and bone quality, detecting the precise location of the anatomical structures to guarantee success rate. This is achieved best by sectional imaging; however, these sophisticated imaging modalities have their own limitations. High-radiation dose, metallic artefacts, high-cost, limited availability and need of trained operators are major limitations.

In compliance with that, some investigators reported that panoramic views could support. Panoramic radiography is a widely used technique with the advantage of providing a satisfactory coverage of both jaws, with a relatively low-radiation dose, in a short-period of time, and at lower cost if compared to more sophisticated techniques [9]. The image quality of the panoramic radiography is increased by the digitization. [10]

Hence this study aimed at documenting anatomical information on appearance, size, horizontal and vertical locations of Mental Foramen in Panoramic Radiograph. We also determined the relationship of age and gender with its radiographic appearance and location.

AIM

- The aim of this study is determination of gender and age estimation using digital panoramic radiographs in dentulous patients.

OBJECTIVES

1. To measure the height of the body of mandible on the right side.
2. To measure the distance between the superior margin and inferior margin of the mental foramen to the inferior border of the mandible on right side.
3. To measure the distance between the superior margin of the mental foramen to the alveolar crest on the right side.
4. To determine the appearance, horizontal and vertical location of mental foramen.
5. To analyze above measurements for estimation of gender and age in dentulous patients.

REVIEW OF LITERATURE

Forensic Science, an amalgamation of almost all faculties of knowledge is an essential and efficient enabler in the dispensation of justice in criminal, civil, regulatory and social contexts. Historically our forefathers in India have practiced forensic application in variety of forms. [11]

4.1 INTRODUCTION

The most acceptable definition of forensic dentistry or forensic odontology (FO) according to Brig. D. V. Taylor (1968) is "The application of dental knowledge to the elucidation of legal problems." [12]

It was further defined by Keiser–Nielson (1980) as "The branch of forensic medicine which in the interest of justice deals with the proper handling and examination of dental evidence and with the proper evaluation and presentation of the dental findings." [12]

As defined by Margot (2011b, p. 91): ''Forensic science is looking at the least likely, fragmented, imperfect, uncontrolled element in an event: the trace. It is the remnant (the memory) of the source and the activity that produced it. It has to be decoded and understood to elicit some knowledge about the event. The study of its relation to other traces as well as their environment provides many, and sometimes unsuspected, clues about the event and is a rich source of hypotheses to be tested as well as providing knowledge about reality.''

According to this definition, the trace exists independently of the forensic process and the technology. In forensic science, the first challenge—that will impact on the entire process—is to recognize and detect the trace since the source or activity that produced it is usually unknown and the event happened in the past (Morelato et al. 2014a). The circumstances surrounding the criminal activity help draw propositions about what sort of trace may be found and where it may be found. The development of relevant hypotheses might lead to the conscious and specific/selective application of technology to be able to detect and localize the trace. [13]

Skeleton has always aided in genetic, anthropological, odontological and forensic investigation of living and non- living individual.[14] Skull bones and pelvis have been majorly used in sex and age determination.[15] The first phase of forensic is to evaluate the difference in morpho- metric characteristics to identify an individual, and many studies reveal that there exist differences in the skull and other bones of male and female, as well as different age groups.[15]

In the adult skeleton, sex determination is usually the first step of the identification process as subsequent methods for age and stature estimation are sex dependent. The reliability of sex determination depends on the completeness of the remains and the degree of sexual dimorphism inherent in the population.[16] When the entire adult skeleton is available for analysis, sex can be determined up to 100% accuracy, but in cases of mass disasters where usually fragmented bones are found, sex determination with 100% accuracy is not possible and it depends largely on the available parts of skeleton.[17]

Skull is the most dimorphic and easily sexed portion of skeleton after pelvis, providing accuracy up to 92%.[17] But in cases where intact skull is not found, mandible may play a vital role in sex determination as it is the most dimorphic, largest, and strongest bone of skull.[2, 7, 18] Presence of a dense layer of compact bone makes it very durable, and hence remains well. Dimorphism in mandible is reflected in its shape and size.[17] Male bones are generally bigger and more robust than female bones. [16]

Chronological age assessment is an important part of medico legal practice. The procedures for age determination are complex and involve the consideration of many factors. Amongst the hard tissues, bones are important as they undergo a series of changes from prenatal to postnatal life and changes in their composition and structure continue into old age and even after death. Hence, bones form a reliable source of information regarding growth and growth changes. Normally well-defined skeletal development in bones, cranial sutures and teeth take place at specific ages. However, these changes are significantly affected by genetics, general health and other environmental factors. [19]

The determination of age becomes more difficult as maturity increases. Where fetal material is concerned, a result may be achieved with an accuracy measured almost in days. As age advances, the situation remains fairly satisfactory until about the cessation of growth and especially the cessation of dental changes so that by the age of 20–25 years all growth markers have ceased to be of assistance. As time goes on through adult life into middle age and into old age, matters become progressively more difficult and the margin of error increases.[20]

Mandible has been used in age and sex determination as it can retain its shape than any other bone in the forensic and physical anthropological field.[21] The mandible is amongst the first bones in the body to start ossifying and is unique in that it has both the patterns of ossification (endochondral and intramembranous). The body of mandible is ossified intramembranously whereas the ossification of the coronoid and condyloid processes is endochondral. Until the third decade of life, morphological and dental changes (time and sequence of eruption of teeth) serve as an aid to estimate age [22]. For ages above the third decade, the changes are subtle and have to be studied in greater detail. [23]

Researchers have studied the processes of human aging by many different methods. These include developmental, histological, biochemical, and anthropological techniques. Anthropologists analyze the fusion of the cranial sutures of the skull, the development of the long bones, features of the pelvic girdle, and along with forensic dentists, features of the teeth. These techniques can be valuable when creating a profile for an unidentified person, whether living or deceased. Estimating an individual's age can also be helpful in assisting law enforcement agencies in determining the attainment of the year of majority of a living individual that will ultimately affect the individual's treatment in the legal system as either a child or an adult. The methods of age estimation using teeth include analyzing tooth development and eruption, studying tooth degradation, and measuring biochemical and trace element changes in dental structures. Each of these methods has its advantages and limitations in accuracy and in the ease of use. Some can be performed through the analysis of dental or other radiographs or with clinical examination; others require laboratory testing or tooth destruction. The individual jurisdiction's requirements and the odontologist's skill and knowledge will help to establish the appropriate techniques for each case. [24]

4.2 HISTORY

The ancient world lacked standardized forensic practices, which aided criminals in escaping punishment. Criminal investigations and trials relied on forced confessions and witness testimony. However ancient sources contain several accounts of techniques that foreshadow the concepts of forensic science that is developed centuries later, such as the "Eureka" legend told of Archimedes. [a11] Present day Indian forensics, as chronicled, owes its genesis to several British – initiated ventures such as Chemical Examiner's Laboratory (Madras, 1849), Anthropometric Bureau (1892), Finger Print Bureau (1897), Inspectorate of Explosives (1898), Office of Government Handwriting Expert (1904), Serology Department (1910), Foot Print Section (1915), Note Forgery Section (1917), Ballistics Laboratory (1930) and Scientific Section (1936) [Ref 57]. Having subsequently undergone clubbing / regrouping / spreading, as of now, there are 28 State / Union Territory Forensic Science Laboratories (State / UT FSLs) along with their Regional FSLs (32 RFSLS) and Mobile FSLs (144 MFSLs); they are mostly with the respective Home Department either directly or through police establishment.

During 1957, the first Central Forensic Science Laboratory (CFSL) was established at Calcutta, followed by the ones at Chandigarh (1961; traceable to Lahore – origin of 1933) and Hyderabad (1965). In 1971, Neutron Activation Analysis (NAA) Unit came into operation at Bhabha Atomic Research Centre (BARC), Mumbai. Thus the Bureau of Police Research & 7 Development (BPR & D) administered three CFSLs, including NAA, and three laboratories of Government Examiners of Questioned Documents (GEQD). Presently (since 2002 / 03) they are all under the Directorate of Forensic Science (DFS; MHA, GoI); CFSL, Hyderabad has in its fold the NAA Unit and GEQD, Shimla has a branch at Chandigarh.[11]

4.2.1 The Current Scenario in India

In India, FO is an upcoming branch of dentistry that has a great scope of development. It has been introduced in the syllabus for Bachelor of Dental Surgery (BDS) by the Dental Council of India. Currently, FO has not been introduced as an individual subject in the curriculum of Dental Council of India but this branch has been linked to two other branches accordingly, namely Oral Medicine and Radiology and Oral and Maxillofacial Pathology. In the near future, FO in India is bound to become a separate discipline of dentistry as in the Western world. [25]

4.2.2 Significance in dentistry

Forensic odontology (dentistry) is a new and growing section of forensic medicine. The journey of forensic dentistry starts from Agrippina, the mother of Roman Emperor Nero, in 49 A.D. when she recognized her rival Lollia-Paulina's discolored front teeth after her assassination.[26]

Dentistry has much to offer law enforcement in the detection and solution of crime or in civil proceedings. Forensic dental fieldwork requires an interdisciplinary knowledge of dental science. They established the essential role which forensic dentistry plays mainly in the identification of human remains. The tooth has been used as weapons and under certain circumstances, may leave information about the identity of the biter. Dental professionals have a major role to play in keeping accurate dental records and providing all necessary information so that legal authorities may recognize mal practice, negligence, fraud or abuse, and identity of unknown individuals. [27, 28]

Dental identification assumes a primary role in the identification of remains when postmortem changes, traumatic tissue injury or lack of a fingerprint record invalidate the use of visual or fingerprint methods. The identification of dental remains is of primary importance when the deceased person is skeletonized, decomposed, burned or dismembered. [29]

The principal advantage of dental evidence is that, like other hard tissues, it is often preserved after death. Even the status of a person’s teeth changes throughout life and the combination of decayed, missing and filled teeth is measurable and comparable at any fixed point in time.[30] The dental record is a legal document owned by the dentist, and contains subjective and objective information about the patient. Results of the physical examination of the dentition and supporting oral and surrounding structures must be recorded.[31]

Comparison of antemortem and postmortem radiographs is the most accurate and reliable method of identifying remains. Observations such as distinctive shapes of restoration, root canal treatment, buried root tips, bases under restorations, tooth and root morphology, and sinus and jawbone patterns can be identified only by examination of radiographs. In some instances a single tooth may be all that remains, and upon comparison of radiographs, a positive identification can be made.[32]

4.2.3 Structure utilized to identification

Human identification can be a challenging task in mass disaster situation, in crime investigation, in ethnic studies and in the identification of decomposed and disfigured bodies such as that of drowned persons, fire victims, and victims of motor vehicle accidents. [31, 32]

The prosthetic dentistry has played a key role in assisting the forensic science to reproduce more accurate reliable and investigatory data. The various methods employed include palatoscopy or palatal rugoscopy, cheiloscopy, prosthesis marking system, implants, preprosthetic surgery records, bite marks. [31, 32]

4.2.4 Role in Medico legal

Forensic Odontology helps the law in the administration of justice. Though in developed countries this branch of dentistry is playing a useful role but as far as India is concerned its role is definitely being recognized nowadays. An overview of the basic and recent trends of this emerging branch of dentistry is presented to make the concerned professionals aware of their role in medico legal matters. [33]

The first recorded medico-legal identification of a body using dental means is that of Dr. Joseph Warren, who was killed at the battle of Bread Hill, more often referred to as the battle of Bunker Hill in New England in 1775.[34] Mass forensic identification by dentition was first used at Paris, in the aftermath of the fire of the Bazaar de la Charite that began around 16:00 h on the afternoon of May 4, 1897.[26] Forensic Odontology a combination of art and science of dental medicine. It is the proper handling, examination and evaluation of dental evidence which are presented in the interest of justice.[35]

The information so obtained is concerned primarily with: [35]

1. Investigation of criminal cases

2. Research purposes

3. Establishment of identity

But forensic dentists are responsible for the following main areas of practice.

A) Identification in mass disasters

B) Age estimation

C) Civil cases involving malpractice

D) Assessment of abuse i.e. child, spousal and elder

E) Assessment of bite marks, injuries

F) Criminal liability

G) Identification of human fragmentary measures

Identification can be further studied under two categories: [35]

a) General or reconstructive identity i.e. to classify unknown persons by age, sex, race, occupation and habits etc.

b) Comparative methods: In it a person's identification is indicated or excluded when the postmortem dental record is compared with the ante mortem dental record.

4.3 MENTAL FORAMEN

The Mental Foramen (MF) is an important anatomical structure located in the body of mandible. It represents the termination of mental canal which opens onto the surface in oblique direction. The mental bundle passes through MF and supplies sensory innervations and nutrition to the chin, lower lip and gingiva on the ipsilateral side of the mandible.[36]

The mandibular canal, through which the inferior alveolar nerve and vessels pass, bifurcates and forms the mental and incisive canals (Shankland, 1994). The mental foramen is a funnel-like opening located on the anterolateral aspect of the mandible which marks the termination of the mental canal. The mental nerve and vessels radiate through the mental foramen and supply sensory innervations and blood supply to the soft tissues of the chin, lower lip and gingiva on the ipsilateral side of the mandible (Sinnathamby, 1999; Williams *et al.*, 2000).[37]

Evidence shows a clear racial trend in the anteroposterior position of the mental foramen. (Zivanovic, 1970; Green, 1987; Santini & Land, 1990; Shankland; Moiseiwitsch, 1998; Ngeow & Yuzawati, 2003; Cutright *et al.*, 2003). It has been demonstrated that in Mongoloid population, the mental foramen was located in line with the longitudinal axis of the lower second premolar teeth (Green). In Caucasoids, the mental foramen was more medially located than in Mongoloid populations whereas in Black populations it was found posterior to the second premolar (Green). Furthermore, it has been shown that traits such as localization of the mental foramen not only differ between populations of different geographic zones but also within the inhabitants of the same geographic environment (Ari et al., 2005). [37]

The anterior-posterior position of the mental foramen (symphysis menti and posterior border of the mandibular ramus)

The mean distance from the anterior border of the MF to the symphysis menti was 24.76 mm for right and 24.92 mm for left side of mandible, whereas the mean distance from the anterior border of the MF to the posterior border of the mandibular ramus was 67.2 mm for right and 67.98 mm for left side of mandible.[38]

The position of the mental foramen in relation to mandibular teeth

The most common position of the mental foramen was between the first and second mandibular premolars in 44.2% for right and 44.6% for left side of mandible, followed closely by location in line with the longitudinal axis of the second mandibular premolar 42.8% for right and 43.6% for left side of the mandible.[38]

The shape, radiographic appearance and number of the mental foramen

The shape of MF was oval in 66% for right and 68.4% for left side of mandible and round in 28% for right and 27.4% for left side of mandible. Other irregular shape of the mental foramen was seen in 6% for right and 4.2% for left side of mandible. The most common radiographic appearance of the MF was the separated type with prevalence of 49.2% for right and 48.6% for left side of mandible. Accessory mental foramina were detected in <1% of the cases and the mental foramen was not bilaterally symmetrical but no statistical differences were found.[38]

4.3.1 Radiographic anatomy of Mental Foramen

The mental foramen is usually the anterior limit of the inferior dental canal that is apparent on periapical radiographs. Its image is quite variable, and it may be identified only about half the time because the opening of the mental canal is directed superiorly and posteriorly. As a result, the usual view of the premolars is not projected through the long axis of the canal opening. This circumstance is responsible for the variable appearance of the mental foramen. Although the wall of the foramen is of cortical bone, the density of the foramen's image varies, as does the shape and definition of its border. It may be round, oblong, slit like, or very irregular and partially or completely corticated. The foramen is seen about halfway between the lower border of the mandible and the crest of the alveolar process, usually in the region of the apex of the second premolar. Also, because it lies on the surface of the mandible, the position of its image in relation to the tooth roots is influenced by projection angulations. It may be projected anywhere from just mesial of the permanent first molar roots to as far anterior as mesial of the first premolar root. The image of two mental foramina, one above the other, has also been observed.[39]

When the mental foramen is projected over one of the premolar apices, it may mimic periapical disease. In such cases, evidence of the inferior dental canal extending to the suspect radiolucency or a detectable lamina dura in the area would suggest the true nature of the dark shadow. It is well to point out, however, that the relative thinness of the lamina dura superimposed with the radiolucent foramen may result in considerable "burnout" of the lamina dura image, which will complicate its recognition. Nevertheless, a second radiograph from another angle is likely to show the lamina dura clearly, as well as some shift in position of the radiolucent foramen relative to the apex.[39]

4.4 ORTHOPANTOMOGRAM (OPG)

Panoramic imaging (also called pantomography) is a technique for producing a single topographic image of the facial structures that includes both the maxillary and mandibular arches and their supporting structures. This is a curvilinear variant of conventional tomography and is also based on the principle of the reciprocal movement of the X-ray source and an image receptor around a central point or plane, called the image layer, in which the object of interest is located. Object in front and behind the image layer are not clearly captured because of their movement relative to the centre of rotation of the receptor and X-ray source.

White and Pharoah stated that panoramic imaging (also called *pantomography*) is a technique for producing a single tomographic image of the facial structures that includes both the maxillary and mandibular dental arches and their supporting structures. [39] **Hallikainen D** stated that at the beginning of this century imaging of the whole jaw was first attempted with intraoral radiation sources. Narrow beam principle was described in 1922. Experimental work and development of equipment in the 1950s result in commercially available in early 1960s. He also stated that it is an essential element in oral radiology. [40] **Numeta and Patero** in early 1960s introduced the panoramic radiographs it gained popularity as a diagnostic tool. [41]

H. Devlin, et al; recommended that it is a common imaging technique in general dental practice.[42] **Gun–Sun Lee** et al. stated that it has been widely used as diagnostic tool because it is easy to provide radiographic overview of the teeth and surrounding anatomical structure.[43] **Thiago L. Beaini.** et al. stated that it is one of the complementary exams most required by dentists for diagnosis purposes.[44] **Fatemeh Salemi** et al. recommended that OPG is a simple extra oral radiographic technique. He stated that it is used for both the diagnosis and treatment planning.[45]

<u>Dental panoramic tomography has become a very popular radiographic technique in dentistry. The main reasons for this include:</u>

Eric Whaites stated that all the teeth and their supporting structures are shown on one film.[46] **A. Cicilia Subbulakshmi** et al. stated that the technique is reasonably simple.[41] **Christoph Klingelhoffer** et al. stated that panoramic radiograph finding serve as indicator of the development of medication-related osteonecrosis of the jaw.[47] **Mioara Decusara**, et al;

recommended that minimal distortion and with minimal overlap of anatomic details from the contra lateral side.[48]

Ujwala Rohan Newadkar, et al; stated that the radiation dose is relatively low, particularly with modern DC units with rare-earth intensifying screens — the dose is equivalent to about three to four perapical radiographs**.**[49] **Joao Cesar Guimaraes Henriques,** et al; stated that low cast and technical simplicity.[50] **White and Pharaoh** stated that this procedure is convenient for the examination of the patient and recommended the use in patients unable to open their mouths. [39] **Langland** stated that it requires short time to make a panoramic image, usually in the range of 3 to 4 minutes (This includes the time necessary for positioning the patient and the actual exposure cycle).[51] **Ongle** stated that patients readily understand panoramic films; thus they are also useful visual aid in patient education and case presentation.[52]

4.4.1 Uses

Langland stated that panoramic radiography is the diagnostic radiograph used for gaining a comprehensive overview of the Dentomaxillofacial complex.[51] **Raza Sadat-Khonsari** et al. stated that it is appropriate screening tool for early temporomandibular joint (TMJ) diagnosis, TMJ disorder cause by malocclusion. **Habets et al. (1988) and Kjellberg et al. (1994),** proposed indices to determine condylar asymmetries by measuring vertical distance on panoramic radiograph.[53] **Mioara Decusara** stated that it is an important and complex factor in both diagnosis and prognosis. Examination of the oromaxillo-facial area in systemic diseases and syndromes.[49] **Griniatsos J**, et al; proposed that it is use to determine the calcified atheromatous plaque in the carotid artery region.[54] **Farman A. G**, et al; stated that it is used as diagnostic tool in endodontic treatment and exact cause of missing teeth.[55]

