CORRELATION OF PANORAMIC RADIOGRAPHIC FINDINGS AND CLINICAL FINDINGS OF DENTAL PATIENTS AT MOI TEACHING AND REFERRAL HOSPITAL, KENYA

BY

ABDULLATIF MUHAJI BADRU

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DECLARATION

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Abdullatif Muhaji Badru

SM/PGR/02/2018

Signature _____ Date _____

Supervisor's Declaration

This thesis has been submitted with our approval as university supervisors.

Prof G. D. Onditi Elias

Associate Professor,

Department of Radiology and Imaging, Moi University

Signature _____ Date _____

Dr. Kenneth. A. Okemwa

Senior Lecturer,

Department of Community, Preventive Dentistry and Periodontology, Moi University

Signature _____ Date _____

DEDICATION

I dedicate this thesis to my family and my supervisors who have been with me throughout my academic journey. I am truly grateful.

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LIST OF ABBREVIATIONS

DP	Dental Pattern (DP)
GBD	Global Burden of Disease
LMICs	Low-and Middle-Income Countries
MTRH	Moi Teaching and Referral Hospital
NCDs	Non-Communicable Diseases
OPG	Orthopantomography
SSA	Sub-Saharan countries
TMJ	Temporomandibular joint
WHO	World Health Organization
YLD	Years Lived with Disability

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DEFINITION OF TERMS

- **Dental caries**- bacterial infection of the calcified tissues of the teeth and is characterized by demineralization of the inorganic, and the destruction of the organic substance of the tooth
- **Dental health**- health of teeth, gums, and the entire oral-facial system that allows smiling, speaking and chewing
- **Digital Panoramic radiography**- this is a type of dental panoramic radiography where film technology is replaced with electronic sensors and computers. There is less exposure to radiation and films can be reprinted
- **Inverted Panoramic Imaging**- type of image processing by transforming radiopaque structures into radiolucent structures and vice-versa
- **Panoramic radiography**- extra-oral procedure which visualizes the entire maxilla-mandibular region on a single film. It is also called OPG (Orthopantomography)
- **Periodontal disease**- infection and inflammation of the gums, ligaments and the bone surrounding teeth

ABSTRACT

Background: Oral health is an integral part of the general health of the human body. Radiographs can help the dental practitioner to evaluate and definitively diagnose many oral diseases and conditions. Panoramic radiography is a simplified extra-oral imaging modality which visualizes the entire maxillary and mandibular region on a single film. However, panoramic radiography exposes the patient to health risks by inducing genotoxic and cytotoxic effects to oral epithelial cells leading to cell death and hereditary disorders to the descendants. Therefore its use should be clinically justified to avoid unnecessary exposure to radiation and cost.

Objective: To describe the panoramic and clinical examination findings, and to assess the level of agreement between the panoramic and clinical examination findings of dental patients at Moi Teaching and Referral Hospital (MTRH), Kenya.

Methods: This was a hospital based cross sectional study conducted at the Radiology and Imaging department and dental department at Moi Teaching and Referral Hospital from September, 2019 to June, 2020. A total of 93 consented patients were enrolled using systematic random sampling. A chart review forms were administered, and findings documented. Panoramic radiograph findings were then discussed with a consultant radiologist and a dentist before findings recorded on the form. Clinical examination findings were recorded from the electronic clinical records in the directorate of dentistry, MTRH. Descriptive statistics were carried out. Categorical variables were summarized as frequencies and proportions, and reported in tables. Numerical variables were summarized as median and interquartile ranges. Cross tabulation was done to compare clinical examination and panoramic radiograph findings where percent agreement was reported as proportions. Chi-square and Fishers exact test were used as statistical tests for the study.

