CHAPTER II
LITERATURE REVIEW

2.1 Types of Skeletal in Human

Bone constantly strives for optimal architecture, it is a living material that is able to renew itself and that adapts its structure and density to changes in mechanical environment. Thus, bone, also mandibular bone, maintains an optimal architecture withstanding forces with the least material possible (Seeman, 2008).

2.1.1 Compact Bone

The human skeleton is made up of two major types of bone textures, which are the compact bone and spongy bone. Compact bone is the strongest form of bone in human body, it makes up the shaft of long bones and the external portion of all bones. The compact bone also provides support and protection, and resists stresses produced by movement and weight (Tortora and Derrickson, 2011).

2.1.2 Spongy Bone

Spongy bone, also referred to as cancellous bone, it consists of trabeculae surrounding many red marrow filled spaces. In contrast to compact bone, spongy bone is commonly located in the inferior layer of a bone. It forms most of the structure of short, flat, and irregular bones. Trabecular bone is light and the bone
marrow is supported and protected by its bone tissue (Tortora and Derrickson, 2011).

2.2 Mandible of Human

The mandible, also referred to as the lower jaw, is the bone that forms the lower part of the skull, and along with the maxilla or upper jaw, forms the mouth structure. It is the strongest bone of the face which serves for the reception of the lower teeth. It consists of the body, which is curved and horizontal, and two perpendicular portions, the rami, which unite with the ends of the body almost at right angles (Gray, 2000).

2.2.1 Muscles of Mandible

Four different muscles associate to the mandible to facilitate its movement. These muscles are the masseter, the temporalis, the medial pterygoid, and the lateral pterygoid. Each of these muscles occurs in pairs, with one of each muscle attaching on either side of the skull. The muscles work in combination to center the mandible up and down and to allow lateral movement of the jaw (Healthline.com, 2016).

2.2.2 Body of Mandible

The body of mandible, also referred as mandibular corpus, is a horseshoe curve-like shape and has two surfaces and two borders, known as the external surface and internal surface; superior border and inferior border. The external surface is notable in the median line by a faint ridge, indicating the symphysis or line of
junction of the two pieces of which the bone is composed at an early period of life, whereas the internal surface is concave from side to side (Gray, 2000).

2.2.3 Ramus of Mandible

The mandibular ramus is quadrilateral in shape, and comprised of two surfaces and two processes. The lateral surface is flat and marked by oblique ridges at its lower part, where the medial surface presents about its center the oblique mandibular foramen, for the entrance of the inferior alveolar vessels and nerve. The coronoid process is a thin, triangular eminence, which is flattened from side to side and varies in shape and size, whereas the condyloid process is thicker than the coronoid, and consists of two portions: the condyle, and the constricted portion which supports it, the neck. (Gray, 2000)

2.2.4 Bone Health of Mandibular Condyle

Mandibular condyle, which is subjected to various mechanical loads forcing it to be highly adaptive, has a unique structure and a relatively high remodeling rate (Willems et al., 2013). When the jaw-closing muscles contract, condyles are mostly subjected to compression forces in supero-inferior direction (Van Eijden, 2000). In some specific situations such as mastication, the condyles may be subjected to dynamic loads that vary to a rather large extent in direction and magnitude (Van Ruijven et al., 2002).
As a result, mandibular condyle adjusts its architecture to these specific, mostly compressive loading in supero-inferior direction with the articular surface supported for the most part by vertically oriented trabeculae (Giesen et al., 2001).

The last developing part of the mandible is the condylar process. It emerges as secondary cartilage from the body of the mandible and ossifies thereafter. The direction of newly formed bone trabeculae suggests that condylar growth takes place in supero-posterior direction. Later on, condylar growth continues in superior and to some extent in dorsal or ventral direction (Mulder et al., 2005).

In a nutshell, mandibular condyle is a bone structure with a high bone turnover rate. Mechanical properties of mandibular condyle improve during adolescence and are optimal during adulthood. Local mineralization degree might not be a definite principal of the local bone tissue stiffness. Bone collagen and its cross links play a role in toughness and tensile strength of bone but not in its compressive properties. Clinical procedures might affect mandibular condyle, which is highly reactive to changes in its mechanical environment (Willems et al., 2013).