Eric Whaites proposed that it is useful for mandibular nerve paresthesia, examination of the oromaxillo-facial area in systemic disease and syndrome.[46] **Sunanda Bhatnagar**, et al proposed that it is an effective indicator of osseous change in post-menopausal osteoporosis.[56] **Kaviena Baskaran** stated that it is an important and complex factor in both diagnosis and prognosis, before and after the surgery in oral maxillo-facial region.[57] **Pasler F. A**; proposed that it is used for facial and maxillary asymmetry, painful or asymptomatic swelling, multiple dental extraction with suspected osteomyelitis.[58] **Babutunde Olamide Bamgbose,** et al; recommended that it is used for diagnosis of cyst and neoplasms, congenital absence of tooth, premature loss, prolonged retention of teeth and maxillary sinus diseases. Diagnostic value of maxillary sinus includes evaluation of cystic lesion, foreign bodies, antroliths, benign soft and hard tissue lesions and antral malignancies.[59]

Eric Whaites stated that vertical alveolar bone height as part of pre implant planning, as part of an assessment of periodontal bone support where there is pocketing greater than5mm, Prior to dental surgery under general anesthesia.[46] **Fatemeh Salami**, et al; proposed its use for assessment of third molars, at a time when consideration needs to be given to whether they should be removed or not.[45] **Rafael Henrique Nunes Rondon,** et al; recommended the use of OPG in examination of teeth to diagnose caries, pulp origin disease, disease of facial bone, radicular cyst, tumor, inflammation, post accidental fracture, sinusitis. Pediatric growth and development.[60]

T. M. Graber, et al; stated that it use to knowing the normal growth and development pattern, delayed tooth eruption, abnormal eruption direction and resorption, ankylosis, mandibular morphology and fracture, space adequacy, treatment progress and post treatment appraisal.[61] **Noriyuki Kitai**, et al; stated that it is used to examine maxillary impacted canine, dental caries, periradicular diseases, mandibular impacted third molar, alveolar bone and developing teeth.[62] **G. A. Zach,** et al; recommended that it used to orthodontic treatment progress and post treatment appraisal, change in condylar position during and after orthodontic treatment, effect of premature loss of deciduous teeth on permanent successors and adjacent teeth, postoperative appraisal of class III malocclusion, develop and eruption of third molar.[63]

White and Pharaoh stated that it is use in Fractures of all parts of the mandible except the anterior region, Antral disease — particularly to the floor, posterior and medial walls of the antra, Destructive diseases of the articular surfaces of the TMJ. [39] **Karina-Morais Faria,** et al; stated that it is used in identification of multiple myeloma bone lesions. According to **international myeloma working group** one or more osteolytic lesion has to be visualized on skeletal radiograph for the diagnosis of multiple myeloma.[64]

4.4.2 <u>Factor affecting</u>

White and Pharaoh stated that the factors that affect its size are variables that influence image definition: arc path, velocity of the receptor and x-ray tube head, alignment of the x-ray beam, and collimator width. The location of the image layer can change with extensive machine use, so recalibration may be necessary if consistently suboptimal images are produced. As the position of an object is moved within the image layer, the size and shape of the resultant image change. [39]

4.4.3 Radiographic magnification

H Devlin et al; stated that radiographic magnification is the magnification and distortion that occurs when the patient's jaws are not positioned near the focal trough of the X-ray beam. One-third had low density and contrast due to poor patient positioning and less than 1% had excellent quality. Even when properly taken, dental panoramic radiography images are associated with enlargement of the actual object size by about 15–25%, and distortion occurs when horizontal magnification differs from vertical magnification with poor patient positioning.[42]

Mehrdad Abdinian, et al; proposed that distortion and magnification might lead in inaccurate and unreliable measurements, horizontal magnifications varies from0.7 to 2.2 time the real dimension. Total vertical magnification mean of planmica machine was95%, and horizontal magnification was 91%. Vertical and horizontal magnification differs in various regions of jaws, and the vertical measurement was more reliable than the horizontal.[65]

Vazquez L et al; stated that vertical measurements showed acceptable accuracy and reproducibility and digital panoramic radiography is reliable in determining the preoperative implant loadings. Magnification may also be influenced by variation in patient's jaw shape and size, and even within a particular jaw distortion and magnification are greatest in the canine and premolar regions and least in the third molar region.[66]

Devlin and Yuan, et al; recommended that less variation in vertical magnification value than horizontal. Two different approaches have been used historically to try to circumvent the problems associated with image magnification. The first was to develop mathematical theory of dental panoramic imaging; the second, practical approach was to use calibration objects with which to calculate magnification at some points on the image. We combined both approaches by developing a set of equations that are precise yet simple enough to be solved easily for magnification from object position, and vice versa, for calibration ball bearings and other small round objects.[42]

4.4.4 Technique and positioning

Eric Whaites stated that the exact positioning techniques vary from one machine to another. However, there are some general requirements that are common to all machines and these can be summarized as follows:

- Patients should be asked to remove any earrings, jewellery, hair pins, spectacles, dentures or orthodontic appliances.
- The procedure and equipment movements should be explained, to reassure patient.
- A protective lead apron should **not** be used.

National radiological protection board and Royal college of radiologist (NRPB/RCR) *Guidelines on Radiology Standards in Primary Dental 'Care* (1994) positively discourage the use of lead aprons because they can interfere with the final image. [46]

White and Pharaoh stated that the patients should be placed accurately within the machines using the various head-positioning devices and light-beam marker positioning guides. (In some units the patients face away from the equipment and towards the operator and in others the patient faces the other way round). Panoramic tomography is generally considered to be unsuitable for children under 5 years old, because of the length of the exposure and the need for the patient to keep still.[39]

Langland stated that the patients should be instructed to place their tongue into the roof of the mouth so that it is in contact with the hard palate and not to move throughout the exposure cycle (approximately 18 seconds). Appropriate exposure setting should be selected, typically in the range 70-100 kV and4-12mA.[52]

4.4.5 The importance of accurate patient positioning

Rafael Henrique Nunes Rondon et al; recommended that correct patient position in the region, a lack of artifacts, good density, and adequate contrast are considered to be of good quality image. Most common error is patient positioning and then after technical and processing are the main error that occur during panoramic radiograph.[60]

H Devlin et al stated that one third had low density and contrast due to poor patient positioning and less than 1% had excellent quality. When the patient teeth are placed in focal trough distortion of image is avoided.[42]

Manu Dhillon et al; stated that appropriate positioning and preparation of the patient is essential for a sharp, accurate, and undistorted image, which is not affected by ghost image. Inaccuracies in patient positioning lead to discrepancies between horizontal and vertical magnification, with consequent distortion of the image. Patients chin is too high causing a flat occlusion plane, and chin is too low occlusion plane is smiling and cervical spine is slumped, appearing a pyramidal shaped opacity, center at lower half of the film.[67]

Eric Whaites stated that the positioning of the patient's head within this type of equipment is critical — it must be positioned accurately so that the teeth lie within the *focal trough. The* effects of placing the head too far forward, too far back or asymmetrically in relation to the focal trough, the parts of the jaws outside the focal trough will be out of focus. The fan-shaped X-ray beam causes patient malposition to be represented mainly as distortion in the horizontal plane, i.e. teeth appear too wide or too narrow rather than foreshortened or elongated.[46]

4.4.6 Factors Affecting Digital Image Quality:

Elizabeth A, et al; stated that image quality is affected by a number of factors, beginning with the acquisition process and device and including the manner in which images are displayed. In digital systems, the functions of acquisition and display are clearly separable, so that the evaluation and optimization of image quality can take place at both ends of this imaging continuum. The analysis of image quality also depends on the particular type of imaging task.[68]

Mark B. Williams, et al; stated that number of factors affect the quality of the image in digital radiography. Contrast, detail, and noise are the primary factors associated with image quality, and they play a major role in computer radiograph and digital radiograph some additional factors are the result of the digital nature of the process.[69]

4.4.7 Matrix Size and Display Size

Elizabeth A. Krupinski et al; stated that soft-copy displays should render images with sufficient pixel density to allow viewing of the whole image with sufficient spatial detail at a normal viewing distance of approximately 30 to 60 cm (with eyeglasses specifically selected for this distance when required). Matrix size should be as close to the for-processing image data as possible or attainable with magnification. US Food and Drug Administration recommends that only monitors that have been approved for digital mammography are used for interpreting digital mammography images. This is true for any size image for which the detector element matrix size exceeds the display pixel matrix size.[68]

4.4.8 Luminance and Contrast

Mark B. Williams, et al; recommended that luminance of a display can affect image quality significantly, so the appropriate range of luminance should be maintained. The ratio of maximum luminance to minimum luminance of a display device for images (other than for mammography) should be at least 100. The maximum luminance of gray-scale monitors used for viewing digital conventional radiographs should be at least 200 cd/m^2. Smaller ranges could lead to inadequate levels of contrast in displayed images, and larger values could lead to poor visualization of details at the extremes of the luminance range because of the limited range of the contrast sensitivity of the human eye. [68, 69]

4.4.9 Bit Depth

Elizabeth A. Krupinski et al; stated that it is necessary for a soft-copy display device to render image details with sufficient luminance quantification to prevent the loss of contrast details or the appearance of contour artefacts. Thus, a minimum of 8-bit luminance resolution (bit depth) is required. Nine-bit resolution or higher is recommended if the for-processing image data are greater than 8-bit. In general, the higher the luminance ratio of the display, the larger the bit-depth resolution that is recommended.[68]

4.4.10 Display Calibration

Elizabeth A. Krupinski et al; stated that all monitors and corresponding video graphics cards used for primary diagnosis or for image adjustment and evaluation (e.g. a technologist review monitor) must provide a means to be calibrated to and conform to the current DICOM GSDF perceptual linearization methods. The intent of the DICOM GSDF is to allow images transferred using the DICOM standard to be displayed on any DICOM-compatible display device with a consistent gray-scale appearance.[68]

4.4.11 Glare and Reflections

Elizabeth A. Krupinski et al; stated that veiling glare or the spread of light within the display can reduce contrast, so the glare ratio should be greater than 400 for primary displays. Light-colour clothing and laboratory coats can increase reflections and glare. The intrinsic minimum luminance of a device should not be smaller than the ambient luminance (minimum luminance should be at least 2.5 times ambient light).[68]

4.4.12 Colour Tint and Colour Displays

Elizabeth A. Krupinski et al; recommended that the tint of the display can affect the comfort of the user. The colour tint of the display (blue, gray, yellow, etc) is based on user preference but should be uniform across the display area, and monitor pairs should be matched from the same manufacturing batch. Currently, most colour displays have lower luminance and thus lower contrast ratios than monochrome displays and are generally not recommended for viewing certain radiographic modalities (chest, bone, and mammography).[68]

4.5 GENDER DETERMINATION

Identification of human skeletal remains is an important part of forensic analysis. In adult skeleton, sex determination is the first step, followed by age and stature as age and stature are sex dependent. In mass disasters sex determination is based on the available parts of the skeleton and in such cases 100% accuracy is not possible.

Skull is the most important and dimorphic portion for sex determination after pelvis but in cases where entire skull is not available mandible can play a very important role in sex determination. [1]

W. Apinhasmit, D. Methathrathip, S. Chompoopong, S. Sangvichien in 2006 conducted a study on 69 adult mandibles (45 male, 24 female) of Thai dry skulls to determine the size, the orientation and the location of the mental foramen (MF) related to gender and side. The results showed that the usual direction of exit of the MF was in a poster superior direction. The most common location of the MF was bilaterally symmetrical and located on the same vertical line with the long axis of the lower second premolar. The mean distances from the MF to the symphysis menti (A), to the posterior border of the mandibular ramus (P), to the lower border of the mandible (mb) and to the buccal cusp tip of the second premolar (cm) were 28.83, 68.85, 14.88 and 24.27 mm, respectively. The mean distances from the alveolar bone crest across the MF to the lower border of the mandible (ab) was 29.97 mm. The mean distance from the buccal cusp tip of the second premolar through the long axis of the clinical crown to the lower border of the mandible (cb) was 39.18 mm. No measurements varied according to the sides ($P > 0.05$). In contrast, gender differences were significant in all measurements with the longer distances in males ($P < 0.05$). [70]

Marin Vodanovic, Jelena Dumancic, Zeljko Demo, Damir Mihelic in 2006 investigated the skeletal remains from two archeological sites in eastern part of continental Croatia. 85 skulls (59 males and 26 females) were investigated. The result showed mean value for distance between mental foramen and basal border of the mandible (MF-BaB) was 13.85 in males and 13.19 in females. Mean value for distance between mental foramen and alveolar border of the mandible (MF-AlB) was 15.21 in males and 13.63 in females. Mean value for mental foramen height (MF-H): distance between the alveolar and basal border of the mental foramen was 2.57 in males and 2.59 in females. Mean value for length of the mandibular body (ManBo-L) was 88.34 in males and 81.41 in females. [71]

Akhilesh Chandra, Anil Singh, Manjunath Badni, Rohit Jaiswal, Archana Agnihotri in 2013 performed a retrospective study on the panoramic radiographs of patients aged between 18 and 62 years. 100 radiographs were selected for the analysis in which the mental foramen was identified as a separate type. The result showed that mean distance from the upper border of the mental foramen to the lower border of the mandible (S-L) on the right side in males was 17.650 mm, whereas it was 16.150 mm in females. On the left side, it was 17.475 mm in males and 15.787 mm in females. The mean distance from the lower border of the mental foramen to the lower border of the mandible (I-L) on the right side in males was 12.670 mm, whereas it was 11.462 mm in females. On the left side, it was 12.583 mm in males and 11.250 mm in females.[72]

K. Udhaya, K.V. Saraladevi, J. Sridhar in 2013 analyzed 90 adult dry human mandibles from the South Indian population, irrespective of age and sex. In a majority of the mandibles, the mental foramen was located at the level of the root of the 2nd premolar, midway between the inferior margin and the alveolar margin of the mandible. Most of the mental foramina were oval in shape. The orientation of the foramen was postero superior in 83% of the mandibles. The accessory foramens were noted in five mandibles.[73]

Moni Thakur, K. Vinay Kumar Reddy, Y. Sivaranjani, Shaikh Khaja in 2014 conducted a study in which orthopantomographs of 102 Dentulous patients were selected. The study sample was divided into three groups of less than 25 years, 25 – 50 years and above 50 years. Measurements were made using the reference lines drawn from anatomical landmarks. Four measurements were made on every radiograph on the right side digitally. The data obtained was tabulated and subjected to statistical analysis. The results of the study showed that there was a statistically significant difference in the measurements between males and females on the right side in relation to the height of the mandible, distance between the superior margins of the mental foramen to the inferior border of the mandible on the right side (SM to IB), distance between the inferior margins of the mental foramen to the inferior border of the mandible on the right side (IM to IB) (p = 0.0031, 0.0020, 0.0077 respectively); whereas distance between the superior margin of the mental foramen to the alveolar crest on the right side (SM to AC) measurements between males and females did not show a statistically significant difference. (p=0.326). The mean value for height of mandible was 34.54mm in males and 33.08mm in females. The mean value for SM to IB was 17.08mm in males and 16.08mm in females. The mean value for IM to IB was 13.88mm in males and 13.08mm in females. The mean value for SM to AC was 17.42mm in males and 17.00mm in females.[3]

Atiyaah Muskaan, Sonali Sarkar in 2015 analyzed 40 digital panoramic radiographs and the age, sex and dental status of the patients were recorded. The radiographs were grouped into four 10-year age groups (by decades). The mental index, maximum and minimum breadth of ramus of mandible and the height of the coronoid were measured. In relation to the mental index, high significance was found between male and females in both the right and left side. In regards to the maximum breadth of ramus of the mandible in both the right and left side a high significant difference is observed between male and female of higher age group. The height of coroniod in both right and left side between male and female of all age group showed a significant result for sex determination.[2]

Juan Muinelo-Lorenzo, Juan-Antonio Suárez-Quintanilla, Ana Fernández-Alonso, Jesús Varela-Mallou, María-Mercedes Suárez-Cunqueiroin 2015 assessed 344 CBCT scans for presence and characteristics (i.e. diameter, area, shape, exit angle) of Mental Foramen (MF) and Accessory Mental Foramen (AMF). Results showed that out of the 344 patients, 344 (100%) MFs and 45 (13%) AMFs were observed on CBCT. Regarding gender, MF diameter and area, MF-MIB (distance from the MF and AMF inferior borders to the lower border of the mandible) and MF-MSB (distances from the alveolar bone crest to the MF and AMF superior borders) distances, and exit angle were all significantly higher in males. Also, statistically significant differences were found in terms of age and dental status. Statistically significant differences in MF long and short diameters and MF area were found with respect to AMF presence. Only 83.87% of the MFs and 45.83% of the AMFs identified on CBCT were also visible on intraoral and rotational panoramic radiograph (PAN). MF diameter, shape, exit angle, and age had a significant influence on MF visualization on PAN.[74]

Priya Sahni, Ronak J. Patel, Shylaja, Jaydeva H. M, Anil Patel in 2015 studied sixty panoramic radiographs for the analysis of mental foramen. Tangents were drawn through the superior and inferior borders of the foramen (S-L and I-L respectively) and perpendicular from the tangents to the lower border of the mandible bilaterally. Digital verniar caliper was used for the distance measurement from S-L and I-L. The data obtained was tabulated and subjected to statistical analysis. The analyzed data of study showed that the mean values of comparison of S-L as well as I-L in males and females were significantly higher in males as compared to females. The comparison of SL and IL on right and left side in the same patient was without any significant difference. The mean distance of S-L on right side in males was 16.866 mm, whereas it was 14.433 mm in females. The comparison of S-L between males and females showed a very high significant difference ($p = 0.002$). The mean distance of I-L on the right side in males was 13.35 mm, whereas it was 11.293 mm in females. The comparison of I-L between males and females suggested a highly significant difference on right side ($p = 0.003$).[7]

Diana Laishram, Deepti Shastri in 2015 studied 67 dry mandibles to analyze the morphometry of mandibular and mental foramen. Results showed that mean of distance between mental foramen and alveolar margin (D1) was 2.09cm on the right side. Mean of distance between mental foramen and lower border of mandible (D2) was 1.89cm on the right side. MFB= mean horizontal diameter (Mental foramen breadth) was 0.45cm on the right side and MFL= mean vertical diameter (Mental foramen length) was 0.35cm on the right side.[75]

Mamta Malik, Sanjeev Laller, Ravinder S Saini, Rakesh Kumar Mishra, Indu Hora, Nisha Dahiya in 2016 selected one hundred panoramic radiographs (50 males and 50 females) for mental foramen analysis. Distance from superior and inferior borders of mental foramen to the lower border of mandible (SL and IL) of both sides were recorded by drawing tangents to the superior and inferior border of mental foramen and perpendiculars to the lower border of mandible from tangents. The mean distance in centimeter with standard deviation for SL on the right side in males was 1.73±0.04, whereas it was 1.53±0.05 in females. On the left side, it was 1.69±0.07 in males and 1.52±0.04 in females. Also the mean distance for IL on the right side in males was 1.42±0.06, whereas it was 1.24±0.05 in females. On the left side, it was 1.41±0.04 in males and 1.22±0.04 cm in females. The comparison of S-L between males and females showed a highly significant difference (*P* = 0.001) on the right side and a highly significant difference (*P* =0.001) on the left side. The comparison of I-L between males and females showed a highly significant difference (*P* = 0.001) on the right side and a highly significant difference (*P* = 0.001) on the left side.[8]