Results: 93 patients whose ages ranged from 5-73 years with a mean of 29 years were included into the study. Radiographic features of dental caries were present in 54% of panoramic radiographs compared to clinical examination (50.5%) while 23.7% of radiographs revealed impacted teeth compared to clinical examination (19.4%). Radiographic features of periodontitis were observed in 14% compared to clinical examination (16.1%). Fractures (12.9%) were observed radiographically compared to (10.7%) clinically. Periapical lesions (8.6%) were observed radiographically compared to clinical examination (6.4%). Temporo-mandibular disorders (6.5%) were observed both on radiographs and clinical examination. Radiographic features of missing teeth (3.2%) were observed compared to clinical examination (1.1%) while only 1.1% of malpositioned teeth were observed radiographically compared to clinical examination (2.2%). Notably, mandibular lesions (3.2%) and nasal congestion (14%) were only discovered radiographically. The overall percent agreement between panoramic radiograph and clinical examination was 75.3% (70/93) with a p value of less than 0.001.

Conclusions: The level of agreement between panoramic radiographs findings and the clinical examination findings for dental conditions in MTRH was high (75.3%) and statistically significant. However, radiographs did reveal slightly more cases for most of the conditions than had been diagnosed clinically, with the exception of periodontitis. Notably, some of the conditions were only discovered following radiographic examination.

Recommendation: Clinical examination is sufficient in most of the cases at MTRH. Therefore, panoramic radiography should be indicated only for specific cases to protect patients from unnecessary radiation and cost.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

Oral health is an integral part of the general health of the human body. It contributes to the overall health and quality of life. The World Health Organization (WHO) defines oral health as "a state of being free from chronic mouth and facial pain, oral and throat cancer, oral infection and sores, periodontal (gum) disease, tooth decay, tooth loss, and other diseases and disorders that limit an individual's capacity in biting, chewing, smiling, speaking, and psychosocial well-being." Poor oral hygiene can lead to various dental conditions, and has well been linked to heart disease, cancer, and diabetes (Adeniyi, Oyapero, Ajieroh, Sofola, & Asiyanbi, 2018).

Panoramic radiography is a simplified extra-oral imaging modality which visualizes the entire maxilla-mandibular region on a single film. Panoramic radiography has become a popular and valuable diagnostic tool in dentistry. Panoramic radiography has been used for routine screening of dental patients because it allows examination of the entire dentition, alveolar bone, temporo-mandibular joints and adjacent structures easily (J.-W. Choi, 2011)

Panoramic radiography has become a common imaging modality in dental practice. It has proven to be a valuable imaging tool in the dentist's armamentarium. However, the panoramic radiograph produces a complex projection of both the mandible and maxilla with multiple superimpositions and distortions which may be exacerbated by technical errors in image acquisition. Furthermore, the panoramic projection shows many anatomic structures outside of the jaws that can result in additional challenges during interpretation (Perschbacher, 2012). Effective interpretation of panoramic

radiographs starts with understanding the normal anatomy of the head and neck and how the structures appear in this type of the image. Some of the examples of challenges experienced during interpretations include variations of anatomy and radiological artefacts (J.-W. Choi, 2011). However, to justify routine use of OPG, it would be necessary to demonstrate a significant diagnostic yield that outweighed the risks of radiation exposure (V. E. Rushton, Horner, & Worthington, 2001).

A study by Han, Cheng, Li, & Ma, (2013) reported that panoramic radiography is one of the most common dental imaging modality for oral examination. However, a minimal increase in the frequency of exposure of diagnostic x-rays is of considerable public health importance (Toossi, Akbari, & Roodi, 2012). A report by Kalinowska, (2021) reported that dental radiology is safe for pregnant women who are protected by a lead apron during exposure. However, a study by Radfar & Sirois, (2003)) argued against routine panoramic radiography since full mouth periapical x-rays was found to be more effective for complete oral examination. Another study by Ghazal et al., (2016) recommended a bi-annual full mouth x-ray examination for high risk patients and an annual examination for pediatric patients with a low risk for tooth decay. The study also concluded that panoramic radiography with a lead body shield is safe for use in pediatric patients.