![Figure 2.1: Side View of Mandible (Gray, 2000)](image-url)
2.3 Remodeling of Bone

Bone remodeling is the ongoing replacement of old bone tissue by new bone tissue, it involves the removal of mineralized bone by osteoclasts followed by the formation of bone matrix through the osteoblasts that subsequently become mineralized. Old bone is constantly destroyed by osteoclasts, whereas new bone is constructed by osteoblasts. For instance, in orthodontics teeth are moved by braces. This places stress on bone in the sockets causing osteoclasts and osteoblasts to remodel the sockets so that the teeth can be properly aligned (Tortora and Derrickson, 2011).

During growth, bone material is fashioned into three-dimensional masterpieces of biomechanical engineering by bone modelling, the formation of bone by osteoblasts without prior bone resorption. This process is vigorous during growth and changes bone size and shape. During remodeling, bone is refashioned first by resorption by osteoclasts, which remove bone, and then osteoblasts deposit bone in the same location. These cells form the basic multicellular unit, which reconstructs bone in different locations on the endocortical, intracortical and trabecular components of its endosteal or inner envelope and to a much lesser extent on the periosteal or outer envelope (Orwoll, 2003).

Remodeling takes place at different rates in different regions of the body. The remodeling cycle consists of three consecutive phases: resorption, during which osteoclasts digest old bone; reversal, when mononuclear cells appear on the bone surface; and formation, when osteoblasts lay down new bone until the resorbed bone is completely replaced (Hadjidakis and Androulakis, 2006). During resorption
phase, the cells that break down bone which known as osteoclasts will act on the trabecular bone surface to erode the mineral and matrix. The bone resorption phase is consider complete when small cavities are created in the surface of the trabecular bone. The process is then followed by bone formation where osteoblasts that form new bone, work to repair the surface and fill the eroded cavities with new bone that then has to be mineralized or calcified. Upon completion, the bone surface is restored and covered by a layer of protective bone cells called lining cells. The new bone is calcified and the remodeling process is completed.

Bone remodeling serves to adjust bone architecture to meet changing mechanical needs and it helps to repair micro damages in bone matrix preventing the accumulation of old bone. It also plays an important role in maintaining plasma calcium homeostasis. The regulation of bone remodeling is both systemic and local. The major regulators include parathyroid hormone, calcitriol, and other hormones such as growth hormone, glucocorticoids, thyroid hormones, and sex hormones (Hadjidakis and Androulakis, 2006).

### 2.4 Bone Quality and Bone Density

#### 2.4.1 Introduction

Each bone or bone part contain a variable supply of cortical and trabecular bone, closely reflective of its structural role at that location. The ability of bone to resist fracture is known as the bone strength, which is an aspect of bone quality as well as bone density. Bone quality reflects factors such as trabecular and cortical
architecture, bone turnover, mineralization, and cellularity (Griffith, Engelke and Genant, 2010).

Among the clinical and scientific community, there is almost universal agreement that measurement of bone mineral density in seemingly healthy individuals is the only means of determining skeletal status and fracture risk. Bone mineral density is the measure of the amount of minerals, mostly calcium and phosphorous, contained in a certain volume of bone. It refers to the ratio of weight to the volume or area of the bones. The child or adult’s age, height and degree of physical maturity are important factors in measuring and understanding bone mineral density (National Cancer Institute, 2016).

Approximately 80% of the variance in the bone strength is explained by bone density, and a decrease in bone density is correlated with increase in the fracture risk for both women and men (Stepan, 2002). When information about bone mineral density is combined with personal and family medical history, findings on physical examination, x-rays and biochemical testing, doctors can get a more complete picture of the child or adult’s bone health (Rauch and Cheung, 2007).

Bone density problems can occur in both the maxillary and mandibular for a number of reasons. A situation that becomes more extensive as an individual ages. Healthy jawbone structures are desired for the retention of teeth and for preserving satisfying oral health. Periodontal disease is only one of numerous conditions that will, if left untreated, will slowly invade and damage the healthy bone tissues (Hampton Dental Associates, 2016).
2.4.2 Measurements of Bone Density

Bone mass can be measured in the total body or in specific regions of the skeleton such as the spine; hips; legs and mandible. These specific sites are chosen because they are easily reachable, or places that prone to fracture. The volume of bone at each site is one of the factors that detect how much trauma or force it can withstand before it breaks (Rauch and Cheung, 2007).