Shweta Thakare, Amit Mhapuskar, Darshan Hiremutt, Versha R Giroh, Kedarnath Kalyanpur, KR Alpana in 2016 conducted a retrospective study on 200 digital panoramic radiographs (100 males & 100 females) of dentate patients. The location of the mental foramen [MF] was traced. Measurements for evaluating distance of superior and inferior borders of the foramen [S-L and I-L] in relation to the lower border of the mandible were made using the reference lines drawn from anatomical landmarks. Of the100 left MF analyzed in males, 53%of the foramen were located with second premolar, while30% of the foramen were in horizontal plane between the first and the second premolar and 46% of the foramen were in line with apex of second premolar, while 37% of the foramen were in a position between apex of the first and the second premolar in vertical plane.. Of the 100 right MF analyzed in males, 44% of the foramen were in line with the second premolar, while 32% of the foramen were situated in horizontal plane between the first and the second premolar and 54% of the foramen were at or in line with the apex of second premolar, while 30% of the foramen were in between the apex of first and the second premolar in vertical plane. Of the 100 left MF analyzed in females, 40% of the foramen were in line with second premolar, while 36% of the foramen were in a position between the first and the second premolar in the horizontal plane and 48% of the foramen were at or in contour with the apices of second premolar, while 30% of the foramen were in between the apex of first and the second premolar in vertical plane. 100 right MF analyzed in female subjects, 50% of the foramen were in line with second premolar, while 24% of the foramen were in a position between the first and the second premolar in horizontal plane and 52% of the foramen were in line with the apex of second premolar, while 24%of the foramen were in between the apex of first and the second premolar in vertical plane. In males, distance in centimeters of S-L on right side was 17.21 ± 1.9mm, on left side was17.18 ± 2.1mm, in females on right side was 15.85 ± 2.4mm, on left side was 15.72 ± 2.2mm. In males, of I-L on right side was 13.02 ± 2.2mm, on left side was 12.97 ± 2.1mm, in females on right side was11.31 ± 2.5mm, on left side was 11.26 ± 2.3mm. The variation in length of S-L and I-L with respect to gender was found to be significant, with p-value <0.05.[76]

Girish Suragimath, S. R. Ashwinirani, Vineetha Christopher, Shobha Bijjargi, Renuka Pawar, and Ajay Nayak in 2016 analyzed 465 patients in the age group between 20 and 40 years undergoing conventional OPG. Only 400 radiographs with separate MF (mental foramen) from mandibular canal (200 males and 200 females) were considered. The measurements from AC (alveolar crest), SMF (superior border of MF), and IMF (inferior border of MF) to LBM (lower border of mandible) were calculated and compared on the right and left side of an individual in both gender. The distance from SMF to LBM on the left side in males was slightly more (17.1 mm) than the right side (17.3 mm), with no significant difference. The distance from SMF to LBM on the right side (15.2 mm) in females was more than the left side (15.6 mm), with a significant difference. The average distance from SMF to LBM in males was 17.3 mm and in females was 15.4 mm. The comparison between the genders showed statistically very high significant differences. The distance from IMF to LBM on the left side in males was slightly more than the right side, with no significant differences. The distance from IMF to LBM on the right side in females was more than the left side, with no significant differences. The average distance from IMF to LBM in males was 11.8 mm and in females 11.4 mm. The comparison between the genders showed statistically highly significant differences. The height of mandible (AC to LBM) in males on the right side was 29.2 mm and on the left side 28.4 mm, whereas in females, 21.1 on the right side and 21.3 mm on the left side. The total mean height of mandible in males was 28.8 mm and in females was 21.2 mm, and comparison showed statistically extremely significant differences.[77]

Noori Ghouse, Tejavathi Nagaraj, Leena James, Navya N. Swamy, C. D. Jagdish, T.V. Bhavana in 2016 carried out a study to predict the validity of the vertical measurements related to the mental and mandibular foramina on digital panoramic images in sex determination. A total of 60 patients, 30 males, and 30 females were examined; age distribution was ranging between 20 and 49 years. Four linear vertical measurements were performed on the radiographic image of each subject on both sides of the mandible.

The following measurements were taken:

D1: Vertical distance from the most inferior point on the mental foramen to the inferior most point on the base of the mandible.

D2: Vertical distance from the most superior point on the mental foramen to the superior most point of the alveolar crest.

D3: Vertical distance from the most inferior point of the mandibular notch to the most superior point on the mandibular foramen.

D4: Vertical distance from the most inferior point of the mandibular notch to the inferior edge of the mandibular ramus.

The result shows D1(mm) was 14.47 in males and 13.60 in females for age 20-29 years, 14.94 in males and 12.60 in females for age 30-39 years and 14.56 in males and 12.38 in females for age group 40-49 years. D2(mm) was 18.57 in males and 18.31 in females for age 20-29 years, 18.40 in males and 18.25 in females for age 30-39 years, 19.48 in males and 16.97 in females for age 40-49 years.[1]

Kusum Singal, Sapna Sharma in 2016 carried out a study on panoramic radiographs of 100 individuals including 50 males and 50 females were assessed by using three linear vertical measurements and after that data was statistically analyzed.

Parameters assessed-

A-B= vertical distance between superior border of alveolar crest to the inferior border body of mandible passing through the center of the mental foramen.

C-D= Vertical distance between alveolar crest to superior border of mental foramen.

E-F= Vertical distance between inferior border of mental foramen to inferior border of mandible.

A-B parameter in case of males the mean value was found to be 40.50 mm while in case of females this value was 38.66mm. C-D parameter in males this value was calculated as 20.18mm while in females it was 18.74mm. E-F parameter in males this value was calculated as 15.24mm while in females it was 14.94mm.[78]

Juan Muinelo-Lorenzo, Ana FernaAndez-Alons, Ernesto Smyth-Chamosa, Juan Antonio SuaArez-Quintanilla, JesuAs Varela-Mallou, MaroAa Mercedes SuaArez-

Cunqueiro in 2017 examined 344 patients using Cone beam computed tomography (CBCT) scans for MF dimensions, as well as for the distances from the MF to the alveolar crest (MF-MSB), and to the inferior mandibular border (MF-MIB). Gender, mandibular side and presence of accessory mental foramina (AMF) significantly influence MF area. Males, left hemi mandibles, and hemi mandibles with no AMF had a higher rate of large MF areas ($B = -0.60$; $p = 0.003$, females; $B = 0.55$; $p = 0.005$; $B = 0.85$; $p = 0.038$). Age, gender and dental status significantly influence MF-MSB distance. The distance decreased as age increased ($B = -0.054$; $p = 0.001$), females showed a lower rate of long MF-MSB distances ($B = -0.94$, $p = 0.001$), and dentate patients showed a higher rate of long MF-MSB distances ($B = 2.27$; $p = 0.001$). Age, gender and emerging angle significantly influenced MF-MIB distance. The distance decreased as age and emerging angle increased ($B = -0.01$; $p = 0.001$; $B = -0.03$; $p = 0.001$), and females had a lower rate of long MF-MIB distances ($B = -1.94$, $p = 0.001$).[79]

Aspalilah Alias, Abdel Nasser Ibrahim, Siti Noorain Abu Bakar, Mohamed Swarhib Shafie, Srijit Das, Faridah Mohd Nor in 2017 studied a total of 79 dentulous patients (48 males, 31 females) from 3 age groups (18-30 years, 31– 50 years, 51-74 years), and ten parameters were observed for each mandible. Results showed that mandibular body length and height were significantly greater in males than in females by independent *t*-test. ($p < 0.05$). However, the mandibular body height was found to decrease significantly with age in both sexes by one-way ANOVAs. It was observed that the shape of mental foramen was 45.6% oval and 54.4% rounded. About 44.3% of them were in line with the longitudinal axis of the second premolar tooth.[80]

Lubis MN and Anfelia G in 2018 conducted a study on 80 panoramic radiographs of data consisting 40 males and 40 females. The method used in this study is comparative analysis. The results show that mean of the vertical height of the mental foramen to the inferior border of the mandible in men (14.9333 mm) is significantly greater than in women (13.3185 mm). However, the mean of horizontal width between the mental foramen in men (57.7395 mm) and women (56.7775 mm) are shown to be similar.[81]

4.6 AGE ESTIMATION

Chronological age assessment is an important part of medico legal practice. The procedures for age determination are complex and involve the consideration of many factors.

Changes related to chronological age are seen in both hard and soft tissue. Amongst the hard tissues, bones are important as they undergo a series of changes from prenatal to postnatal life and changes in their composition and structure continue into old age and even after death. Hence, bones form a reliable source of information regarding growth and growth changes. Normally well-defined skeletal development in bones, cranial sutures and teeth take place at specific ages. However, these changes are significantly affected by genetics, general health and other environmental factors.[19]

Dental hard tissues and bone are extremely resistant to fire and are usually the only remains after an extended period of burial. As a result, forensic odontology has gained importance as a tool in identifying the skeletal/ dental remains. As existing age-at-death estimation techniques have limited precision; researchers have sought to demonstrate age-related changes in the dental hard tissues.[19]

Gershenson A, Nathan H, Luchansky E. in 1986 conducted a study on 525 dry mandibles and dissections in 50 cadavers, the mental foramen (MF) was found: single in 94.67% of the cases and multiple in 5.33%. Its shape was round in 34.48% with an average diameter of 1.68 mm and oval in 65.52% with an average long diameter of 2.37 mm. In 43.66% the MF was located in front of the apex of the root of the second premolar.[82]

Luay N. Kaka, Amal R S. Mohammed, Fatin Kh. Abbas in 2010 studied forty five digital views (OPG) for the patients, using computerized digital panoramic x-ray machine, which are examined for estimation the position of the mental foramen for each patient. The samples were divided into 3 equal groups- First group: 21-30 years (15 patients), Second group: 31-40 years (15 patients), Third group: 41-50 years (15 patients). The results show that the distance between the mental foramen and the base border of the mandible, for (first age group) ranged between 12.21mm to 27.50mm with the mean value 15.7, for the (second age group) ranged between 11.75mm to 16.12mm with the mean value 13, and for (third age group) ranged between 9.25mm to 12.56 mm with the mean value 10.6 and there is high significant differences between age groups. The mental foramen to be most commonly located below the apex of second premolar for right and left sides (closed to the second premolar) in all age groups. The total number of mental foramen that were close to the second premolar was 72 in all age groups and the mean distance was 6.06 while the total no. of mental foramen that closed to the first premolar was 18 in all age groups and the mean distance was 7.08, and there are no significant differences between groups.[83]

D. P. Mohite, M. S. Chaudhary, P. M. Mohite, S. P. Patil in 2011 conducted a study in which the sample consisted of 50 mandibles from cadavers of known age who died from natural cause and those that were not affected by any disease altering the structure of the skeleton. The ages of the bones ranged from 20–69 years. The samples were divided into five groups according to decades in the age group from 20–69 years. Out of the total 50 samples 41 (82%) were males and nine (18%) were females. Length of ramus (mm), height of body of mandible (mm), distance of lower border of mandible (LB) to inferior margin of mental foramen (IMF) (mm) (left and right), distance of inferior margin of mental foramen (IMF) to crest of alveolar bone (CAR) (mm) (left and right), gonial angle, antegonial (AG) angle, antegonial (AG) depth, width of the cortex at the body and at the antegonial region (TCB at AG). For age group 20-29 years the mean and SD of distance of inferior border of mental foramen to the crest of alveolar ridge is greater than the mean and SD of distance of lower border of mandible to inferior border of mental foramen. This indicates that the height of the body of the mandible is more above the mental foramen in this age group. In the age group 30–39 years. The value for the length of ramus is higher than that for the previous group. The distance of the IMF to CAR on (left and right) sides is more than the distance of LB to IMF. In the age group 40–49 years. The value for the length of ramus is higher than that for the previous group. The distance of the IMF to CAR on (left and right) sides is similar to the distance of LB to IMF. The distances IMF to CAR show negative correlation to age. In the age group 50–59 years. The distance of the IMF to CAR on (left and right) sides is less than the distance of LB to IMF. In the age group 60–69 years. The distance of the IMF to CAR on (left and right) sides is distinctly less than the distance of LB to IMF. This is in accordance with the advancing age. Of the parameters showing significant correlation, the distance of IMF to CAR (left and right sides) shows negative correlation with age.[84]

Anshuman Suresh Jamdade, Satyapal Yadav, Rahul Bhayana, Vikram Khare, Nilesh Pardhe, Nikunj Mathur in 2013 studied 500 digital panoramic radiographs (354 males and 146 females) to determine the most common location of the mental foramen (MF), its gender differences and bilateral symmetry in a selected Indian population and to compare the results with those reported for other populations. The result of this study was commonest position of the mental foramen was located between the first and second premolars (46.1%) followed closely by in line with the longitudinal axis of the second premolar (45.5%). MF was symmetrical in 64.8% of patients. In both males and females, again position 3 (Between the first and second premolars) 46.4% and 46.1% was found to be most common position of MF followed by position 4 (In line with second premolar) 45.3% and 45.5% respectively.[85]

Virendra Budhiraja, Rakhi Rastogi, Rekha Lalwani, Prabhat Goel, and Subhash Chandra Bose in 2013 analyzed 105 dry adult human mandibles of unknown sex were observed for position, shape, and number of mental foramina. In most cases (74.3%), the MF was oval in shape and situated on the longitudinal axis of the 2nd premolar tooth (61% on right side and 59.1% on left side). Distance from alveolar crest to upper margin of mental foramen (AC) was 11.46 on the right side. Distance from lower border of mandible to lower margin of mental foramen (BD) was 15.25 on the right side. Distance from alveolar crest to lower border of mandible (AB) was found to be 29.30 on the right side. Vertical diameter of foramen (VD) = AB − (AC + BD) was 2.61 on the right side. [86]

Akhilanand Chaurasia in 2014 studied panoramic radiographs of 560 subjects. In 60 subjects mental foramina could not be identified on the panoramic radiographs so they were excluded from study. The study population included subjects of all age groups. The maximum subjects were in 20-29 years age group followed by 30-39 years and 40-49 years age groups. Vertical position of the mental foramen was 14.463 for age 20-29 years, 14.119 for 30-39 years, 13.235 for age 40-49 years, 12.124 for age 50-59 years. The diameter of the mental foramen was found to be 0.458 for age 20-29 years, 0.446 for 30-39 years, 0.450 for age 40-49 years, 0.444 for age 50-59 years. Diameter was 0.451 in males and 0.448 in females on the right side.[87]

Kunihiro Saito, Ney Soares de Araujo, Miki Taketomi Saito et al. in 2015 evaluated one hundred cone beam computerized tomographs of the mandible. The tomographs were taken using a single tomographic device. Each image chosen was evaluated repeatedly from both sides of the mandible, the position of the mental foramen, indicating the region in which the foramen was found and the measures of the mental foramen, the lingual cortex and the mandibular base. A value of $p<0.05$ was chosen as the level of significance. Forty-two percent of the mental foramina were located in the apex of the second pre-molar. The lingual margin of the mental foramen was located, on average, 3.1mm from the lingual cortex. The lower margin of the mental foramen was located 7.25 mm above the lower edge of the mandible.[88]

Priyanka Parnami, Deepak Gupta, Vishal Arora, Saurabh Bhalla, Adarsh Kumar and Rashi Malik in 2015 analyzed six hundred digital panoramic radiographs regarding the location and symmetry of mental foramen. Selected radiographs comprised of 600 completely dentate patients within the age range of 15-59 years with equal number of males and females. The mean age for males and females was 28.2 years and 27.4 years, respectively. In horizontal plane, in 61% of the cases, the mental foramen was in line with second premolar in both the left and right sides while in 28.7% of the cases the mental foramen was between the first and second premolar. It was symmetrical in 86.8% of the cases. In asymmetrical cases also, it was more commonly found below the second premolar (45.5%) followed by in between first and second premolars (24.7%). In vertical plane the highest percentage of mental foramen was found to be located inferior to the apex of second premolar (72.2%) followed by the position at or in line with the apex of second premolar (21.6%). It was symmetrical in 91.8% (534 out of 582) of the cases. In asymmetrical cases also, it was more commonly found inferior to the apex of second premolar in 45.8% of the cases followed by at or in line with the apex of second premolar in 42.7% cases. Further, both males and females exhibit similar pattern of mental foramen distribution in horizontal as well as in vertical planes. [89]

Vaibhav Gupta, Parag Pitti, Amar Sholapurkar in 2015 documented information on appearance, size, horizontal and vertical locations of Mental Foramen (MF) in Panoramic Radiograph. They also analyzed the age and gender differences with radiographic appearance and location of MF. 1662 panoramic radiographs were evaluated out of which 245 fulfilled the inclusion criteria. The radiographs were those of 156 males and 89 females in the age range of 19 and 65 years. The appearance of MF was found to be “Continuous” type in 34.3% males and “Separated” in 33.1% females. However in both age groups Group A (19-40 years) and Group B (41-65 years) majority of MF appeared to be continuous type in 28.1% and 37.3% cases respectively. The test results however showed a significant association of age ($p = 0.0004$) and gender ($p =0.006$). The most common horizontal location of MF was found to be Location “c” accounting to be 39.9% and 39.1% in males and females respectively. Location “c” was again commonest among both the age groups with 38.6% cases in Group A and 42.1% cases in Group B. However there was no significant association of age ($p = 0.841$) and gender ($p = 0.767$) with the horizontal location of MF. The average position of MF relative to the apex of second premolar was found to be 47% on the mesial side, 34.7% on the distal side and 18.3% intersecting with the apex of respective second premolar. However there was no statistical significant association with gender (p = 0.910 for male, p = 0.055 for female). The vertical location of MF was found to vary on left and right sides (X: Z = 1.34±0.99 on left and 1.48±1.12 on the right). The results of t test were not significant. The average horizontal dimensions of foramen on right and left sides were 2.61±1.83 mm and 2.81±1.71 mm respectively. The average vertical dimensions of foramen on right and left sides were 2.24±1.55 mm and 2.29±1.39 mm respectively. The difference between Horizontal and vertical diameter on the left and right side was not statistically significant.[6]

Saritha Maloth, Shrinivas TR, Padmashree S, Pramod Krishna B, Priya M in 2015 determined the appearance and location of the mental foramen of 480 subjects on panoramic radiographs; of these, 257 were males and 223 females. In 48.96% of cases, the mental foramen situated in line with the second premolar (position 4) and was common in age group of 25-35 years and in 40.83% in situated in line with the second premolar (position 3). Only in 9.97% of cases, mental foramen was in situated between the second premolar and molar (position 5). The position of the mental foramen was symmetric in 74.6% and asymmetric in 25.4% of cases. For symmetrically placed mental foramen, the most common position was position 4 (38.13%) followed by position 3 (30.41%). In the asymmetric cases, on the right side of the mandible, 54.55% of mental foramen was located in position 4 in males and 43.39 % in females. While on the left side, 39.44% mental foramen was located in position 3 in males and 46.29% in females. Position 4 was most common in male (49.2%) than in females (48.65%). On the right side, the most common position was position 4 (50.63%) and 47.29% on the left side. No statistically significant differences were seen between males and females in symmetric and asymmetric location of mental foramen on both sides. The most frequent vertical position of mental foramen was apical to premolar apex (69.58% cases), 19.79% of cases at premolar apex and 10.63% cases coronal to premolar apex. [90]

Mahnaz Sheikhi, Mitra Karbasi Kheir, and Ehsan Hekmatian in 2015 analyzed a total of 180 cone-beam computed tomography projections were in terms of shape, size, direction, and horizontal and vertical positions of mental foramen in the right and left sides. Results showed that the most common shape was oval, opening direction was posterior-superior, horizontal position was in line with second premolar, and vertical position was apical to the adjacent dental root. The mean of foremen diameter was 3.59 mm.[91]

Angel Fenol, Ashitha Mohan Das, Jayachandran Perayil, Susan Jebi in 2016 analyzed OPGs of 90 patients for recording the position of mental foramen. All patients above the age of 18 were included in the study. Of the 90 panoramic radiographs that were analyzed, 41 were of female patients and the rest 49 were of male patients. The mental foramen was found to be bilaterally symmetrical in 58 (64.4%) radiographs with the remaining 32 (35.5%) being asymmetrical. In this study, the most common position for the mental foramen in relation to the premolars was in line with the second premolar (position F) ,both on the right and left side. The second most common location was mesial to the second premolar (position E), followed by (position G) distal to the second premolar. Position D (mental foramen between 1st and 2nd premolar) was recorded on the right side for 7 cases and on the left side for 5 cases. Position C (mental foramen distal to the 1st premolar) was recorded in only one case on the right side. Position a (mental foramen mesial to 1st premolar) and position B (mental foramen below 1st premolar) were not recorded in any of the cases.[92]