A precise assessment of dental patients is important to achieve adequate diagnostic and treatment of dental patients. It is necessary to document both intra oral and extra oral findings while assessing for dental pathologies. The clinical dental examination includes assessment of restoration and prosthetic treatment of teeth, and examination of periodontal areas (Dentino, Kassab, & Renner, 2005). Bitewing intraoral

radiography is the method of choice for the assessment of interproximal dental caries (N B Pitts, 2004).

Radiation exposure is associated with a long-term risk of malignant neoplasms in the exposed persons, as well as a low potential of risk of hereditary diseases in their descendants. Panoramic radiography is the most frequently performed procedure in the dental clinical practice. The radiation dose associated with dental panoramic radiography is low. However, any radiograph taken should be justified and optimized to protect the patient from the risks associated with ionizing radiation (Teunen, 1998). There is a wide variation in the patient dose with the same imaging procedure performed at different facilities or even within the same facility. This difference in radiation dose may vary by up to a few hundreds (S. C. White & Pharoah, 2018).

A review of articles by Elmorabit & Ennibi, (2021) reported that the effective dose for dental panoramic radiography was in the range of 5-49µSv which depends on the equipment used. A study by Iannucci & Howerton (2013) also reported that panoramic radiography is the most often used imaging modality in dentistry. X-ray beam during dental panoramic radiography passes through oral mucosa, salivary glands and orbits (Pakbaznejad Esmaeili, Ekholm, Haukka, & Waltimo-Sirén, 2016). In spite of low radiation dose associated with dental panoramic radiography, the cumulative effects of the small doses can induce chromosomal abnormalities and gene mutations (Antonio, Nascimento, Lima, Leonart, & Fernandes, 2017). Radiation protection guidelines require that all exposure to diagnostic radiation should be clinically justified for each patient Therefore, there is no justification to perform panoramic radiography before a clinical examination for all new patients and for screening of asymptomatic patients (V. E. Rushton et al., 2001).

The use of bitewing radiography for the diagnosis of proximal caries is critical to avoid missing the disease. It was also concluded that panoramic radiography had a lower diagnostic accuracy of carious lesions than intraoral radiographs. Panoramic radiography showed a lower accuracy in the detection of anterior caries than intra oral radiography due to lower image quality of panoramic radiographs (Akkaya, Kansu, Kansu, Çağirankaya, & Arslan, 2006). A study by Wyatt, Farman, Orbeil, Silveira, & Scarfe (1995) concluded that most of the proximal molar caries were detected by bitewing radiographs. The detectability of carious molars by panoramic radiography was found to be inferior to that of bitewing intra oral radiography (خان, 2003).

A study by V. E. Rushton, Horner, & Worthington (1999) reported that 42% of dentists with dental panoramic radiography equipment carried out routine panoramic radiography for all new adult patients. Another study by Pakbaznejad Esmaeili et al., (2016) reported that one fourth of panoramic radiography performed lacked proper referral. A study by (V. E. Rushton et al., 1999) also reported that indiscriminate use of dental panoramic radiography resulted in a negligible or extremely low yield for most the patients. The total diagnostic benefits of any radiography should be weighed against the harm that the radiation exposure might cause to the patient(K Horner, Jacobs, & Schulze, 2013). Efforts should be made to reduce the radiation dose to the patient further despite the dose from panoramic radiography being reported to be low (Smith-Bindman et al., 2019). A study by Elmorabit & Ennibi (2021) concluded that dental panoramic radiography should be indicated only when necessary using accurate technique and following radiation protection guidelines to avoid unnecessary repetition, and to keep the radiation dose to the patient as low as reasonably possible.