2.4.2.1 Dual X-ray Absorptiometry (DXA)

Bone densitometry measurements are often used to estimate the risk of fracture in people of all ages and as part of research studies. It uses a low radiation dosage in an easy and painless way to measure bone mineral (Rauch and Cheung, 2007). DXA is a projectional imaging technique that measures the relative tissue absorption of a dual energy X-ray spectrum and offers areal density as g/cm² (Griffith, Engelke and Genant, 2010). It is based on the use of photons emitted at two different energies, which allows measurements on the sites with the uneven soft tissue composition to be performed, generally measured at two different sites, the postero–anterior lumbar spine and proximal femur (Stepan, 2002).

2.4.2.2 Panoramic Radiographs

The panoramic radiographs provides a general view of the structures in the stomatological area of interest. Structures visible on a panoramic X-ray are teeth and periodontal elements, teeth ridges, bone underneath the tooth ridge, mandibulary canal and the maxillary sinus, mental foramen and other structures
Panoramic radiography indices may be likely useful classify screening tools for estimating individuals with an increased probability of having low bone mineral density, osteoporosis and osteoporotic fractures (Taguchi, 2009). It is suggested that trabecular bone analysis of the jaws and evaluation of the cortical width of the mandible may be useful in screening for osteoporosis on panoramic radiographs (Miliuniene et al., 2008).

### 2.4.2.3 Cone-Beam Computed Tomography (CBCT)

CBCT is an imaging accomplished by using a rotating gantry to which an x-ray source and detector are fixed. A divergent pyramidal-or cone-shaped source of ionizing radiation is directed through the middle of the area of interest onto an area x-ray detector on the opposite side. The x-ray source and detector rotate around a rotation fulcrum fixed within the center of the region of interest. It is specifically dedicated to imaging the maxillofacial region heralds a true paradigm shift from a 2-dimension to a 3-dimension approach to data acquisition and image reconstruction (Scarfe & Farman, 2008).

The overall advantages of CBCT are its high resolution, potentially lower radiation dose, and reduced costs compared with CT (Loubele et al. 2007). When CT is used, bone density can be obtained in Hounsfield (HU). For CBCT, however, there is no standard unit such as HU because no calibration has been conducted as yet. Therefore, bone density obtained by CBCT was expressed in density values (Isoda et al., 2012).
2.4.2.4 Quantitative Computed Tomography (QCT)

In recent years, the use of a computed tomography (CT) scan has been common for preoperative quantitative and qualitative assessment of implant sites, and the Hounsfield unit (HU) is routinely used to determine the bone density objectively (Cassetta et al., 2014).

QCT has an advantage over the other techniques in its ability to measure the true volumetric density (expressed in mg/cm³). Furthermore, the trabecular bone located in the lumbar spine (L1–L3) can be measured independently of the surrounding cortical bone, it is more sensitive than DXA at detecting bone density differences or serial change (Genant et al., 1996). The spine QCT may be used as a primary diagnostic method in patients with severe degenerative disease of the spine, scoliosis, lumbar compression fractures, or obesity (Stepan, 2002).

2.4.2.5 Magnetic Resonance Imaging (MRI)

MRI has several advantages in assessing bone quality compared to CT, such as the lack of ionizing radiation, orthogonal plane imaging, and the ability to investigate aspects of bone physiology beyond structure, such as marrow fat content, marrow diffusion, and marrow perfusion. A small magnetic susceptibility difference exists between bone and marrow. This leads to signal dampening at the bone marrow interface, with overestimation of trabecular thickness known as trabecular broadening (Griffith, Engelke and Genant, 2010).
2.5 Angle's Classification of Malocclusion

Edward Angle classified malocclusion based on the mesial-distal relation of the teeth, dental arches and jaws. He considered the maxillary first permanent molar as a fixed anatomical point in the jaws and the key to occlusion. He based his classification on the relationship of this tooth to other teeth in the mandibular jaw (Singh, 2007).

2.5.1 Types of Malocclusion

2.5.1.1 Class I Malocclusion

The mandibular dental arch is in normal mesiodistal relation to the maxillary arch, with the mesiobuccal cusp of the maxillary first molar occluding in the buccal groove of the mandibular first permanent molar and the mesiolingual cusp of the maxillary first permanent molar occludes with the occlusal fossa of the mandibular first permanent molar when the jaws are at rest and the teeth approximated in centric occlusion (Singh, 2007).