Kusum Singal, Sapna Sharma in 2017 examined a total of 100 panoramic radiographs. The study samples were divided into 5 age groups as Group I, Group II, Group III, Group IV and Group V showing age 11-20, 21-30, 31-40, 41-50 and 51-60 years respectively. Each age group consists of 20 samples. The results showed that age group of 21-30 years was found to be having the highest mean value among all the age groups i.e. 40.7±3.3 for vertical distance between superior border of body of mandible and inferior border of body of mandible. However participants of age group of 11-20 years showed the lowest mean value of 37.0±2.5. Age group 21- 30 was found to be having a highest mean value for vertical distance between superior border of body of mandible and superior border of mental foramen i.e. 21.7±2.3. However 41-50 years age group subjects were reported with mean value of17.9±2.5. For vertical distance between inferior border of mental foramen and inferior border of body of mandible 51-60 years age group mean value was 15.80±1.51 which is the highest one.[93]

Rudyard dos Santos Oliveira, Maria Rodrigues Coutinho, and Francine Kuhl Panzarella in 2018 evaluated the effects of age and sex on the location and size of the mental foramen (MF). A total of 104 cone-beam computed tomography (CBCT) scans from patients' aged 18–80 years were selected. Images were evaluated using the following parameters: position and size of the MF, and Distances A (distance from the upper limit of the MF to the apex of the first lower premolar), B (distance from the upper cortical border of the MF to the alveolar crest), and C (distance from the border of the MF to the base of the mandible). Results revealed that the location of the MF was predominantly apical (44.4%), between the long axes of the premolars, at an average distance of 4.92mm from the root of the first lower premolar. The height of the MF was significantly different between both sexes (3.41 and 2.99 mm, respectively; mean height: 3.11 mm; P =0.003). The MF was located on average at 11.21mm from the alveolar crest and 12.31mm from the base of the mandible; the former measurement was significantly different between both sexes (13.13 and 11.98 mm, resp.; $P \leq 0.001$). In conclusion, the location of the MF was predominantly apical between the long axes of the premolars, and the mean size and distance of the MF were greater in men.[94]

Gloria Cartes, Ivonne Garay, Naira Figueiredo Deana, Pablo Navarro and Nilton Alves in 2018 conducted a study to analyze the morphology and morphometry of the mandibular canal (MC) course and the mental foramen (MF) position in relation to the inferior teeth by panoramic X-ray (PAN). Of the 442 panoramic X-rays examined, 262 were from females and 180 from males. Of the 262 females, 191 were aged between 18 and 34 years, mean 23.01 (±4.21 years); 71 were aged over 35 years, mean 44.52 (±6.93 years); of the 180males, 145 were aged between 18 and 34 years, mean 23.08 (±4.29 years); and 35 were aged over 35 years, mean 47.29 (±9.95 years). The results showed that the vertical distance from the inferior border of the mental foramen to the inferior limit of the base of mandible (D1) was 11.33 for females and 12.85 for males of age 18-34 years, and 11.56 for females and 12.82 for males of age ≥35 years on the right side. Vertical distance from the superior border of the mental foramen to the superior limit of the highest alveolar ridge (D2) was 15.83 for females and 17.19 for males of age 18-34 years, and 14.91 for females and 16.56 for males of age ≥35 years on the right side. [95]

MATERIALS AND METHODS

5.1 INTRODUCTION

This study was conducted in Department of Oral Medicine and Radiology of Babu Banarasi Das College of Dental Sciences, Lucknow (UP). Ethical clearance for the study was obtained from the institutional ethical committee.

The study population was drawn from the patients attending the outpatient Department of Oral Medicine and Radiology. The study sample consisted of 200 patients from both genders. Two hundred panoramic radiographs of the patients were studied and send for statistical analysis.

5.2 ARMAMENTARIUM

1. Dental chair with illuminating facility.
2. A pair of sterile disposable gloves and mouth mask.
3. Stainless steel kidney tray, mouth mirror, straight probe, tweezers and explorer.

Materials and Equipments used in the study with specifications and company :-

1. Digital panoramic radiograph
   [Planmeca Proline XC, SN: XC430638, 180-240V, 50 Hz]
   Installed in AERB (Atomic Energy Radiation Board) certified quality assurance facility.
2. AutoCAD software 2009

5.3 SELECTION OF THE PATIENTS

Eligibility criteria were set for the patients to be included or excluded in the study.

5.3.1 Inclusion criteria

- Age groups from 20 years to 60 years.
- All teeth in the region of measurement have to be present.

- Evidence of alveolar crest resorption in premolar and first molar regions should be absent.
- Radiographic images of the mental foramen and the borders of the mandible should be distinct, free of artifacts in the site of measurement.
- First and second premolars should be in reasonably normal position and alignment.

5.3.2 Exclusion Criteria

- Patients should not have history of any systemic disease that might affect bone metabolism.
- Any pathology or congenital anomaly in the mandible that could affect the interpretation of the radiographic image.
- Presence of severe crowding and spacing in lower arch.

5.4 SAMPLING METHOD

1. The study group consists of randomly selected samples of 200 patients within the age of 20-60 years. The study subjects were divided into two groups on the basis of age.
    a. Group I (20-39 years)
    b. Group II (40-60 years)
2. The subjects were selected according to the inclusion and exclusion criteria.
3. Case history was recorded in a case history proforma.

- The study sample consisted of **200 patients (100 males and 100 females)** attending the Department of Oral Medicine and Radiology, referred for digital panoramic radiographs for various purposes.
- The collected data was tabulated on spread sheets and subjected to statistical analysis.

5.5 METHODOLOGY

In the present study, all the subjects fulfilling the above criteria were enrolled after obtaining informed consent.

- All the enrolled subjects were then subjected for digital panoramic radiographs

5.5.1 For gender determination

- Radiographs were viewed digitally. Measurements will be made using the reference lines drawn from anatomical landmarks. A line joining the most prominent point on the chin the 'menton' and the most prominent point of the angle of the mandible 'joining' will be marked using AutoCAD software.
- The mental foramen will be identified and marked on the right side. A line perpendicular to this tangent is marked from the inferior mandibular border to the alveolar crest such that it intersected the inferior edge of the mental foramen on the right side.
- **Four measurements were made on every radiograph on the right side digitally for gender determination:-**

1) Distance from the inferior surface of the mandibular body to the height of the alveolar crest on the right side (height).
2) Distance between the superior margins of the mental foramen to the inferior border of the mandible on the right side (SM to IB).
3) Distance between the inferior margins of the mental foramen to the inferior border of the mandible on the right side (IM to IB).
4) Distance between the superior margin of the mental foramen to the alveolar crest on the right side (SM to AC) – were measured.

- All the morphological variables will be analyzed.

5.5.2 <u>For age estimation</u>

- **The appearance of mental foramina on the panoramic radiograph will be classified as any one of the four different types:-**

1) **Continuous type:** foramen which showed continuity with the mandibular canal.
2) **Separated type:** foramen which was distinctly separated from mandibular canal.
3) **Diffuse type:** foramen which had an indistinct border.
4) **Unidentified type:** the foramen which could not be identified on the panoramic radiographic under given exposure and viewing conditions.

- If there appeared to be multiple foramina, then the uppermost and the nearest landmark to the mandibular canal was considered as true radiographic mental foramen.
- The horizontal location in relation to the apices of the teeth will be determined and categorized as follows

1) Anterior to first premolar (Location 1)
2) In line with first premolar (Location 2)
3) Between first and second premolar (Location 3)
4) In line with second premolar (Location 4)
5) Between second premolar and first molar (Location 5)
6) In line with first molar (Location 6)

- The long axis of the premolars and 1st molar will be considered as vertical references to determine the horizontal location.
- The average position was determined. A horizontal line XY will be drawn at the occlusal level. Another line EF will be drawn parallel to the line XY at the apex of second premolar. Perpendicular line AB will be drawn passing through the apex of the mandibular second premolar through the long axis of the clinical crown (perpendicular to lines XY and EF) to the inferior border of the mandible. The average position of the mental foramen (in relation to the line AB) relative to the apex of 2nd premolar will be recorded as mesial, distal or intersecting this line.
- The vertical location was estimated by determining the shortest perpendicular line joining the alveolar ridge and the lower border of mandible, passing through the center of mental foramen. Measurements will be made (in mm) from the alveolar ridge to the upper border of mental foramen (a), from the lower border of foramen to the lower border of mandible (b), the diameter of mental foramen itself.

5.6 STATISTICAL ANALYSIS

The results are presented in frequencies, values, percentages and mean ± SD. Chi-square test and t-test was used to compare the categorical variables. The p-value <0.05 was considered significant. All the analysis was carried out on SPSS 16.0 version (Chicago, Inc., USA).

Formula

- **Mean and standard deviation**

The sample mean is the average and is computed as the sum of all the observed outcomes from the sample divided by the total number of events. We use "x" as the symbol for the sample mean. In math terms:-

$$\overline{x} = \frac{\Sigma x_i}{n}$$

Where "n" is sample size and the "x" corresponds to the observed valued.

We define the ***variance*** to be:-

$$s^2 = \frac{\sum (X - \overline{X})^2}{N-1}$$

The ***standard deviation (SD)*** is the positive square root of the variance, calculated as:-

$$s = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}}$$

n= number of observations

The ***standard error se*** of the difference between the two means is calculated as:

$$se(\bar{x_1} - \bar{x_2}) = s \times \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}$$

- **Chi-square test**

This test is applied to a single categorical value variable from two or more different populations. It is used to determine whether frequency counts are distributed identically across different populations.

$$\chi_c^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

O=observed frequency

E=expected frequency

- **Paired "t" test**

To compare the change in a parameter at two different time intervals paired "t" test was used.

$$t = \frac{\bar{d}}{\sqrt{s^2/n}}$$

d = mean difference; s = standard deviation; n = number of pairs

- **Student "t" test**

To test the significance of two mean the student "t" test was used.

$$t = \frac{(x_1 - x_2)}{\sqrt{\frac{(s_1)^2}{n_1} + \frac{(s_2)^2}{n_2}}}$$

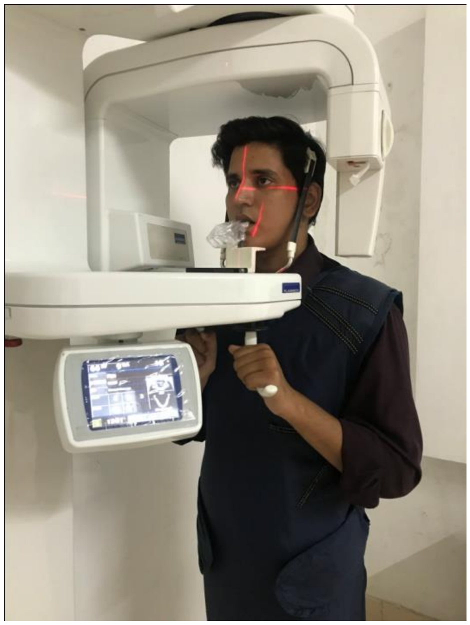
x1, x2 = group 1 and group 2, n = no. of observation; s = standard deviation

- **Level of significance: "p"**

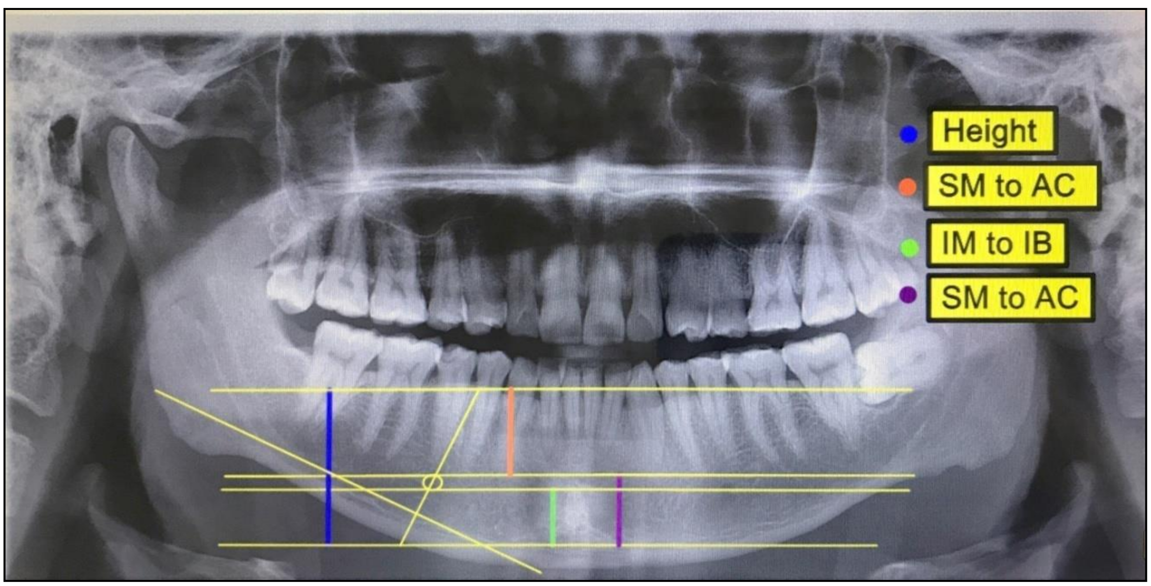
In statistical hypothesis testing, the p-value or probability value or asymptotic significance is the probability for a given statistical model that, when the null hypothesis is true, the statistical summary (such as the sample mean difference between two compared groups) would be the same as or of greater magnitude than the actual observed results. The use of p-values in statistical hypothesis testing is common in many fields of research. The smaller the p-value, the higher the significance.

- $p > 0.05$ :: Not significant
- $p < 0.05$ :: Significant
- $p < 0.01$ :: Highly significant
- $p < 0.001$ :: Very highly significant

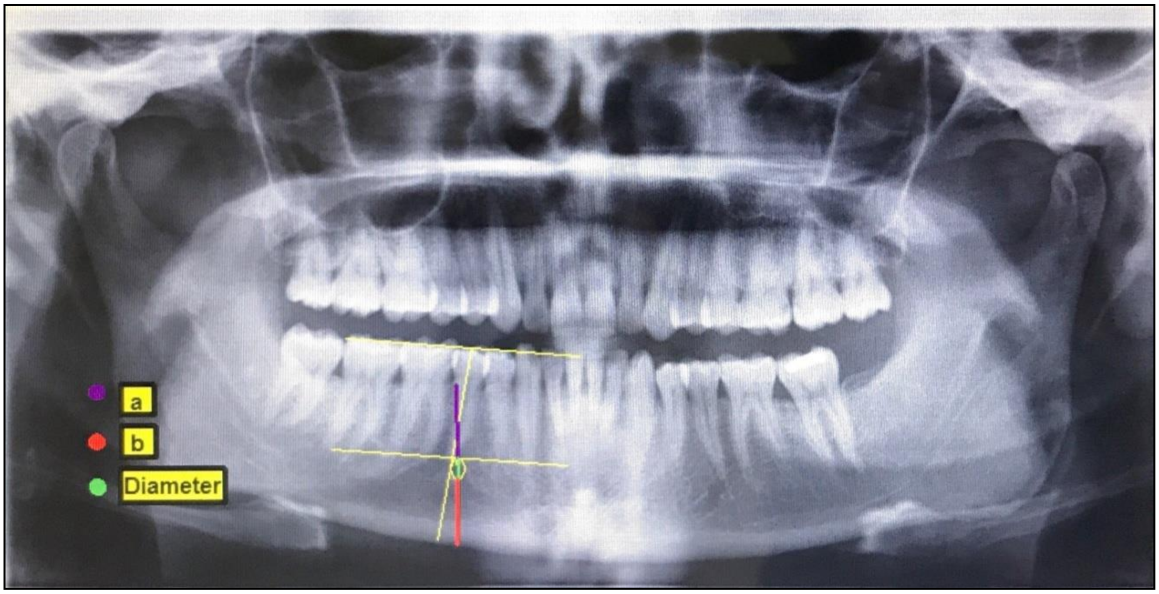
<u>Photograph 1: Armamentarium used for the study</u>



Photograph 2: Patient along with Orthopantomogram machine



Photograph 3: Measurements in orthopantomogram radiograph for gender determination.



Photograph 4: Measurements in orthopantomogram radiograph for age estimation

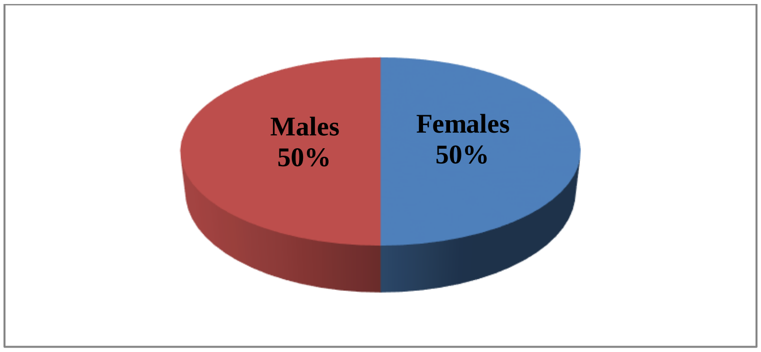
RESULTS

The present study was conducted in the **Department of Oral Medicine and Radiology** with the aim of **Determination of Gender and Age Estimation using Digital Panoramic Radiographs in dentulous patients.** A total of 200 patients were included in the study i.e. 100 males and 100 females within the age of 20-60 years. The patients were divided into 2 age groups: Group I (20-39 years) and Group II (40-60 years). **The level of significance for this study was set at p value at 5% (0.05).**

Table 1: Age distribution of patients

Age in years	No. (n=200)	%
29-39	100	50
40-60	100	50

Table 2: Gender distribution of patients		
Gender	**No. (n=200)**	**%**
Male	100	50
Females	100	50



Graph 1: Gender distribution of patients

Table 2 and Figure 1 shows the gender distribution of patients where both the genders were equally distributed in 1:1 ratio.

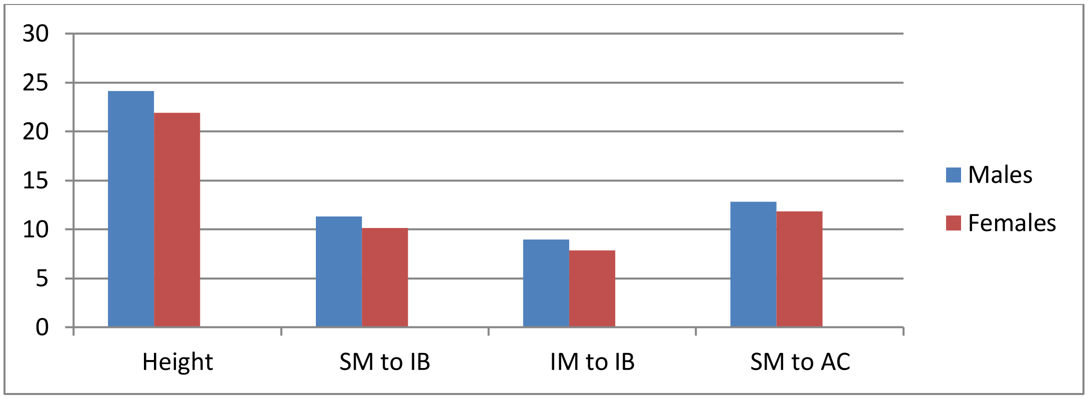
Gender Determination

Present study showed that there was a statistically significant difference in the measurements between males and females on the right side in relation to the height of the mandible (distance from the inferior surface of the mandibular body to the height of the alveolar crest on the right side), SM to IB (distance between the superior margins of the mental foramen to the inferior border of the mandible on the right side), IM to IB (distance between the inferior margins of the mental foramen to the inferior border of the mandible on the right side) and SM to AC (Distance between the superior margin of the mental foramen to the alveolar crest on the right side). The values were seen higher in males.