Panoramic radiography is not reliable for accurately assessing the shape of the mandibular condyle (Schmitter et al., 2006). The main diagnostic tool for the assessment of temporo-mandibular joint is the comprehensive clinical examination of the masticatory system (Okeson & de Kanter, 1996). In addition, dental panoramic radiography was also found by Barclay, Hollender, Maravilla, & Truelove (1999) to be unreliable for the assessment of temporo-mandibular joint (TMJ) status. Magnetic resonance imaging (MRI) has been reported to be the gold standard for the examination of the temporo-mandibular joint. Magnetic resonance imaging gives a clear definition of the hard and soft tissue structures of the temporo-mandibular joint (Takagi, Westesson, Ohashi, & Togashi, 1998). A validity of 93% by Magnetic Resonance imaging was reported by Tasaki, Westesson, Kurita, & Mohl (1993) in a cadaveric study of the TMJ. The modality of choice, therefore, in the screening of arthrosis of the temporo-mandibular joint is Magnetic Resonance Imaging (Schmitter et al., 2006). However, the high cost played a big role in the limited indications of Magnetic Resonance Imaging as an additional diagnostic procedure (Dahlström & Lindvall, 1996). As a result, panoramic radiography is often used for the assessment of erosions of the mandibular condyle (Callender & Brooks, 1996). However, panoramic radiography did not lead to changes in the clinical diagnosis of the examined patients (Epstein, Caldwell, & Black, 2001).

Intra oral radiographs are commonly used for the diagnosis of various dental conditions in the clinical practice. They can use film technology or digital receptors during image acquisition. The intra oral radiographs fall into two main types: periapical and bitewings. Bitewing radiographs are the best imaging modality for the assessment of interproximal caries and alveolar bone levels. Periapical radiographs show the entire tooth and the supporting bone on a film. They are used to assess for

the extent of caries and periodontal bone loss. In addition, periapical radiographs assist in the diagnosis and treatment of bony and root pathologies (Williamson, 2006).

Teeth are multifunctional structure embedded to the maxilla (upper jaw) and mandible (lower jaw). Human beings have two generations of teeth in their lifespans: 20 primary (deciduous) and 32 permanent teeth. The deciduous teeth consist of 2 incisors, canines, and two molars. The permanent dentition consists of 3 molars (first, second and third). The Universal National System is commonly used for teeth identification. In the upper jaw, permanent teeth are numbered 1 through 16 from right to left. The deciduous teeth are labeled with letters A through J from right to left in the upper jaw. In the lower jaw, the permanent teeth are numbered 17 through 32 from left to right. The primary teeth in the lower jaw are labeled with letters K through T from left to right (Zohrabian, Poon, & Abrahams, 2015).