Figure 2.2: Class I Malocclusion (Proffit, 2007)
Dewey's Modification of Angle's Class I

1. Type 1
   Angles Class I with crowded maxillary anterior teeth (Singh, 2007).

2. Type 2
   Angles Class I with maxillary incisors in labio-version or proclined. (Singh, 2007).

3. Type 3
   Angle's Class I with maxillary incisor teeth in linguoversion to mandibular incisor teeth also known as anteriors in cross bite (Singh, 2007).

4. Type 4
   Molars or premolars are in buccoversion or linguoversion, but incisors and canines are in normal alignment also known as posteriors in cross bite (Singh, 2007).

5. Type 5
   Molars are in mesio-version due to early loss of teeth mesial to them or early loss of deciduous molars or second premolar (Singh, 2007).

### 2.5.1.2 Class II Malocclusion

The relative mesiodistal relations of the dental arches is abnormal with all the lower teeth occluding distal to normal, producing a marked disharmony in the incisor region and in the facial lines. The distobuccal cusp of the permanent upper first molar fits into the sulcus between the mesial and middle buccal cusps of the lower first molar. The mandible is retrusive (Bishara, 2001).
Angle divided the Class II malocclusions into two divisions based on the labiolingual angulation of the maxillary incisors as:

1. Class II-Division 1
   Along with the molar relation which is typical of class II malocclusions the maxillary incisor teeth are in labioversion (Singh, 2007).

2. Class II-Division 2
   Along with the typical Class II molar relationship, the maxillary incisors are near normal anteroposteriorly or slightly in linguoversion whereas the maxillary lateral incisors are tipped labially and/or mesially (Singh, 2007).

2.5.1.3 Class III Malocclusion
The mandibular dental arch and body is in mesial relationship to the maxillary arch; with the mesiobuccal cusp of the maxillary first molar occluding in the interdental space between the distal aspect of the distal cusps of the mandibular first molar and the mesial aspect of the mesial cusps of the mandibular second molar (Singh, 2007).
Dewey's Modification of Angle's Class III

1. Type 1

Individual arches when viewed individually are in normal alignment, but when in occlusion the anteriors are in edge to edge bite (Singh, 2007).

2. Type 2

The mandibular incisors are crowded and lingual to the maxillary incisors (Singh, 2007).

3. Type 3

Maxillary arch is underdeveloped, in cross bite with maxillary incisors crowded and the mandibular arch is well developed and well aligned (Singh, 2007).

2.5.2 Etiology of Malocclusion

2.5.2.1 Hereditary

Hereditary causes of malocclusion include all factors that result in an malocclusion and are inherited from the parents by the offspring. These mayor may not be evident at birth, but are likely to express themselves as the child grows. These can be those influencing the neuromuscular system, dentition skeletal structures and soft tissues (Singh, 2007).
2.5.2.2 Primary Position of Tooth Germ and the Path

The position of tooth germs and the path of eruption are considered by some researchers to be inherited. Similar cross-bites or other malocclusions might be a result of similar jaw structure and tooth size rather than the position of tooth germs. Yet, ectopic teeth have shown to occur more frequently in some families collaborating the theory that these anomalies are genetically determined (Singh, 2007).

2.5.2.3 Number of Teeth

The number of teeth is a partially inherited characteristic. It can vary considerably especially in cases with cleft palate and cleidocranial dysostosis. The latter condition is known for the significant hyperdontia generally associated with it. Hypodontia is more widely seen as compared to hyperdontia. Hypodontia is more commonly seen in the permanent dentition as compared to the deciduous dentition. The most frequently missing teeth are the maxillary lateral incisors (Singh, 2007).

2.6 Effect of Malocclusion towards Mandibular Bone Density

2.6.1 Masticatory Activity

In a recent study, the duration of masseter muscle activity was increased in the malocclusion group. It is suggested that unstable occlusion extends the duration of electromyography activity. Also, patients with malocclusion have less area of occlusal contact in the intercuspal position, so masticatory performance is poor. It
is possible that malocclusion patients compensated for their reduced masticatory efficiency with a longer period of muscle activity (Nakamura et al., 2013). Recent research also showed that the average amplitude of the masseter muscle activity was decreased in the malocclusion group. It has been reported that the average amplitude of the masseter muscle activity in crossbite patients is significantly smaller on the crossbite side than in normal subjects. The presence of tooth contact in an unstable position can cause discomfort or pain. Therefore, an inhibitory-protective reflex might activate to avoid injury of the stomatognathic system (Nakamura et al., 2013).