In the present study, on comparison of males and females, the mean value for the height of the mandible was recorded at 24.14 ± 2.04 mm for males and 21.93 ± 1.96 mm for females which was statistically highly significant at p-value 0.0001 (t value = -7.616). The mean value for the SM to IB was recorded at 11.29 ± 1.42 mm for males and 10.12 ± 1.17 mm for females which was statistically highly significant at p-value 0.0001 (t value = -6.359). The mean value for the IM to IB was recorded at 8.98 ± 1.39 mm for males and 7.84 ± 1.21 mm for females which was statistically highly significant at p-value 0.0001 (t value = -6.186). The mean value for the SM to AC was recorded at 12.83 ± 1.72 mm for males and 11.84 ± 1.62 mm for females which was statistically highly significant at p-value 0.0001 (t value = -4.19) (Table 3).

Table 3 : Comparison of Males and Females in Different Variables on Right Side

Summary	Height			SM to IB			IM to IB			SM to AC		
	Male	Female	Combined	Male	Female	Combined	Male	Female	Combined	Male	Female	Combined
N	100	100	200	100	100	200	100	100	200	100	100	200
Minimum	16.49	17.61	16.49	7.98	7.62	7.62	5.88	4.87	4.87	8.02	8.7	8.02
Maximum	29.19	28.81	29.19	15.25	12.61	15.25	13.16	10.61	13.16	18.17	17.49	18.17
Mean (mm)	24.14	21.93	23.04	11.29	10.12	10.71	8.98	7.84	8.41	12.83	11.84	12.34
SD	2.04	1.96	2.28	1.42	1.17	1.42	1.39	1.21	1.42	1.72	1.62	1.74
SE	0.20	0.20	0.16	0.14	0.12	0.10	0.14	0.12	0.10	0.17	0.16	0.12
95% CI-Upper Bound	24.35	22.13	23.20	11.43	10.24	10.81	9.12	7.96	8.51	13.01	12.00	12.46
95% CI-Lower Bound	23.94	21.74	22.88	11.15	10.01	10.61	8.84	7.72	8.31	12.66	11.68	12.22
t-value	-7.616			-6.359			-6.186			-4.19		
p-value	0.0001			0.0001			0.0001			0.0001		



Graph 2: Mean value for different variables on right side for both genders

Graph 2 shows that the mean value for different variables on right side is significantly greater in males than in females.

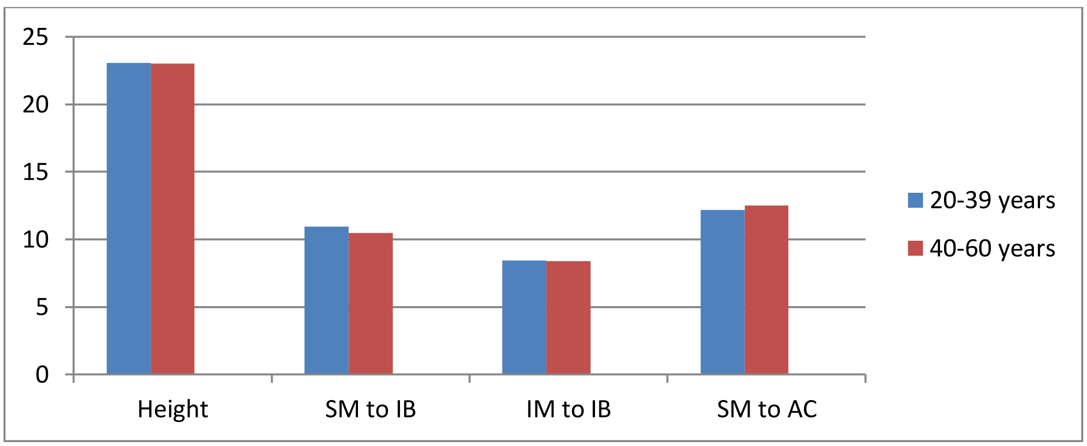
In the present study there was no statistically significant difference between the two age groups (20-39 years and 40-60 years) different variables on the right side except for SB to IB which showed significant difference.

On comparison of different variables in different age groups on the right side, the mean value for the height of the mandible was recorded at 23.07 ± 2.16 mm for age group between 20-39 years and 23.01 ± 2.41 mm for age group between 40-60 years which was statistically non significant at p-value 0.8531 (t value = -0.185). The mean value for the SM to IB was recorded at 10.95 ± 1.50 mm for age group between 20-39 years and 10.46 ± 1.31 mm for age group between 40-60 years which was statistically significant at p-value 0.0147 (t value = -2.46). The mean value for the IM to IB was recorded at 8.42 ± 1.57 mm for age group between 20-39 years and 8.40 ± 1.26 mm for age group between 40-60 years which was statistically non significant at p-value 0.921 (t value = -0.099). The mean value for the SM to AC was recorded at 12.16 ± 1.68 mm for age group between 20-39 years and 12.52 ± 1.78 mm for age group between 40-60 years which was statistically non significant at p-value 0.1429 (t value = 1.471) (Table 4).

Table 4 : Comparison of Different Variables in Different Age Groups (20-39 and 40-60 years) on Right Side

Summary	Height			SM to IB			IM to IB			SM to AC		
	20-39	40-60	Combined	20-39	40-60	Combined	20-39	40-60	Combined	20-39	40-60	Combined
N	100	100	200	100	100	200	100	100	200	100	100	200

Minimum	**16.49**	**17.61**	**16.49**	**7.83**	**7.62**	**7.62**	**4.87**	**5.34**	**4.87**	**8.02**	**9**	**8.02**
Maximum	**27.94**	**29.19**	**29.19**	**15.25**	**13.93**	**15.25**	**13.16**	**11.89**	**13.16**	**16.21**	**18.17**	**18.17**
Mean (mm)	**23.07**	**23.01**	**23.04**	**10.95**	**10.46**	**10.71**	**8.42**	**8.40**	**8.41**	**12.16**	**12.52**	**12.34**
SD	**2.16**	**2.41**	**2.28**	**1.50**	**1.31**	**1.42**	**1.57**	**1.26**	**1.42**	**1.68**	**1.78**	**1.74**
SE	**0.22**	**0.24**	**0.16**	**0.15**	**0.13**	**0.10**	**0.16**	**0.13**	**0.10**	**0.17**	**0.18**	**0.12**
95%CI Lower Bound	**22.85**	**22.77**	**22.88**	**10.80**	**10.33**	**10.61**	**8.26**	**8.27**	**8.31**	**11.99**	**12.34**	**12.22**
95% CI-Upper Bound	**23.29**	**23.25**	**23.20**	**11.10**	**10.59**	**10.81**	**8.58**	**8.52**	**8.51**	**12.33**	**12.69**	**12.46**
t-value	**-0.185**			**-2.46**			**-0.099**			**1.471**		
P-value	**0.8531**			**0.0147**			**0.921**			**0.1429**		



Graph 3: Mean value for different variables on right side for both age groups

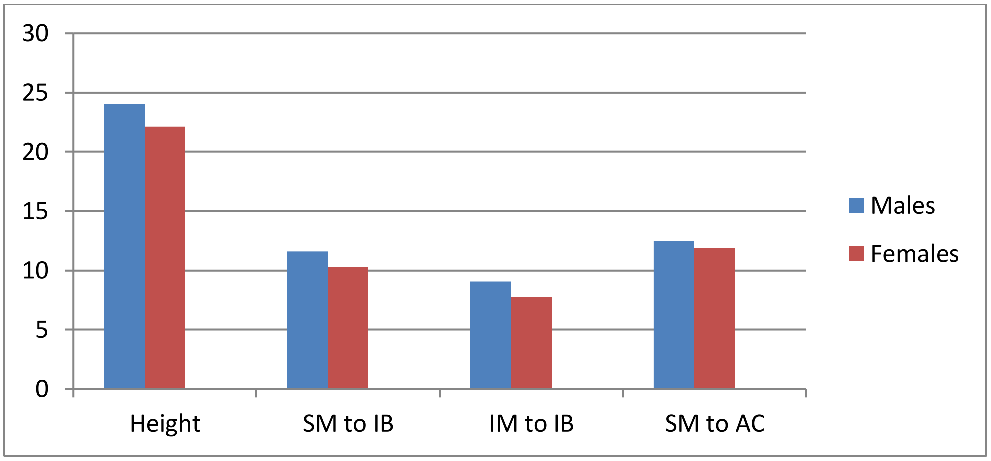
Graph 3 shows that mean value for different variables on right side had no difference when compared between the two age groups.

In the present study, statistically highly significant difference was observed when comparison of males and females in different variables of age group between 20-39 years.

On comparison of males and females in different variables of age group between 20-39 years, the mean value for the height of the mandible was recorded at 24.02 ± 2.19 mm for males and 22.13 ± 1.68 mm for females which was statistically highly significant at p-value <0.0001 (t value = -4.842). The mean value for the SM to IB was recorded at 11.58 ± 0.22 mm for males and 10.33 ± 1.13 mm for females which was statistically highly significant at p-value <0.0001 (t value = -4.569). The mean value for the IM to IB was recorded at 9.06 ± 1.54 mm for males and 7.78 ± 1.34 mm for females which was statistically highly significant at p-value <0.0001 (t value = -4.434). The mean value for the SM to AC was recorded at 12.47 ± 1.79 mm for males and 11.86 ± 1.52 mm for females which was statistically non significant at p-value 0.0693 (t value = -1.837) (Table 5).

Table 5 : Comparison of Males and Females in Different Variables of age group 20-39

Summary	Height			SM to IB			IM to IB			SM to AC		
	Male	Female	Combined	Male	Female	Combined	Male	Female	Combined	Male	Female	Combined
N	50	50	100	50	50	100	50	50	100	50	50	100
Minimum	16.49	17.88	16.49	7.98	7.83	7.83	6.00	4.87	4.87	8.02	8.70	8.02
Maximum	27.94	25.50	27.94	15.25	12.61	15.25	13.16	10.59	13.16	16.21	15.07	16.21
Mean (mm)	24.02	22.13	23.07	11.58	10.33	10.95	9.06	7.78	8.42	12.47	11.86	12.16
SD	2.19	1.68	2.16	1.57	1.13	1.50	1.54	1.34	1.57	1.79	1.52	1.68
SE	0.31	0.24	0.22	0.22	0.16	0.15	0.22	0.19	0.16	0.25	0.22	0.17
95% CI-Upper Bound	23.70	21.89	22.85	11.35	10.17	10.80	8.85	7.59	8.26	12.21	11.64	11.99
95% CI-Lower Bound	24.33	22.36	23.29	11.80	10.49	11.10	9.28	7.97	8.58	12.72	12.07	12.33
t-value	-4.842			-4.569			-4.434			-1.837		
p-value	< 0.0001			< 0.0001			< 0.0001			0.0693		



Graph 4: Mean value for different variables in age group 20-39 years for both genders

Graph 4 shows that the mean value for different variables in age group 20-39 years was significantly higher in males than in females.

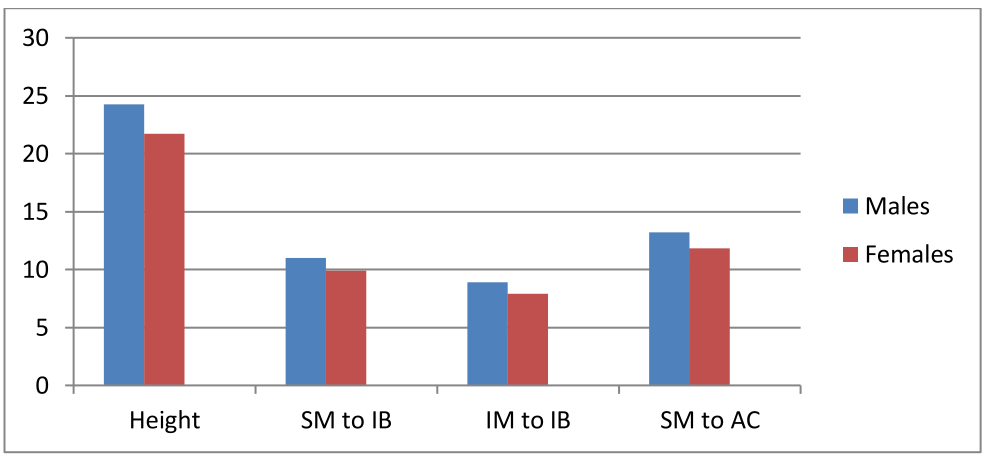
Present study also observed statistically highly significant difference on comparison of males and females in different variables of age group between 40-60 years.

On comparison of males and females in different variables of age group between 40-60 years, the mean value for the height of the mandible was recorded at 24.27 ± 1.89 mm for males and 21.74 ± 2.21 mm for females which was statistically highly significant at p-value <0.0001 (t value = -6.152). The mean value for the SM to IB was recorded at 11.01 ± 1.20 mm for males and 9.92 ± 1.18 mm for females which was statistically highly significant at p-value <0.0001 (t value = -4.58). The mean value for the IM to IB was recorded at 8.89 ± 1.23 mm for males and 7.90 ± 1.08 mm for females which was statistically highly significant at p-value <0.0001 (t value = -4.277). The mean value for the SM to AC was recorded at 13.20 ± 1.56 mm for males and 11.83 ± 1.73 mm for females which was statistically highly significant at p-value <0.0001 (t value = -4.159) (Table 6).

Table 6 : Comparison of Males and Females in Different Variables of age group 40-60

Summary	Height			SM to IB			IM to IB			SM to AC		
	Male	Female	Combined	Male	Female	Combined	Male	Female	Combined	Male	Female	Combined
N	50	50	100	50	50	100	50	50	100	50	50	100
Minimum	19.08	17.61	17.61	8.49	7.62	7.62	5.88	5.34	5.34	9.00	9.11	9.00

Maximum	**29.19**	**28.81**	**29.19**	**13.93**	**12.23**	**13.93**	**11.89**	**10.61**	**11.89**	**18.17**	**17.49**	**18.17**
Mean (mm)	**24.27**	**21.74**	**23.01**	**11.01**	**9.92**	**10.46**	**8.89**	**7.90**	**8.40**	**13.20**	**11.83**	**12.52**
SD	**1.89**	**2.21**	**2.41**	**1.20**	**1.18**	**1.31**	**1.23**	**1.08**	**1.26**	**1.56**	**1.73**	**1.78**
SE	**0.27**	**0.31**	**0.24**	**0.17**	**0.17**	**0.13**	**0.17**	**0.15**	**0.13**	**0.22**	**0.25**	**0.18**
95% CI-Upper Bound	**24.01**	**21.43**	**22.77**	**10.84**	**9.75**	**10.33**	**8.72**	**7.75**	**8.27**	**12.98**	**11.58**	**12.34**
95% CI-Lower Bound	**24.54**	**22.05**	**23.25**	**11.18**	**10.08**	**10.59**	**9.07**	**8.05**	**8.52**	**13.42**	**12.07**	**12.69**
t-value	**-6.152**			**-4.58**			**-4.277**			**-4.159**		
p-value	**< 0.0001**			**< 0.0001**			**< 0.0001**			**< 0.0001**		



Graph 5: Mean value for different variables in age group 40-60 years for both genders

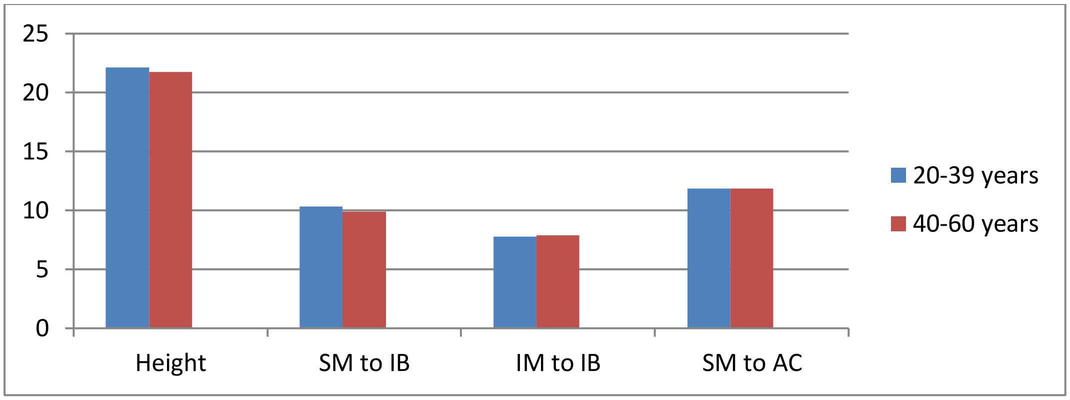
Graph 5 shows that the mean value for different variables in age group 40-60 years was also significantly higher in males than in females.

Females showed statistically no significant difference in the measurements of height of the mandible and SM to AC, SM to IB, and IM to IB on comparison of age groups between 20-39 years and 40-60 years.

On comparison of age groups in different variables in females, the mean value for the height of the mandible was recorded at 22.13 ± 1.68 mm for age group between 20-39 years and 22.74 ± 2.21 mm for age group between 40-60 years which was statistically non significant at p-value 0.323 (t value = -0.993). The mean value for the SM to IB was recorded at 10.33 ± 1.13 mm for age group between 20-39 years and 9.92 ± 1.18 mm for age group between 40-60 years which was statistically non significant at p-value 0.0791 (t value = -1.774). The mean value for the IM to IB was recorded at 7.78 ± 1.34 mm for age group between 20-39 years and 7.90 ± 1.08 mm for age group between 40-60 years which was statistically non significant at p-value 0.493 (t value = -0.6231). The mean value for the SM to AC was recorded at 11.86 ± 1.52 mm for age group between 20-39 years and 11.83 ± 1.73 mm for age group between 40-60 years which was statistically non significant at p-value 0.9268 (t value = -0.092) (Table 7).

Table 7 : Comparison of age group in Different Variables of Females

Summary	Height			SM to IB			IM to IB			SM to AC		
	20-39	40-60	Combined	20-39	40-60	Combined	20-39	40-60	Combined	20-39	40-60	Combined
N	50	50	100	50	50	100	50	50	100	50	50	100
Minimum	17.88	17.61	17.61	7.83	7.62	7.62	4.87	5.34	4.87	8.70	9.11	8.70
Maximum	25.50	28.81	28.81	12.61	12.23	12.23	10.59	10.61	10.61	15.07	17.49	17.49
Mean (mm)	22.13	21.74	21.93	10.33	9.92	10.12	7.78	7.90	7.84	11.86	11.83	11.84
SD	1.68	2.21	1.96	1.13	1.18	1.17	1.34	1.08	1.21	1.52	1.73	1.62
SE	0.24	0.31	0.20	0.16	0.17	0.12	0.19	0.15	0.12	0.22	0.25	0.16
95%CI Lower Bound	21.89	21.43	21.74	10.17	9.75	10.01	7.59	7.75	7.72	11.64	11.58	11.68
95% CI-Upper Bound	22.36	22.05	22.13	10.49	10.08	10.24	7.97	8.05	7.96	12.07	12.07	12.00
t-value	-0.993			-1.774			0.493			-0.092		
P-value	0.323			0.0791			0.6231			0.9268		



Graph 6: Mean value of different variables of females in both age groups

Graph 6 shows that the mean value of different variables of females shows no statistical difference when compared between the two age groups.