According to a previous study, there was a positive correlation between occlusal stability in the intercuspal position and masseter muscle activity during mastication. The correlation between occlusal stability and elevator muscle function is probably based on feedback from periodontal receptors. It is believed that sensory feedback from mechanoreceptors in the maxillofacial area modifies the basic chewing pattern and coordinates movements of the tongue, lips, and jaw (Nakamura et al., 2013).

Based on these findings, it was concluded that periodontal receptors are primarily responsible for facilitating jaw-closing muscle activity. When sensory input from periodontal ligaments is blocked, the occlusal force is significantly reduced, and masticatory efficiency is decreased. The loss of masticatory efficiency may be compensated for by increasing the number of chewing cycles in a masticatory sequence. In malocclusion patients, occlusal hypofunction induced by bite raising causes decreased alveolar bone volume and density. This indicates that decreased mechanical stimulation of the periodontal ligament and surrounded
alveolar bone may cause reduction of bone mineral density of the jaw (Nakamura et al., 2013).

### 2.6.2 Morphology

Condylar width and mandibular bone mineral density were significantly less in the malocclusion group. It has been suggested that feeding soft food may cause a decrease in condylar width in malocclusion patients. In previous study, malocclusion is considered to cause reduced masticatory demand on teeth and, thereby, decreased masticatory muscle activity, which in turn may have affected bone mass and bone quality of the condyle. Likewise, a reduced late-closing phase, also referred to as power phase of the chewing cycle, indicates decreased masticatory muscle activity, which could inhibit condylar growth and decrease bone mineral density of mandible (Nakamura et al., 2013).

### 2.6.3 Periodontal Disease

It has been proven that malocclusion had relevant effect towards periodontal health, the malpositioned of teeth generally leads to difficulties in management of oral hygiene, thus the occurrence of periodontal diseases. Periodontal diseases are ongoing infections of the gums that gradually destroy the support natural teeth. It affects one or more of the periodontal tissues: alveolar bone, periodontal ligament, cementum, or gingiva. While there are many diseases which affect the tooth-supporting structures, plaque-induced inflammatory lesions make up the majority of periodontal issues (Surgery, 2016).
Periodontitis is affected by bacteria that adhere to the tooth’s surface, along with an overly aggressive immune response to these bacteria. If gingivitis progresses into periodontitis, the supporting gingival tissue and the jaw bone that position teeth in place will deteriorates. The progressive loss of quality of the alveolar bone, can lead to reduced bone mineral density of the jaw (Surgery, 2016).

2.6.4 Vertical Dimension

The analysis of the anatomy and function of the masticatory muscles and bone structures in different regions of mandible was carried out adopting the most common types of occlusion disorder, the increase of the vertical occlusal dimension and the mandibular retrusion. By using different methods it was possible to observe that the increase of vertical occlusal dimension promotes the muscle hypofunction, resultant of a limited and inefficient chewing capable to cause reduction of the volume of temporalis and masseter muscle fibers and reduction of bone composition from the ramus of the mandible and base regions, insertion places of the masseter muscle, hence this phenomenon had laid out the reduced levels of jaw bone mineral density (Casarin, Bocalini, Leite et al., 2015).

2.6.5 Retrusion of Mandible

According to Casarin, Bocalini, Leite et al., any change in the activity of temporalis and masseter muscles from the malocclusion, regardless of intensity, may cause disruption in the architecture and consequently loss of bone mineral density of the jaw. The mandible’s retrusive displacement, also evaluated by
different techniques showed changes in the morphology of the condylar process, negative influences on the structural characteristics of the temporomandibular joint and mainly of the masticatory muscles (Casarin, Bocalini, Leite et al., 2015).

The retruded mandible was capable to make the incisor teeth incapable to perform its functions, which resulted in a mastication difficulty, increasing the effort of the masseter and temporalis muscles, especially of the masseter muscles. Therefore, it was possible to observe an increase on the volume area of its fibers and in consequence, the increase of bone density in regions of insertion of the masseter muscle, as ramus and base of the mandible, while in the incisors alveolar process the bone density was reduced (Ohmure, Miyawaki, Nagata et al., 2008).

2.7 Panoramic Radiography

2.7.1 Introduction

Numerous panoramic radiographs, approximately 10 million are taken yearly for examining dental diseases such as dental caries and periodontal disease. Several studies have investigated the utility of panoramic radiographs in identifying individuals with undetected low bone mineral density. The bone mass, or bone mineral density, of the general skeleton, especially of the vertebrae and proximal femur, is an important factor related to fracture risk. Several bone mineral assessment technologies, have been developed and applied worldwide (Taguchi, 2009).

General dental practitioners are capable of determining from panoramic radiographs whether patients have low bone mineral density, researchers studied
observer agreement and diagnostic efficacy in detecting women with low bone mineral density. This was accomplished when general dental practitioners assessed the appearance of the mandibular inferior cortex on dental panoramic radiographs of postmenopausal women who had completed bone mineral density assessments of the lumbar spine and of the femoral neck. Hence, it was concluded that dental panoramic radiographs might be used in clinical dental practice to identify low bone mineral density (Farman, 2007).

A retrospective investigation was carried out to determine the strength of association of spinal bone density and the density of selected mandibular sites as determined from panoramic radiographs. The usefulness of width and morphology of the inferior cortex of the mandible on panoramic radiographs was evaluated in the diagnosis of postmenopausal osteoporosis. The width and morphology of the mandibular inferior cortex on panoramic radiographs were compared with trabecular bone mineral density of the third lumbar vertebrae measured by dual energy quantitative computed tomography (Farman, 2007).

2.7.2 Advantages of Panoramic Radiography

Panoramic radiography or dental panoramic tomography has become a very popular technique in dentistry. The main reasons for this includes, a large area is imaged and all the tissues within the focal trough are displayed, including the anterior teeth, even when the patient is unable to open the mouth. The image is easy for patients to understand, and is therefore a useful teaching aid. Besides, Patient movement in the vertical plane distorts only that part of the image being produced
at that instant and the positioning is relatively simple and minimal expertise is required (Whaites, 2007).

In dental hospitals, panoramic radiographs are also used to view the overall view of the jaws which allows rapid assessment of any underlying, possibly unsuspected, disease. The view of both sides of the mandible on one film is useful when assessing fractures and is comfortable for the injured patient, moreover it is useful for evaluation of periodontal status and in orthodontic assessments. In addition, the antral floor, medial and posterior walls are well shown. Both condylar heads are shown on one film, allowing easy comparison and the radiation dose (effective dose) is about one fifth of the dose from a full-mouth survey of intra-oral films (Whaites, 2007).

2.7.3 Disadvantages and Limitations of Panoramic Radiography

The tomographic image represents only a section of the patient, structures or abnormalities not in the focal trough may not be evident. In addition, soft tissue and air shadows can overlie the required hard tissue structures. Ghost or artefactual shadows can overlie the structures in the focal trough. Besides that, the technique is not suitable for children under six years or on some disabled patients because of the length of the exposure cycle. Some patients do not conform to the shape of the focal trough and some structures will be out of focus and movement of the patient during the exposure can create difficulties in image interpretation (Whaites, 2007).
2.7.4 Technique and Positioning

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:

1. Patient preparation

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 patients and if necessary use a test exposure to show them the machine’s movements (Whaites, 2007).

2. Equipment preparation

The cassette containing the film or phosphor plate should be inserted into carriage assembly. The operator should put on suitable protective gloves. The collimation should be set to the size of field required. The appropriate exposure factors should be selected according to the size of the patient (Whaites, 2007).

3. Patient positioning

The patient should be positioned in the unit so that their spine is straight and instructed to hold any stabilizing supports or handles provided. The patient should be instructed to bite their upper and lower incisors edge-to-edge on the bite-peg with their chin in good contact with the chin support. The head should be immobilized using the temple supports. The light beam markers should be used so that the mid-sagittal plane is vertical, the Frankfort plane is horizontal and the
canine light lies between the upper lateral incisor and canine. The patient should be instructed to close their lips and press their tongue on the roof of their mouth so that it is in contact with their hard palate and not to move throughout the exposure cycle (Whaites, 2007).

4. After exposure

The temple supports should release automatically to enable the patient to leave the machine. The equipment should be wiped down with a surface disinfectant and the bite-peg sterilized. Gloves should be discarded as clinical waste. The film should be processed (Whaites, 2007).