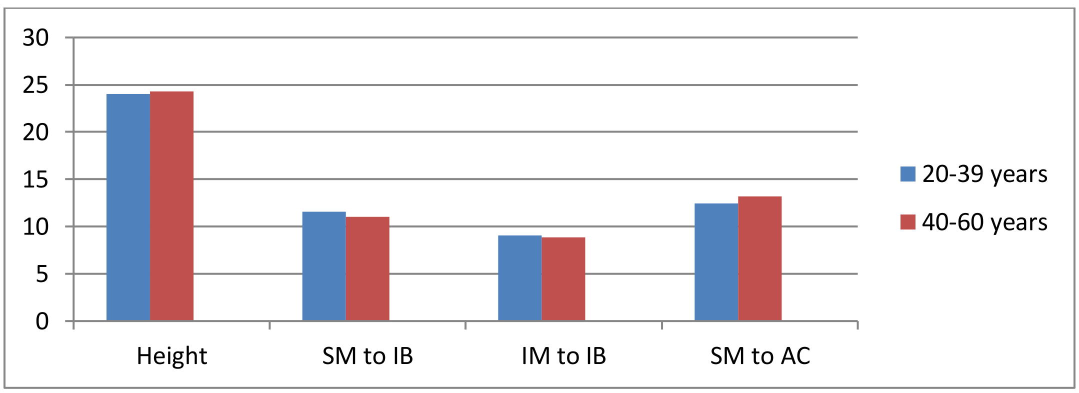
Similarly males also showed statistically no significant difference in the measurements of height of the mandible and IM to IB but SM to IB and SM to AC showed statistically significant difference on comparison of age groups between 20-39 years and 40-60 years.

On comparison of age groups in different variables in males, the mean value for the height of the mandible was recorded at 24.02 ± 2.19 mm for age group between 20-39 years and 24.27 ± 1.89 mm for age group between 40-60 years which was statistically non significant at p-value 0.5426 (t value = 0.611). The mean value for the SM to IB was recorded at 11.58 ± 1.57 mm for age group between 20-39 years and 11.01 ± 1.20 mm for age group between 40-60 years which was statistically significant at p-value 0.0441 (t value = 2.04). The mean value for the IM to IB was recorded at 9.06 ± 1.54 mm for age group between 20-39 years and 8.89 ± 1.23 mm for age group between 40-60 years which was statistically non significant at p-value 0.5433 (t value = -0.61). The mean value for the SM to AC was recorded at 12.47 ± 1.79 mm for age group between 20-39 years and 13.20 ± 1.56 mm for age group between 40-60 years which was statistically significant at p-value 0.0321 (t value = 2.174) (Table 8).

Table 8 : Comparison of age group in Different Variables of Males

Summary	**Height**			**SM to IB**			**IM to IB**			**SM to AC**		
	20-39	**40-60**	**Combined**	**20-39**	**40-60**	**Combined**	**20-39**	**40-60**	**Combined**	**20-39**	**40-60**	**Combined**

N	**50**	**50**	**100**	**50**	**50**	**100**	**50**	**50**	**100**	**50**	**50**	**100**
Minimum	**16.49**	**19.08**	**16.49**	**7.98**	**8.49**	**7.98**	**6.00**	**5.88**	**5.88**	**8.02**	**9.00**	**8.02**
Maximum	**27.94**	**29.19**	**29.19**	**15.25**	**13.93**	**13.93**	**13.16**	**11.89**	**11.89**	**16.21**	**18.17**	**18.17**
Mean (mm)	**24.02**	**24.27**	**24.14**	**11.58**	**11.01**	**11.29**	**9.06**	**8.89**	**8.98**	**12.47**	**13.20**	**12.83**
SD	**2.19**	**1.89**	**2.04**	**1.57**	**1.20**	**1.42**	**1.54**	**1.23**	**1.39**	**1.79**	**1.56**	**1.72**
SE	**0.31**	**0.27**	**0.20**	**0.22**	**0.17**	**0.14**	**0.22**	**0.17**	**0.14**	**0.25**	**0.22**	**0.17**
95%CI Lower Bound	**23.70**	**24.01**	**23.94**	**11.35**	**10.84**	**11.15**	**8.85**	**8.72**	**8.84**	**12.21**	**12.98**	**12.66**
95% CI-Upper Bound	**24.33**	**24.54**	**24.35**	**11.80**	**11.18**	**11.43**	**9.28**	**9.07**	**9.12**	**12.72**	**13.42**	**13.01**
t-value	**0.611**			**2.04**			**-0.61**			**2.174**		
P-value	**0.5426**			**0.0441**			**0.5433**			**0.0321**		



Graph 7: Mean value of different variables of males in both age groups

Graph 7 shows that the mean value of different variables of males shows no statistical difference when compared between the two age groups except for SM to IB.

Age Estimation

Each radiograph was analyzed to record the horizontal and vertical locations. Chi-square and t-test were employed.

The most common appearance of MF was found to be “Separated” type in 50% males and in 52% females and the least common appearance was found to be “Diffused” type in 10% males and 12% females. However in both age groups (Group I and Group II) majority of MF appeared to be “Separated” type in 52% cases in Group I (20-39 years) and 48% cases in Group II (40-60 years) respectively and the least common appearance appeared to be “Diffused” type in 11% cases in Group I (20-39 years) and 11% cases in Group II (40-60 years) respectively. The test results however showed a statistically non significant association of gender ($p = 0.8059$) and age ($p = 0.6614$) (Table 9).

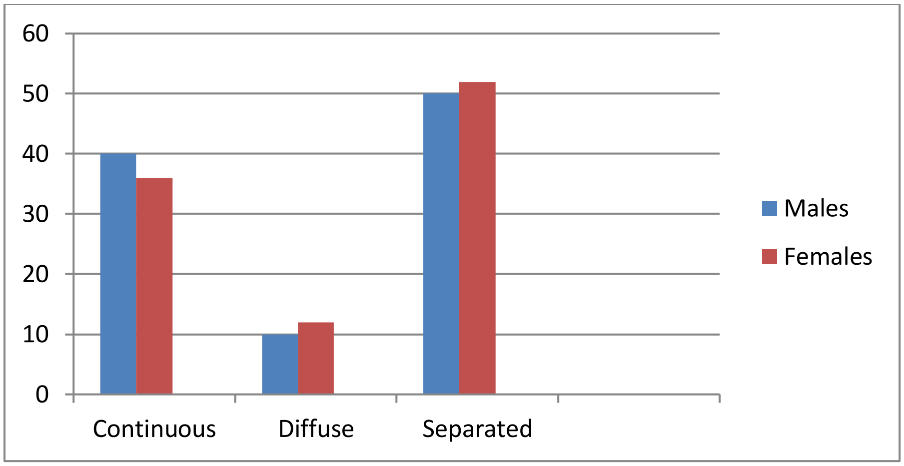
Table 9 : The appearance of mental foramina on panoramic radiograph

Appearance	GENDER					AGE				
	Males	%	Females	%	Grand Total	20-39 years	%	40-60 years	%	Grand Total
Continuous	40	40	36	36	76	35	35	41	41	76
Diffuse	10	10	12	12	22	11	11	11	11	22
Separated	50	50	52	52	102	54	54	48	48	102
Grand Total	100	100	100	100	200	100	100	100	100	200

*** X2= 0.431560183882, df = 2, *p* = 0.805912509044**

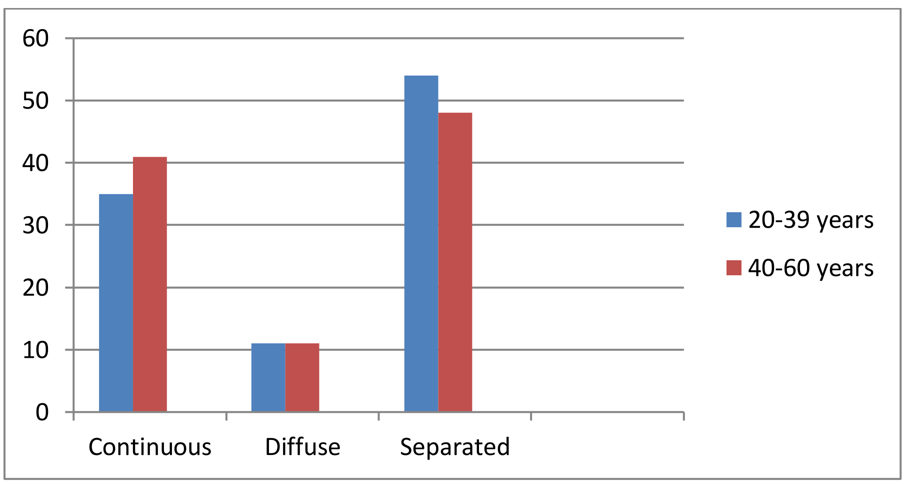
 # X2= 0.826625386997, df=2, *p* = 0.661455417678

X2 is chi square and df is degree of freedom



Graph 8: The appearance of mental foramina on panoramic radiograph (gender)

Graph 8 shows that the most common appearance of mental foramina on panoramic radiograph was separated type in both males and females.



Graph 9: The appearance of mental foramina on panoramic radiograph (age)

Graph 9 shows that the most common appearance of mental foramina on panoramic radiograph was separated type in both the age groups.

The most common horizontal location of MF was found to be Location "4" accounting to be 56% and 58% in males and females respectively. The least common horizontal location of MF was found to be Location "2" accounting to be 1% and 1% in males and females respectively. No cases were recorded with horizontal location 1. Location "4" was again commonest among both the age groups with 53% cases in Group I and 61% cases in Group II. However there was no significant association of gender (p =0.9415) and age (p = 0.1898) with the horizontal location of MF (Table 10).

Table 10 : Frequency of horizontal location of mental foramen (in relation to the apices of the teeth on the panoramic radiograph)

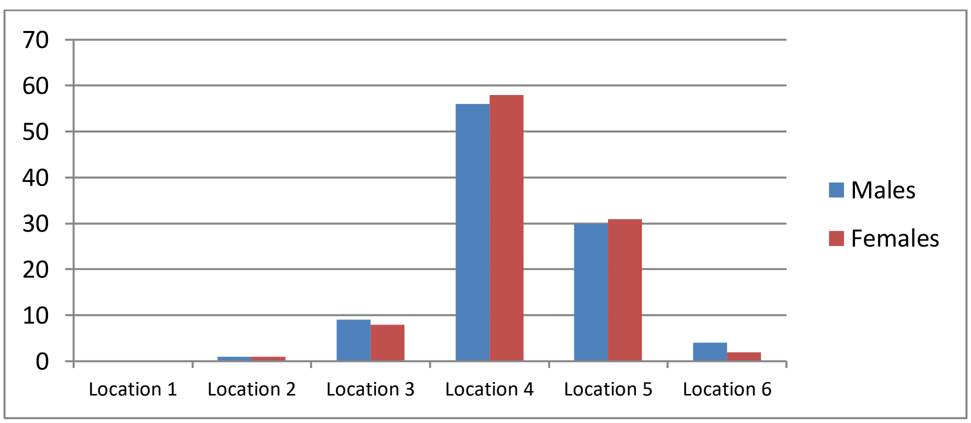
Location of Mental Foramen	GENDER					AGE					
	Males	%	Females	%	Grand Total	20-39 years	%	40-60 years	%	Grand Total	%
Location 1	0		0			0		0		0	
Location 2	1	1	1	1	2	2	2	0	0	2	1
Location 3	9	9	8	8	17	12	12	5	5	17	8.5
Location 4	56	56	58	58	114	53	53	61	61	114	57
Location 5	30	30	31	31	61	31	31	30	30	61	30.5
Location 6	4	4	2	2	6	2	2	4	4	6	3
Grand Total	100	100	100	100	200	100	100	100	100	200	100

X2= 0.776971358, df = 4, *p* = 0.941508441139

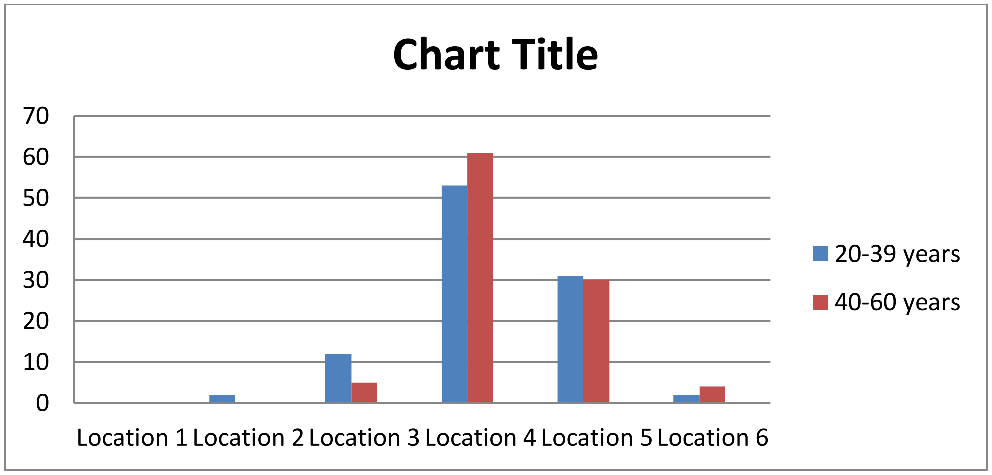
 # X2= 6.126816559238, df=4, *p* = 0.189875595759

X2 is chi square and df is degree of freedom

Location 1:Anterior to first premolar, Location 2: In line with first premolar, Location 3: Between first and second premolar, Location 4: In line with second premolar, Location 5: Between second premolar and first molar, Location: In line with first molar



Graph 10: Frequency of horizontal location of mental foramen (gender)



Graph 11: Frequency of horizontal location of mental foramen (age)

Graph 10 and 11 shows that location 4 was the most common location in both males and females and in both the age groups respectively.

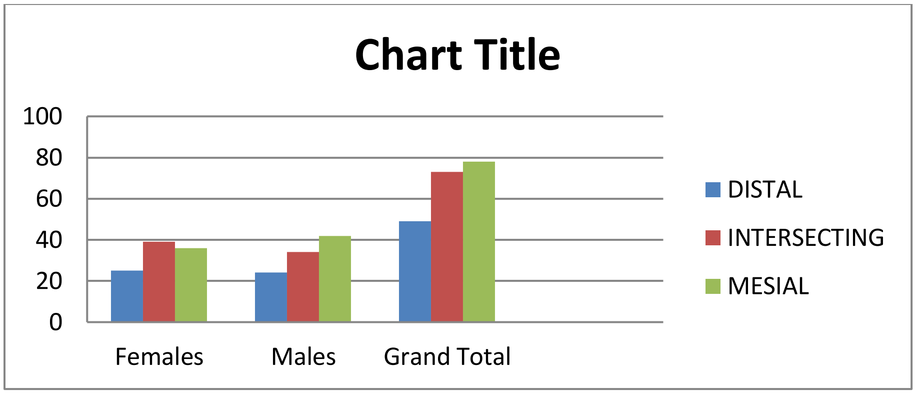
The position of MF relative to the apex of second premolar was found to be 78 on the mesial side, 49 on the distal side and 73 intersecting with the apex of respective second premolar. However there was no statistical significant association with gender (p = 0. 6621). The commonest position of MF relative to the apex of second premolar was found to be intersecting (39 cases) in females and mesial (42 cases) in males (Table 11).

Table 11: Average position of mental foramen relative to the apex of second premolar.

	Position Of Mental Foramen			
	DISTAL	INTERSECTING	MESIAL	Grand Total
Females	25	39	36	100
Males	24	34	42	100
Grand Total	49	73	78	200

X2= 0.824412378228, df = 2, *p* = 0.662187726074

X2 is chi square and df is degree of freedom



Graph 12: Average position of MF relative to the apex of second premolar

Graph 12 shows that most common average position of MF relative to the apex of second premolar was intersecting in case of females and mesial in case of males.

The vertical location of MF (a/b) was found to be 1.419 ± 0.2878 mm on the right side. The mean value for the distance from alveolar ridge to the upper border of mental foramen (A) was recorded as 12.8194 ± 1.8073. The mean value for the distance from the lower border of foramen to the lower border of mandible (B) was recorded as 9.2425 ± 1.4799. The mean value for the diameter was recorded as 2.3225 ± 0.6674 (Table 12).

Table 12 : Vertical Location of mental foramen (mm)

	MEAN	SD
A	12.8194	1.807303
Diameter	2.32255	0.667467
B	9.2425	1.479918
a/b	1.41934	0.287825

a – Distance from the alveolar ridge to the upper border of mental foramen

Diameter - Diameter of mental foramen itself

b – Distance from the lower border of foramen to the lower border of mandible.

a/b – Vertical position of the mental foramen

DISCUSSION

Remains of human skeleton identification are an important part in forensic science. Gender determination using the remains of human skeleton is the first step which is followed by estimation of age and stature which is dependent on gender.[1]

The Mental Foramen (MF) is an important anatomical structure located in the body of mandible. It represents the termination of mental canal which opens onto the surface in oblique direction. The mental bundle passes through MF and supplies sensory innervations and nutrition to the chin, lower lip and gingiva on the ipsilateral side of the mandible. As there are no absolute anatomical landmarks for reference and the foramen cannot be directly visualized or palpated, radiographic evaluation of the position of MF becomes an obligation for accurate diagnosis.[6]

The Mental Foramen is an important anatomical structure located in the body of mandible. It represents the termination of mental canal which opens onto the surface in oblique direction. The mental bundle passes through MF and supplies sensory innervations and nutrition to the chin, lower lip and gingiva on the ipsilateral side of the mandible.[36]

The mandibular canal, through which the inferior alveolar nerve and vessels pass, bifurcates and forms the mental and incisive canals (*Shankland, 1994*). The mental foramen is a funnel-like opening located on the anterolateral aspect of the mandible which marks the termination of the mental canal. The mental nerve and vessels radiate through the mental foramen and supply sensory innervations and blood supply to the soft tissues of the chin, lower lip and gingiva on the ipsilateral side of the mandible (*Sinnathamby, 1999; Williams et al., 2000*).[37]

Evidence shows a clear racial trend in the anteroposterior position of the mental foramen. (*Zivanovic, 1970; Green, 1987; Santini & Land, 1990; Shankland; Moiseiwitsch, 1998; Ngeow & Yuzawati, 2003; Cutright et al., 2003*).[37]

The most common position of the mental foramen was between the first and second mandibular premolars in 44.2% for right and 44.6% for left side of mandible, followed closely by location in line with the longitudinal axis of the second mandibular premolar 42.8% for right and 43.6% for left side of the mandible.[38]

Hence this study aimed at documenting anatomical information on appearance, size, horizontal and vertical locations of Mental Foramen in Panoramic Radiograph. We also determined the relationship of age and gender with its radiographic appearance and location.

A total of 200 patients were included in the study i.e. 100 males and 100 females within the age of 20-60 years. The patients were divided into 2 age groups: Group I (20-39 years) and Group II (40-60 years).

Gender Determination

Present study showed that there was a statistically significant difference in the measurements between males and females on the right side in relation to the height of the mandible (distance from the inferior surface of the mandibular body to the height of the alveolar crest on the right side), SM to IB (distance between the superior margins of the mental foramen to the inferior border of the mandible on the right side), IM to IB (distance between the inferior margins of the mental foramen to the inferior border of the mandible on the right side) and SM to AC (Distance between the superior margin of the mental foramen to the alveolar crest on the right side).

In the present study there was no statistically significant difference between the two age groups (20-39 years and 40-60 years) different variables on the right side.

In the present study, on comparison of males and females (Table 3), the mean value for the height of the mandible was recorded at 24.14 ± 2.04 mm for males and 21.93 ± 1.96 mm for females which was statistically highly significant at p-value 0.0001 (t value = -7.616). The value for measurement of height of the mandible was more in males than in females.