2.7.5 Anatomical Landmarks on Panoramic Radiographs

While evaluating panoramic radiographs, first of all, normal anatomic structure of the region must be known well. Complicated structure of the regions, superposition of these structures and variations of the projection orientations may lead to problems during the evaluation process (Altug & Ozkan, 2011).

The four diagnostic regions in the panoramic radiography are dentoalveolar region, maxillary region, mandibular region, temporomandibular region (Altug & Ozkan, 2011).

1. Dentoalveolar Region

It is surrounded by maxillary sinus and inferior border of the nasal cavity from above and mandibular canal from below. Frontal side of ramus takes place on its
left and its right. The teeth which are located in the upper and lower jaws and alveolus supporting them are seen in this region. Caries, fillings and prostheses are evaluated for the teeth whereas periodontal problems and intraalveolar pathologies related to the teeth are evaluated for alveolus (Altug & Ozkan, 2011).

2. Maxillary Region

It is surrounded by orbita from above and maxillary sinus and the inferior border of the nasal cavity from below. Coronoid processus of the mandible and zygoma take place on its left and its right. Maxillary sinuses, zygomatic complex, nasal cavity and conchae, sphenoid, ethmoid, palate, frontal bones and pterygomaxillary fissure can be observed in this region (Altug & Ozkan, 2011).

3. Mandibular Region

It is comprised of the mandibular teeth. Condylar and coronoid processes, ramus, body and angle and symphysis take place in this region. Mandibular canal, mental foramen, submandibular fossa, superimposed shadow of cervical vertebrae, external oblique ridge, posterior surface of tongue, soft palate and uvula, floor of nasopharynx and hyoid bone can also be observed in this region. Internal bone lesions and fractures are evaluated (Altug & Ozkan, 2011).

4. Temporomandibular Region

It is surrounded by temporal bone from above, and hyoid bone from below. Anterior of the ramus of the mandible takes place in its anterior. Cervical vertebra takes place in its posterior. The most important anatomic formation in this region is
temporomandibular joint (TMJ). TMJ is comprised of glenoid fossa, articular eminence and articular process of mandibular condyle. Cervical vertebra, ear lobe, soft palate and uvula, posterior pharyngeal airway, flow of nasopharynx, zygomatic arch, styloid process of temporal bone, pterygomaxillary fissure and maxillary tuberosity can be observed in this region (Altug & Ozkan, 2011).

Figure 2.5: Panoramic Radiograph (White, 2009)
2.7.6 Oral and Maxillofacial Pathology on Panoramic Radiographs

Odontogenic cysts and tumors present problems of diagnosis, radiology and histopathology. In general, their differential diagnosis requires radiographic clinical data, since many of them possess similar histological characteristics. Radiologic appearance of jaw cysts and odontogenic tumors varies considerably. The common lack of physical findings and the development of most of these lesions within the confines of the bone make radiologic investigation and interpretation uniquely important. Radiographs are also important in treatment planning for surgical removal. They can evaluate encroachment on vital structures, extent into soft tissue, size of the lesion, and requirements for reconstruction. Radiography allows for creation of a radiologic differential diagnosis (Ochsenius, Escobar, Godoy, & Peñafiel, 2007).

Radiolucent lesions of the jaws include, dental granuloma, radicular cyst, dentigerous cyst, keratocystic odontogenic tumor, ameloblastoma, incisive canal cyst, simple bone cyst, central giant cell granuloma, odontogenic myxoma. On the other hand, radiopaque lesions of the jaws include, odontoma, torus, osteoma, cementoblastoma, fibrous dysplasia (late stage). While mixed radiolucent and radiopaque lesions of the jaws include, fibrous dysplasia (early stage), ossifying fibroma, cemento-osseous dysplasia, chronic osteomyelitis, metastasis (Altug & Ozkan, 2011).
2.8 Races of Indonesia

2.8.1 Introduction

Geologists estimate that in the Pleistocene era during glaciation, the archipelago united with the mainland of Asia. Shallow seas between the islands in the western archipelago forming exposure at low tide, known as the Sunda Land, unified the western Indonesia with mainland of Asia. The same condition happened in eastern Indonesia, where the Sahul Land united eastern Indonesia with the mainland of Australia. The above is evidenced by the results of the study developed by Wallace investigating about the spread of fauna, in the Indonesian archipelago.