Similar result was observed by **Aspalilah Alias et al. (2017)** that height of mandible was significantly greater in males than in females ($p < 0.05$). It was found to be 24.6 ± 0.04mm in males and 24.3 ± 0.03mm in females.[80] Similarly **Girish Suragimath et al. (2016)** assessed that the height of the mandible (AC to LBM) was 29.2mm in males and 21.1mm in females on the right side and comparison showed statistically extremely significant differences as the value was more in males.[77] Similar result was concluded by **Moni Thakur et al. (2014)** that the height of the mandible was 34.54 ± 2.40mm in males and 33.08 ± 2.47mm in females which showed statistically significant difference ($p = 0.0031$).[3] Similar result was observed by **W. Apinhasmit et al (2006)** that mean distances from the alveolar bone crest across the MF to the lower border of the mandible (height of the mandible) was 29.97 mm. Gender differences were significant in all measurements with the longer distances in males ($p < 0.05$).[70] Similar result was assessed by **Kusum Singal et al. (2016)** that vertical distance between superior border of alveolar crest to the inferior border body of mandible passing through the center of the mental foramen was found to be 40.50 mm while in case of females this value was 38.66mm. The comparison between males and females showed statistically extremely significant differences.[78]

In the present study, on comparison of males and females (Table 3), the mean value for the SM to IB was recorded at 11.29 ± 1.42 mm for males and 10.12 ± 1.17 mm for females which was statistically highly significant at p-value 0.0001 (t value = -6.359).

Similar result was assessed by **Moni Thakur et al. (2014)** that the mean value for the SM to IB was 17.08 ± 1.33mm in males and 16.08 ± 1.82mm in females which showed statistically significant difference ($p<0.0020$).[3] Similar result was concluded by **Akhilesh Chandra et al (2013)** that the mean distance from the upper border of the mental foramen to the lower border of the mandible (S-L) on the right side in males was 17.650 mm, whereas it was 16.150 mm in females which was statistically higher in males than in females.[72] Similar result was observed by **Priya Sahni et al. (2015)** the mean distance of S-L on right side in males was 16.866 mm, whereas it was 14.433 mm in females. The comparison of S-L between males and females showed a very high significant difference ($p = 0.002$).[7] Similar result was concluded by **Mamta Malik et al. (2016**) the mean distance in centimeter with standard deviation for SL on the right side in males was 1.73±0.04, whereas it was 1.53±0.05 in females. The comparison of S-L between males and females showed a highly significant difference ($p = 0.001$) on the right side.[8] Similar result was observed by **Shweta Thakare et al (2016)** that in males, the mean value of S-L was 17.21 ± 1.9mm on right side and in females the value was 15.85 ± 2.4mm. The variation in length of S-L with respect to gender was found to be significant, with p-value <0.05.[76] Similar result was assessed by **Girish Suragimath et al. (2016)** that the average distance from SMF (superior border of MF) to LBM (inferior border of MF) in males was 17.3 mm and in females was 15.4 mm. The comparison between the genders showed statistically very high significant differences.[77]

In this study the mean value for the IM to IB was recorded at (Table 3) 8.98 ± 1.39 mm for males and 7.84 ± 1.21 mm for females which was statistically highly significant at p-value 0.0001 (t value = -6.186).

Similar results was observed by **Akhilesh Chandra et al. (2013)** that the mean distance from the lower border of the mental foramen to the lower border of the mandible (I-L) on the right side in males was 12.670 mm, whereas it was 11.462 mm in females which was significantly higher in males.[72] Similar result was concluded by **Moni Thakur et al (2014)** that the mean value for IM to IB was 13.88mm in males and 13.08mm in females which was significantly higher in males.[3] Similar results was observed by **Priya Sahni et al. (2015)** that the mean distance of I-L on the right side in males was 13.35 mm, whereas it was 11.293 mm in females. The comparison of I-L between males and females suggested a highly significant difference on right side ($p = 0.003$).[7] Similar results was assessed by **Mamta Malik et al. (2016)**

that the distance from inferior borders of mental foramen to the lower border of mandible (IL) was 1.42±0.06 in males, whereas it was 1.24±0.05 in females. The comparison of I‑L between males and females showed a highly significant difference ($P = 0.001$) on the right side.[8] Similar results was observed by **Shweta Thakare et al. (2016)** that the mean value of I-L (inferior borders of the foramen in relation to the lower border of the mandible) on right side was 13.02 ± 2.2mm in male and was 11.31 ± 2.5mm in females.[76] Similar results was concluded by **Noori Ghouse et al. (2016)** that D1(mm) [vertical distance from the most inferior point on the mental foramen to the inferior most point on the base of the mandible] was 14.47 in males and 13.60 in females for age 20-29 years, 14.94 in males and 12.60 in females for age 30-39 years and 14.56 in males and 12.38 in females for age group 40-49 years which was significantly higher in males.[1]

On the contrary, **Girish Suragimath et al. (2016)** observed that the distance from IMF to LBM on the right side in females was more than the left side, with no significant differences. The average distance from IMF to LBM in males was 11.8 mm and in females 11.4 mm.[77] On the contrary, **Vodanovic et al. (2006)** found that the mean value of IM-IB does not exhibit sexual dimorphism.[71]

The mean value for the SM to AC was recorded at (Table 3) 12.83 ± 1.72 mm for males and 11.84 ± 1.62 mm for females which was statistically highly significant at p-value 0.0001 (t value = -4.19).

Similar result was assessed by **Marin Vodanovic et al. (2006)** that the mean value for distance between mental foramen and alveolar border of the mandible (MF-AlB) was 15.21 in males and 13.63 in females which was significantly higher in males.[71] Similar result was observed by **Juan Muinelo-Lorenzo et al. (2016)** that the mean value of MF-MIB (distances from the alveolar bone crest to the MF) was 13.55 ± 1.06 mm in males and 11.42 ± 3.34 mm in females. The result showed statistically significant difference which was higher in males.[74] Similar result was concluded by **Noori Ghouse et al. (2016)** that the vertical distance from the most superior point on the mental foramen to the superior most point of the alveolar crest (D2) was 14.47 in males and 13.60 in females for age 20-29 years, 14.94 in males and 12.60 in females for age 30-39 years and 14.56 in males and 12.38 in females for age group 40-49 years. The comparison between the genders showed statistically very high significant differences.[1]

Similar result was observed by **Kusum Singal et al. (2016)** that the vertical distance between alveolar crest to superior border of mental foramen (C-D) was 20.18mm in males and 18.74mm in females which was significantly higher in males.[78] Similar result was assessed by **Juan Muinelo-Lorenzo et al. (2017)** that the distances from the MF to the alveolar crest (MF-MSB) was significantly higher in males than female.[79]

On the contrary, **Moni Thakur et al. (2014)** observed that the distance between the superior margin of the mental foramen to the alveolar crest on the right side (SM to AC) measurements between males and females did not show a statistically significant difference (p=0.326) and was 17.42mm in males and 17.00mm in females.[3] **Aspalilah Alias et al (2017)** also concluded that AC (distance from alveolar crest to upper margin of mental foramen) showed no significant difference when compared between males and females.[80]

In the present study there was no statistically significant difference between the two age groups (20-39 years and 40-60 years) different variables on the right side except for SB to IB which showed significant difference (Table 4). In the present study, statistically highly significant difference was observed when comparison of males and females in different variables of age group between 20-39 years. Present study also observed statistically highly significant difference on comparison of males and females in different variables of age group between 40-60 years.

Similar result was observed by **Moni Thakur et al. (2014)** the mean value of SM-IB was significantly higher in males compared to females in the age group of <25yrs. The mean value of IM-IB was significantly higher in males compared to females in the age group of >50yrs. The mean value of SM-AC was significantly higher in males compared to females in the age group of >50yrs. On comparing different variables (height, SM-IB, IM-IB and SM-AC) in different age groups (<25, 25-50 and >50yrs) showed highly significant values in comparison between males and females of height of the mandible and SM-AC in <25 vs. >50 and 25–50 vs. >50yrs.[3] Similar result was assessed by **Noori Ghouse et al. (2016)** that **w**hen comparison of mean values between male and female subjects of the mandible were done, the means of overall values for D1 (Vertical distance from the most inferior point on the mental foramen to the inferior most point on the base of the mandible) and D2 (Vertical distance from the most superior point on the mental foramen to the superior most point of the alveolar crest) were significantly higher in males in comparison to females in all the age groups.[1]

On the contrary, **Juan Muinelo-Lorenzo et al (2015)** found that MF-MIB (distance from the MF inferior borders to the lower border of the mandible) and MF-MSB (distances from the alveolar bone crest to the MF superior borders) distances showed statistically significant difference when compared between age group <50 years and age group >50 years.[74]

Aspalilah Alias et al (2017) observed that mean values for AC (distance from alveolar crest to upper margin of mental foramen) and AB (distance from alveolar crest to lower border of mandible) showed statistical difference with p value 0.01 for both but mean value for BD (distance from lower border of mandible to lower margin of mental foramen) showed no statistical difference with p value 0.84 when compared in different age groups.[80]

Age Estimation

In the present study the most common appearance of MF was found to be “Separated” type in 50% males and “Separated” type in 52% females and the least common appearance was found to be “Diffused” type in 10% males and 12% females (Table 9).However in both age groups (Group I and Group II) majority of MF appeared to be “Separated” type in 52% cases in Group I (20-39 years) and 48% cases in Group II (40-60 years) respectively and the least common appearance appeared to be “Diffused” type in 11% cases in Group I (20-39 years) and 11% cases in Group II (40-60 years) respectively. The test results however showed a statistically non significant association of gender ($p = 0.8059$) and age ($p = 0.6614$).

On the contrary, **Vaibhav Gupta et al. (2015)** observed that the appearance of MF was found to be “Continuous” type in 34.3% males and “Separated” in 33.1% females. However in both age groups Group A (19-40 years) and Group B (41-65 years) majority of MF appeared to be continuous type in 28.1% and 37.3% cases respectively. The test results however showed a significant association of age ($p = 0.0004$) and gender ($p = 0.006$).[6]

Youse et al. (1989) evaluated 297 patients, and reported that the most frequent appearance was separated (43%), followed by diffuse (24%), continuous (21%), and unidentified (12%) whereas in our study most frequent appearance was continuous (30.4%) followed by separated (28.6%), unidentified (22.2%) and the diffuse (18.8%) variant respectively.[96]

Navya N. Swamy et al. (2015) concluded that the most common Type I is mental canal is continuous with the mandibular canal of mental foramen (53.5%), followed by Type III diffuse with a distinct border of the foramen (31.5%), Type II the foramen is distinctly separated from the mandibular canal (14.0%) Type IV unidentified group (1%). Comparison of type in males and females appears significant.[97]

In the present study the most common horizontal location of MF was found to be Location "4" (In line with second premolar) accounting to be 56% and 58% in males and females respectively (Table 10). The least common horizontal location of MF was found to be Location "2" (In line with first premolar) accounting to be 1% and 1% in males and females respectively. No cases were recorded with horizontal position 1 (Anterior to first premolar). Location "4" was again commonest among both the age groups with 53% cases in Group I and 61% cases in Group II. However there was no significant association of gender (p =0.9415) and age (p = 0.1898) with the horizontal location of MF.

Similar result was observed by **Gershenson A et al. (1986)** that the most common location of MF was in front of the apex of the root of the second premolar which was 43.66%. [82] Similar results was assessed by **Luay N. Kaka et al. (2010)** that the most common location of MF was close to the second premolar in all age groups and there are no significant differences between groups.[83] Similar result was observed by **Kunihiro Saito et al. (2015)** that forty-two percent of the mental foramina were located in the apex of the second pre-molar which was found to be most common.[88] Similar result was concluded by **Priyanka Parnami et al (2015)** that in horizontal plane, in 61% of the cases, the mental foramen was in line with second premolar in both the left and right sides while in 28.7% of the cases the mental foramen was between the first and second premolar. Further, both males and females exhibit similar pattern of mental foramen distribution in vertical plane.[89] Similar result was observed by **Saritha Maloth et al. (2015)** in 48.96% of cases, the mental foramen situated in line with the second premolar (position 4) and was common in age group of 25-35 years and in 40.83% in situated in line with the second premolar (position 3). Only in 9.97% of cases, mental foramen was in situated between the second premolar and molar (position 5).[90] **Mahnaz Sheikhi et al. (2015)** assessed that the horizontal position of MF was in line with second premolar.[91]

On the contrary, **Anshuman Suresh Jamdade et al. (2013)** observed that the most common location of MF was located between the first and second premolars (46.1%) followed closely by in line with the longitudinal axis of the second premolar (45.5%). In both males and females, again position 3 (Between the first and second premolars) 46.4% and 46.1% was found to be most common position of MF followed by position 4 (In line with second premolar) 45.3% and 45.5% respectively.[85] On the contrary, **Vaibhav Gupta et al. (2015)** found that the most common horizontal location of MF was found to be Location “c” (Between first and second premolar) accounting to be 39.9% and 39.1% in males and females respectively. Location “c” was again commonest among both the age groups with 38.6% cases in Group A and 42.1% cases in Group B. However there was no significant association of age (p = 0.841) and gender (p = 0.767).[6]

The position of MF relative to the apex of second premolar was found to be 78 on the mesial side, 49 on the distal side and 73 intersecting with the apex of respective second premolar However there was no statistical significant association with gender (p = 0. 6621) The commonest position of MF relative to the apex of second premolar was found to be intersecting (39 cases) in females and mesial (42 cases) in males. (Table 11) On the contrary, **Vaibhav Gupta et al. (2015)** concluded that the average position of MF relative to the apex of second premolar was found to be 47% on the mesial side, 34.7% on the distal side and 18.3% intersecting with the apex of respective second premolar.[6]

The vertical location of MF (a/b) was found to be 1.419 ± 0.2878 mm on the right side (Table 12). The mean value for the distance from alveolar ridge to the upper border of mental foramen (A) was recorded as 12.8194 ± 1.8073. The mean value for the distance from the lower border of foramen to the lower border of mandible (B) was recorded as 9.2425 ± 1.4799. The mean value for the diameter was recorded as 2.3225 ± 0.6674.

Similar result was observed by **Vaibhav Gupta et al. (2015)** that the vertical location of MF was found to vary on left and right sides (X: Z = 1.34±0.99 on left and 1.48±1.12 on the right). The results of t test were not significant. The average horizontal dimension of MF on right side was 2.61 ± 1.83mm and 2.81 ± 1.71mm. The average vertical dimension of MF on right side was 2.24 ± 1.55mm.The mean value for the diameter of MF on the right side was recorded as 2.24 ± 1.32mm. The mean value for the distance from alveolar ridge to the upper border of mental foramen was recorded as 14.11 ± 7.55mm. The mean value for the distance from the lower border of foramen to the lower border of mandible was recorded as 8.55±4.84.[6] Similar result was assessed by **Gershenson A et al. (1986)** that shape of MF was round in 34.48% with an average diameter of 1.68 mm and oval in 65.52% with an average long diameter of 2.37 mm.[82] Similar results were concluded by **Virendra Budhiraja et al. (2013)** that the mean distance from alveolar crest to upper margin of mental foramen (AC) was 11.46 on the right side. Distance from lower border of mandible to lower margin of mental foramen (BD) was 15.25 on the right side. Vertical diameter of foramen was 2.61 on the right side.[86]

Rudyard dos Santos Oliveira et al. (2018) observed that MF was located on average at 11.21mm the alveolar crest which was similar to the present study but MF was located on average 12.31mm from the base of the mandible which was contrary to the present study. [94]

On the contrary, **D. P. Mohite et al. (2011)** assessed that that the mean distance of lower border of mandible (LB) to inferior margin of mental foramen (IMF) (mm) was 12.47 ± 3.08 and the mean distance of inferior margin of mental foramen (IMF) to crest of alveolar bone (CAR) (mm) was 22.53 ± 3.23.[84] On the contrary, **Kunihiro Saito et al. (2015)** observed that the lower margin of the mental foramen was located 7.25 mm above the lower edge of the mandible.[88] **Mahnaz Sheikhi et al. (2015)** concluded that the mean of diameter of MF was 3.59 mm.[91] On the contrary, **Gloria Cartesssssssssssssss et al. (2018)** observed that the vertical distance from the inferior border of the mental foramen to the inferior limit of the base of mandible (D1) was 11.33 for females and 12.85 for males of age 18-34 years, and 11.56 for females and 12.82 for males of age ≥35 years on the right side. Vertical distance from the superior border of the mental foramen to the superior limit of the highest alveolar ridge (D2) was 15.83 for females and 17.19 for males of age 18-34 years, and 14.91 for females and 16.56 for males of age ≥35 years on the right side. [95]

CONCLUSION

The knowledge on the variations in the position, appearance and size of the mental foramen may be of much use to dental surgeons. Analyzing mental foramen can be considered as an additional radiographic method for gender determination and age estimation. Skeletal remains become efficient for making the proposed measurements which is particularly important in mass disaster events, in which the jaws are available in fragments.

Determining the morphological appearance and positional variation of MF is important for isolation of mental nerves and vessels when administering local anesthesia and performing surgeries. We therefore stress the importance of accurate radiographic identification of MF and interpretation.

From the present study it is possible to conclude that statistically significant results were observed which was higher in males for the mean value of height of the mandible, SM to IB, IM to IB and SM to AC when compared between males and females.

In the present study there was no statistically significant difference between the two age groups (20-39 years and 40-60 years) different variables on the right side except for SB to IB which showed significant difference and higher in males.

It is possible to conclude that the height of the mandible, distance from the superior margin of the mental foramen to the alveolar crest, distance between the superior margins of the mental foramen to the inferior border of the mandible and distance between the inferior margins of the mental foramen to the inferior border of the mandible can be used to determine the gender.

The most common appearance of MF was found to be “Separated” type in males and females and the least common appearance was found to be “Diffused” type. However in both age groups majority of MF appeared to be “Separated” type and the least common appearance appeared to be “Diffused” type. The test results however showed a statistically non significant association of gender and age.

The most common horizontal location of MF was found to in line with second premolar when compared between the gender and between the two age groups. However there was no significant association of gender and age with the horizontal location of MF.

The most common position of MF relative to the apex of second premolar was found to be intersecting in males and mesial in females with no statistical significant association.

However, large study groups and comprehensive assessment of various other parameters related to the height of the mandible and mental foramen may be required for more definitive and confirmatory results.

REFERENCES

1. Noori Ghouse, Tejavathi Nagaraj, Leena James, Navya N. Swamy, C. D. Jagdish, T.V. Bhavana. Digital analysis of linear measurements related to the mental and mandibular foramina in sex determination. Journal of Medicine, Radiology, Pathology & Surgery 2016; 2:5-9.
2. Atiyaah Muskaan, Sonali Sarkar. Mandible-An Indicator for age and sex determination using digital Orthopantomogram. Scholars. Journal of Dental Sciences (SJDS) 2015;2(1):82-95.
3. Moni Thakur, K. Vinay Kumar Reddy, Y.Sivaranjani, Shaikh Khaja. Gender Determination by Mental Foramen and Height of the Body of the Mandible in Dentulous Patients: A Radiographic Study. J Indian Acad Forensic Med.2014; 36:13-18.
4. Bekir Karaarslan, Emine Sirin Karaarslan, Abdul Semih Ozsevik, Ertan Ertas. Age Estimation for Dental Patients Using Orthopantomographs, European Journal of Dentistry. October 2010 - Vol.4; 289-294.
5. Raghda Al-Shamout, Mohammad Ammoush, Raed Alrbata, Ahmad Al-Habahbah. Age and gender differences in gonial angle, ramus height and bigonial width, Pakistan Oral & Dental Journal Vol 32, No. 1 (April 2012): 81-87.