The migration process that occurred during the Pleistocene caused the Malay Archipelago inhabited by humans. Tracing of human physical Indonesia right now, the majority can be grouped into race Mongoloid and Austroloid. Experts estimate that in about the 19th century, Java Island is the area of the confluence of several races and meeting area.

It appears that due to migration flows originating from mainland Asia, mongoloid traits are currently found in Indonesians. Their arrival eventually get rid of the mankind who's been living in the land of the archipelago, namely the Austroloid race. Migration flows of migrants from the region to the Archipelago occurs gradually.

At about 3,000-5,000 years ago, all of the current entrants into Java are called the proto-Malays. Malays are an ethnic group of Austronesian peoples predominantly inhabiting the Malay Peninsula, eastern Sumatra and coastal Borneo, as well as the other smaller islands. Their descendants currently contained in the
Mentawai Islands of West Sumatra, Tengger in East Java, Dayak in Kalimantan, Sasak on Lombok. After that, came the current entrants are called Deutero-Malays, also known as the Iron Age people descended partly from the subsequent Austronesian peoples who came equipped with more advanced farming techniques and new knowledge of metals, which is expected to come from Taiwan and southern China, where many of their descendants now live in the West of Indonesia. They are kindred but more Mongolized and greatly distinguished from the Proto-Malays which have shorter stature, darker skin, slightly higher frequency of wavy hair (Fahmi, 2014). The Deutero-Malay settlers were not nomadic compared to their predecessors, instead they settled and established kampungs which serve as the main units in the society. These kampungs were normally situated on the riverbanks or coastal areas and generally self-sufficient in food and other necessities. By the end of the last century BC, these kampungs beginning to engage in some trade with the outside world. The Deutero-Malays are considered the direct ancestors of present-day Malay people (Jamil, 2002).

2.8.2 Bone Density of Mongoloid Race

Bone mineral density and fracture incidence vary widely across racial and ethnic groups. Race was identified as the main explanatory variable of bone density and this is consistent with the results of many other investigations (Ong & Stevenson, 1999). Mongoloids are reported to have lower BMD than Caucasians, yet they have lower hip fracture rates (Finkelstein et al., 2015). This is because despite their low calcium intake and lower bone density, Mongoloids have a lower incidence of hip
fractures than Caucasians because they have a lifestyle with higher levels of physical activity (Ong & Stevenson, 1999).

In 2004, forensic anthropologist Caroline Wilkenson said Mongoloids are characterized by absent supraorbital ridges (Liquisearch.com, 2016). Findings suggest that Mongoloids have higher bone density than Caucasoid subjects contrast with those of previous studies (Ong & Stevenson, 1999). Previous research also found that Mongoloid subjects had about 20% higher bone density at the angle of the mandible when compared to Caucasoid subjects (Liquisearch.com, 2016).

Most studies report comparable or higher bone mineral content (BMC) and bone mineral density (BMD) for Caucasians compared with Mongoloids. Racial differences in bone mass in older populations may reflect differences in peak bone mass, differences in the rate of loss, or a combination of the two. Besides, racial differences in body and bone size may also contribute to apparent differences in BMC and BMD, since both of these conventional expressions of bone mass are influenced by bone size.

According to RGK Ong and MR Stevenson’s research, from the measurement of bone density on panoramic radiographs, it had shown that the mean optical density of male Caucasians was 18% higher than the Mongoloids. The findings indicated that the Caucasoid subjects had significantly less dense bones than the Mongoloid. From the relationship of bone density to lifestyle factors, mongoloid subjects had shown higher mean bone density than the Caucasoid, irrespective of whether or not they drank alcohol (Ong & Stevenson, 1999).
Research that explored the association of race, gender, pubertal stage, body mass, diet, and physical activity with bone mineral in healthy Mongoloid and Caucasian youths, observed that some racial differences in BMC, where the expression of bone mineral most influenced by bone size. These findings support the hypothesis that differences in bone mass between Mongoloids and Caucasians are largely attributable to differences in bone size. Weight and pubertal stage are found to be the clinical variables most strongly associated with most expressions of bone mass, although calcium and weight-bearing activity were correlated with femoral neck BMD (Bhudhikanok et al., 1996). However, currently there is still lack of publication and references of research that precisely study about bone mineral content and bone mineral density of deutero-malays, hence the findings are yet to be study as further analytical research in the future.