6. Vaibhav Gupta, Parag Pitti , Amar Sholapurkar. Panoramic radiographic study of mental foramen in selected Dravidians of south Indian population: A hospital based study. J Clin Exp Dent. 2015; 7(4):e451-6.
7. Priya Sahni, Ronak J. Patel, Shylaja, Jaydeva H. M, Anil Patel. Gender Determination By Pantomographic (OPG) Analysis Of Mental Foramen In North Gujarat Population- A Retrospective Study. Med. Res. Chron 2015; 2 (5):701-706.
8. Mamta Malik, Sanjeev Laller, Ravinder S Saini, Rakesh Kumar Mishra, Indu Hora, Nisha Dahiya. Mental foramen: An Indicator for Gender Determination - A Radiographic Study. Santosh University Journal of Health Sciences 2016; 2(1):12-14.
9. Abdolaziz Haghnegahdar and Pegah Bronoosh. Accuracy of linear vertical measurements in posterior mandible on panoramic view. Dent Res J (Isfahan) 2013; 10(2):220-224.
10. Çargi Ural, Cihan Bereket , Ismail Şener , Ali Murat Aktan , Yusuf Ziya Akpinar. Bone height measurement of maxillary and mandibular bones in panoramic radiographs of edentulous patients. J Clin Exp Dent 2011;3(1):e5-9.
11. Gopal Ji Misra, C. Damodaran. Perspective Plan for Indian Forensics. JULY 2010; 6-7.
12. Karandeep Singh Arora and Prabhpreet Kaur. Role of forensic odontology in the Indian Armed Forces: An unexplored arena. J Forensic Dent Sci. 2016 Sep-Dec; 8(3): 173.
13. Marie Morelato, Mark Barash, Lucas Blanes. Forensic Science: Current State and Perspective by a Group of Early Career Researchers. Foundations of Science. September 2016; DOI 10.1007/s10699-016-9500-0.
14. Rai B, Anand SC, Madan M, Dhattarwal SK. Criteria for determination of sex from mandible. The internal journal of science. 2007; 4(2).
15. Suazo GIC, San Pedro VJ, Schilling QNA, Celis CCE, Hidalgo RJA. Ortopantomographic Blind Test of Mandibular Ramus Flexure as a Morphological Indicator of Sex in Chilean Young Adults. Int. J. Morphol, 2008; 26(1):89-92.
16. Scheuer L. Application of osteology to forensic medicine. Clin Anat, 2002; 15:297–312.
17. Saini V, Srivastava R, Rai RK, Shamal SN, Singh TB, Tripathi SK. Mandibular ramus; An indicator for sex in fragmentary mandible. J Forensic Sci, 2011; 56(Suppl1):S13–6.
18. Juan Muinelo-Lorenzo, Juan-Antonio Suarez-Quintanilla, Ana Fernandez-Alonso, Jesus Varela-Mallou, Maria-Mercedes Suarez-Cunqueiro. Radiographic study of the mental foramen variations. Med Oral Patol Oral Cir Bucal. 2015 Nov 1; 20 (6):e707-14.

19. D. P. Mohite et al. Age assessment from mandible: comparison of radiographic and histologic methods. Rom J Morphol Embryol 2011, 52(2):659–668.
20. Paul P. Murder under the microscope: the story of Scotland Yard’s Forensic Science Laboratory. MacDonald Publishing; London; 1990.
21. Hu KKS, Koh KS, Han SH, Shin KJ, Kim HJ. Sex determination using nonmetric characteristics of the mandible in Koreans. J Forensic Sci, 2006; 51(6):1376-82. 15.
22. Singh IJ, Gunberg DL. Estimation of age at death in human males from quantitative histology of bone fragments. Am J Phys Anthropol; 1970, 33(3):373– 381. 16.
23. Sharpe WD. Age changes in human bone: an overview. Bull N Y Acad Med; 1979; 55(8):757– 773.
24. Luay N. Kaka, Amal R S. Mohammed, Fatin Kh. Abbas. Estimation of the position of mental foramen and its relation to lower premolars and base border of the mandible during aging. J Bagh College Dentistry. 2010 Vol. 22(3).
25. Karandeep Singh Arora and Prabhpreet Kaur. Role of forensic odontology in the Indian Armed Forces: An unexplored arena. J Forensic Dent Sci. 2016 Sep-Dec; 8(3): 173.
26. J. Taylor. A Brief History Of Forensic Odontology And Disaster Victim Identification Practices In Australia. The Journal of forensic odonto-stomatology ·December 2009.
27. Singaraju and Sharada. Age estimation using pulp/tooth area ratio: A digital image analysis. Journal of Forensic Dental Sciences, January-June 2009, Vol 1, Issue 1.
28. Javier Ata-Ali, Fadi Ata-Ali. Forensic dentistry in human identification: A review of the literature. J Clin Exp Dent. 2014; 6(2):e162-7.
29. Nadeem Jeddy, Shivani Ravi, T. Radhika. Current trends in forensic odontology. Journal of Forensic Dental Sciences. September-December 2017; Volume 9, Issue 3.
30. Anoop K. Verma, Sachil Kumar, Shiuli Rathore, Abhishek Pandey. Role of dental expert in forensic odontology. National Journal of Maxillofacial Surgery Jan-Jun 2014. Vol 5, Issue 1.
31. Raihan Hariz, Pallavi Sabarad, Riaz Abdulla, Sneha Dhar, Vishnudas Prabhu. Review of cases involving forensic odontology and its relevance in world statistics: an original study. IOSR Journal of Dental and Medical Sciences (IOSR-JDMS) e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 16, Issue 9 Ver. VIII (September. 2017), PP 99-102.
32. Dar MA, Nayyar AS. A comparative analysis between various teeth in Kvaal's and Cameriere's methods of age estimation in a specific populace of Andhra Pradesh: An original study. Int J Forensic Odontol 2016; 1:26-35.

33. Robert Michael Bruce-Chwatt. A brief history of Forensic odontology since 1775. Journal of Forensic and Legal Medicine 17 (2010) 127–130.
34. Shiva Kumar B et al. Forensic Odontology: The Investigative Branch of Dentistry - A Review. International Journal of Oral Health Dentistry. January – March 2016; 2(1):29-34.
35. Gurjot Kaur, Shivangi Chanana. Forensic Odontology and Its Indian Perspectives. JPAFMAT 2009; 9(1). ISSN 0972-5687.
36. John L. Phillips, R. Norman Weller, James C. Kulild. The Mental Foramen Part I. Size, Orientation, and Positional Relationship to the Mandibular Second Premolar. Journal of Endodontics. May 1990; Vol. 16, No. 5, 221-223.
37. Ilayperuma, I.; Nanayakkara, G. & Palahepitiya, N. Morphometric analysis of the mental foramen in adult Sri Lankan mandibles. Int. J. Morphol., 2009; 27(4):1019-1024.
38. L. Kqiku et al. Position of the Mental Foramen, Coll. Antropol. 37 (2013) 2: 545–549.
39. White SC, Pharoah MJ. Oral Radiology. Principles and Interpretation. Sixth Edition. Mosby, St. Louis, 2012.
40. Hallikainen D. History of panoramic radiography. ActaRadiol. 1996 May; 37 (3 Pt 2): 441-445.
41. Subbulakshmi AC, Mohan N, Thiruneervannan R, Naveen S, Gokulraj S. Positioning errors in digital panoramic radiographs: A study. J Orofac Sci 2016; 8: 22-6.
42. H Devlin, J Yuan. Object position and image magnification in dental panoramic radiography: a theoretical analysis. Dentomaxillofacial Radiology; (2013) 42, 1-7.
43. Gun- Sun Lee, Jin-Soo Kim, Yo-Seob Seo, Jae-Duk Kim. Effective dose from direct and indirect digital panoramic units. Imaging Science in Dentistry 2013; 43: 77-84.
44. Thiago L. Beaini, Paulo Eduardo Miamoto Dias, Rodolfo F. H. Melani. Exposure Standard for Digital and Analogue Dry Skull Orthopantomography. J Rorensic Res 2011; 2:1, 1-6.
45. Fatemeh Salemi, Abbas Shokri, Sepideh Falah-Kooshki. Common Errors on Conventional and Digital Panoramic Radiographs. Avicenna J Dent Res. 2014 June; 6(1), 1-4.
46. Whaites E. Essentials of dental radiography and radiology. Fourth edition, Churchill Livingstone Elsevier 2007.
47. Christoph Klingelhoffer, Manja Klingelhoffer, Steffen Muller et al. Can dental panoramic radiographic findings serve as indicators for the development of medication- related osteonecrosis of the jaws? Dentomaxillofacial Radiology (2016); 45, 20160065.
48. Mioara Decusara, Viorica Milicescu. Image Quality Assessment Of Orthopantomograms. Romanian Journal Of Oral Rehabilitation, December 2011; Vol. 3: No. 4, 54-58.

49. Ujwala Rohan Newadkar, Lalit Chaudhari, Yogita K. Khalekar. Common errors on panoramic radiograph: A time to reflect and review and not to sweep them under the carpet. SRM Journal of Research in Dental Sciences; 2016: Vol 7, Issue 3, 146-149.
50. Joao Cesar Guimaraes Henriques, Eliane Maria Kreich, Maracia Helena Baldani, Mariely Luciano, Julio Cezar de Melo Castilho and Luiz-Cesar de Moraes. Panoramic Radiography in the Diagnosis of Carotid Artery Atheromas and the Associated Risk Factors. The Open Dentistry Journal, 2011; 5, 79-83.
51. Olaf E. Langland, Robert P. Langlais, John W. Preece. Principle of dental imaging. 2nd Edition. Lippincott Williams and Wilkins. 2002;201-219.
52. Ravikiran Ongole, Praveen B.N. Textbook of Oral Medicine, Oral Diagnosis and Oral Radiology. Second Edition. Elsevier 2014, 724-797.
53. Reza Sadat-Khonsari, Christian Fenske, Leyli Behfar, Oskar Bauss. Panoramic radiography: effects of head alignment on the vertical dimension on the mandibular ramus and condyle region. European Journal of Orthodontics; 34 (2012): 164-169.
54. Griniatsos J, Damaskos S. Correlation of calcified carotid plaque detected by panoramic radiograph with risk factors for stroke development. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009, 13.
55. Farman A.G. Panoramic radiology Seminars on Maxillo-facial Imaging and Interpretation, Ed. Springer, 2007.
56. Sunanda Bhatnagar, Vasavi Krishnamurthy, Sandeep S. Pagare. Diagnostic Efficacy of panoramic Radiography in Detection of Osteoporosis in post-menopausal women with low bone mineral density. Journal of Clinical Imaging Science. 2013 Apr-Jun; 3(2): 1-7.
57. Kaviena Baskaran. Comparison of the image quality of intraoral radiograph (IOPA) and orthopentomograms (OPG). International Journal Of science and Research. 2017 May; 6(5): 67-71.
58. Pasler F.A. Color Atlas of Dental Medicine Radiology, Ed. Thieme, 1993.
59. Bamgbose BO, Ismail A, Yahaya AI, Oginni FO. Diagnostic anatomy of the maxillofacial region on orthopantomograph..Niger J Basic Clin Sci 2017;14:1-7.
60. Rafael Henrique Nunes Rondon et al. Common positioning errors in panoramic radiography: A review. Imaging Science in Dentistry 2014; 44: 1-6.
61. T.M.Graber. Panoramic Radiography. The Angle Orthodontist 1966; 36: 293-311.

62. Noriyuki Kitai, Yousuke Mukai, Manabu Murabayashi et al. Measurement accuracy with a new dental panoramic radiographic technique based on tomosynthesis. Angle Orthodontist 2013; Vol 83: No 1, 117-126.
63. G. A. Zach, O. E. Langland, F. H. Sippy. The Use of the Orthopantomograph in Longitudinal Studies. Department of Oral Diagnosis, University of Iowa. Jan 1969 Vol 39; 1, 42-50.
64. Karina-Morais Faria, Thais-Bianca Brandao, Wagner-Gomes Silva et al. Panoramic and skull imaging may aid in the identification of multiple myeloma lesions. Oral Medicine and Pathology Jan 2018; 1: 23(1), 38-43.
65. Mehrdad Abdinian, Fatemeh Soheilipour, Rehman Nazeri et al. Investigations of the magnification of digital panoramic radiographs in different regions of the jaws. SRM Journal of Research in Dental Sciences 2016; Vol 7, Issue 1, 10-16.
66. Vazquez L, Saulacic N, Belser U, Bernard JP. Efficacy of panoramic radiographs in the preoperative planning of posterior mandibular implants: A prospective clinical study of 1527 consecutively treated patients. Clin Oral Implants Res 2008; 19:81-5.
67. Manu Dhillon, Srinivasa M Raju, Sankalp Verma et al**.** Positioning errors and quality assessment in panoramic radiography. Imaging Science in Dentistry 2012; 42: 207-12.
68. Elizabeth A. Krupinski, Mark B. Williams, Katherine Andriole et al. Digital Radiography Image Quality: Image Processing and Display. J Am Coll Radiol 2007; 4: 389-400.
69. Mark B. William, Elizabeth A. Krupinski, Keith J. Strauss et al. Digital radiography Image Quality: Image acquisition. J Am Coll Radiol 2007; 4: 371- 388.
70. W. Apinhasmit, D. Methathrathip, S. Chompoopong, S. Sangvichien. Mental foramen in Thais: an anatomical variation related to gender and side. Surgical and Radiologic Anatomy. October 2006, Volume 28, Issue 5, pp 529–533.
71. Marin Vodanovic, Jelena Dumancic, Zeljko Demo, Damir Mihelic. Determination of sex by discriminant function analysis of mandibles from two Croatian archeological sites. Acta Stomatol Croat. 2006;40(3):263-77.
72. Akhilesh Chandra, Anil Singh, Manjunath Badni, Rohit Jaiswal, Archana Agnihotri. Determination of sex by radiographic analysis of mental foramen in North Indian population. J Forensic Dent Sci. 2013 Jan-Jun; 5(1): 52–55.
73. K. Udhaya, K.V. Saraladevi, J. Sridhar. Themorphometric analysis of the mental foramen in adult dry human mandibles: a study on the south Indian population. Journal of Clinical and Diagnostic Research. 2013 Aug, Vol-7(8): 1547-1551.

74. Juan Muinelo-Lorenzo, Juan-Antonio Suárez-Quintanilla, Ana Fernández-Alonso, Jesús Varela-Mallou, María-Mercedes Suárez-Cunqueiro. Radiographic study of the mental foramen variations. Med Oral Patol Oral Cir Bucal. 2015 Nov 1; 20 (6):e707-14.
75. Diana Laishram, Deepti Shastri. Morphometric Analysis of Mandibular and Mental Foramen. IOSR Journal of Dental and Medical Sciences. Volume 14, Issue 12 Ver. V (Dec. 2015), PP 82-86.
76. Shweta Thakare, Amit Mhapuskar, Darshan Hiremutt, Versha R Giroh, Kedarnath Kalyanpur, KR Alpana. Evaluation of the Position of Mental Foramen for Clinical and Forensic Significance in terms of Gender in Dentate Subjects by Digital Panoramic Radiographs. The Journal of Contemporary Dental Practice 2016; 17(9):762-768.
77. Girish Suragimath, S.R.Ashwinirani, Vineetha Christopher, Shobha Bijjargi, Renuka Pawar, and Ajay Nayak. Gender determination by radiographic analysis of mental foramen in the Maharashtra population of India. J Forensic Dent Sci. 2016 Sep-Dec; 8(3): 176.
78. Kusum Singal, Sapna Sharma. Gender Determination by Mental Foramen Using Linear Measurements on Radiographs: A Study in Haryana Population. Indian Journal of Forensic Medicine & Toxicology, January-June 2016, Vol. 10, No. 1, 44-49.
79. Juan Muinelo-Lorenzo, Ana FernaAndez-Alons, Ernesto Smyth-Chamosa, Juan Antonio SuaArez-Quintanilla, JesuAs Varela-Mallou, MaroAa Mercedes SuaArez-Cunqueiro. Predictive factors of the dimensions and location of mental foramen using cone beam computed tomography. PLoS ONE August 17, 2017,12(8): e0179704.
80. Aspalilah Alias, Abdel Nasser Ibrahim, Siti Noorain Abu Bakar, Mohamed Swarhib Shafie, Srijit Das, Faridah Mohd Nor. Morphometric and Morphological Study of Mental Foramen in the Malaysian Population: Anatomy and Forensic Implications. International Medical Journal Malaysia, Volume 16, Issue 2, 2017, pp. 47-53.
81. Lubis MN and Anfelia G. Vertical Height and Horizontal Width Assessment of Mental Foramen for Sex Determination from Panoramic Radiograph. EC Dental Science 17.2 (2018): 34-38.
82. Gershenson A, Nathan H, Luchansky E. Mental foramen and mental nerve: changes with age. Acta Anat (Basel). 1986; 126(1):21-8.
83. Luay N. Kaka, Amal R S. Mohammed, Fatin Kh. Abbas. Estimation of the position of mental foramen and its relation to lower premolars and base border of the mandible during aging. J Bagh College Dentistry. 2010 Vol. 22(3).

84. D. P. Mohite, M. S. Chaudhary, P. M. Mohite, S. P. Patil. Age assessment from mandible: comparison of radiographic and histologic methods. Rom J Morphol Embryol 2011, 52(2):659–668.
85. Anshuman Suresh Jamdade, Satyapal Yadav, Rahul Bhayana, Vikram Khare, Nilesh Pardhe, Nikunj Mathur. Radiographic Localization Of Mental Foramen In A Selected Indian Population, Innovative Journal of Medical and Health Science 2013; 3 : 5 249- 253
86. Virendra Budhiraja, Rakhi Rastogi, Rekha Lalwani, Prabhat Goel, and Subhash Chandra Bose. Study of Position, Shape, and Size of Mental Foramen Utilizing Various Parameters in Dry Adult Human Mandibles from North India. ISRN Anatomy Volume 2013, Article ID 961429, 5 pages.
87. Akhilanand Chaurasia. Age Prediction of Individuals on The Basis of Vertical Positions of Mental Foramen on Panoramic Radiograph–A South Indian Experience. Indian Journal of Forensic Odontology. July – December 2014, Volume 7, Number 3-4.
88. Saito, Araújo, Saito et al. Analysis of the mental foramen using cone beam computerized tomography. Rev Odontol UNESP. 2015 July-August; 44(4): 226-231.
89. Priyanka Parnami, Deepak Gupta, Vishal Arora, Saurabh Bhalla, Adarsh Kumar and Rashi Malik. Assessment of the Horizontal and Vertical Position of Mental Foramen in Indian Population in Terms of Age and Sex in Dentate Subjects by Panoramic Radiographs: A Retrospective Study with Review of Literature. The Open Dentistry Journal, 2015, 9, (Suppl 2: M8) 297-302.
90. Saritha Maloth, Shrinivas TR, Padmashree S, Pramod Krishna B, Priya M. Study on the position and symmetry of the mental foramen on panoramic radiographs in Indian population. Journal of International Medicine and Dentistry 2015; 2(3): 147-155.
91. Mahnaz Sheikhi, Mitra Karbasi Kheir, and Ehsan Hekmatian. Cone-Beam Computed Tomography Evaluation of Mental Foramen Variations: A Preliminary Study. Radiology Research and Practice Volume 2015, Article ID 124635, 5 pages.
92. Angel Fenol, Ashitha Mohan Das, Jayachandran Perayil, Susan Jebi. Radiographic Determination of the Position of Mental Foramen in a Selected Population of Kerala (South India). IOSR Journal of Dental and Medical Sciences (IOSR-JDMS) e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 15, Issue 2 Ver. XII (Feb. 2016), PP 23-25.
93. Singal K, Sharma S. Age Estimation by Position of Mental Foramen in Haryana Population: A Radiographic Study. J Adv Med Dent Scie Res 2017; 5(12):68-73.

94. Rudyard dos Santos Oliveira, Maria Rodrigues Coutinho, and Francine Kuhl Panzarella. Morphometric Analysis of the Mental Foramen Using Cone-Beam Computed Tomography. International Journal of Dentistry. Volume 2018, Article ID 4571895, 1-7.
95. Gloria Cartes, Ivonne Garay, Naira Figueiredo Deana, Pablo Navarro and Nilton Alves. Mandibular Canal Course and the Position of the Mental Foramen by Panoramic X-Ray in Chilean Individuals. BioMed Research International Volume 2018, Article ID 2709401, 10 pages.
96. Youse T, Brooks SL. The appearance of mental foramen on panoramic radiographs. I. Evaluation of patients. Oral Surg Oral Med Oral Pathol. 1989; 68:360-4.
97. Navya N. Swamy, Tejavathi Nagaraj, Noori Ghouse, C. D. Jagadish, N. Sreelakshmi, Rahul Dev Goswami. Radiographic study of mental foramen type and position in Bangalore population. Journal of Medicine, Radiology, Pathology & Surgery (2015), 1, 5–8.