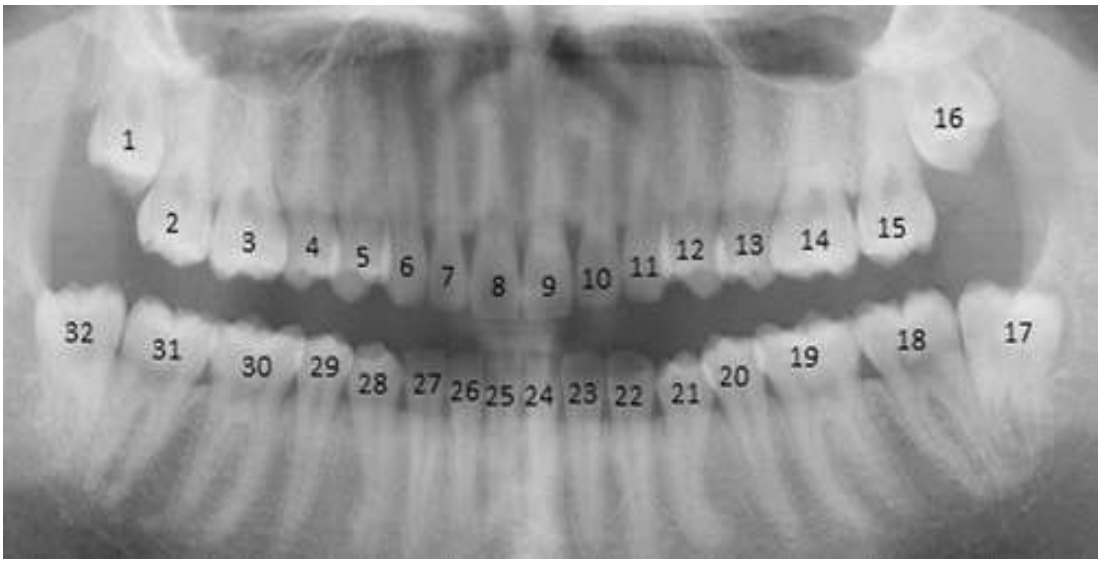

Figure 1.1: Adult teeth numbering based on the universal system (Source: (Sams, Dietsche, Swenson, DuPont, & Ayyala, 2021)

Figure 1.2: Pediatric teeth numbering in a 5 year old using universal system (Source: (Sams et al., 2021)

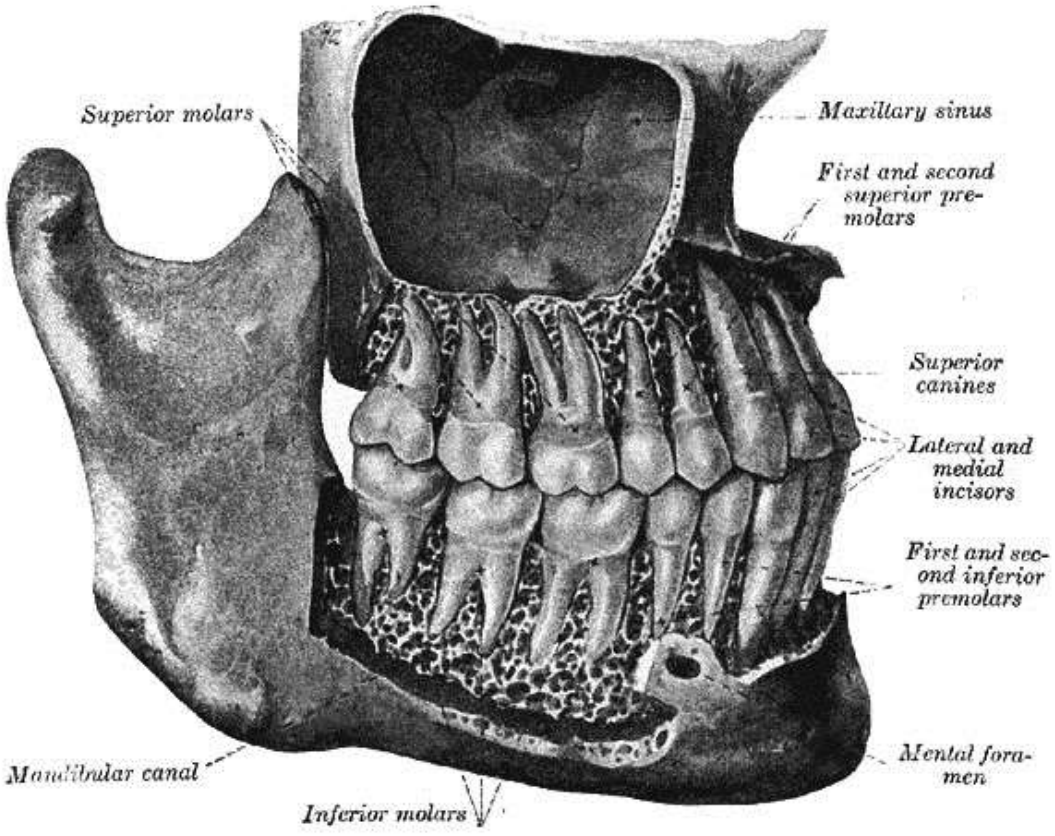

Figure 1.3: Picture showing permanent teeth (Source: (Morris & Tadi, 2020)

A panoramic radiograph is a fusion of two lateral projections and one postero-anterior projection of the face into one image. The radiograph is obtained with the x-ray source located posteriorly and the image detector located anteriorly to the patient with both of them rotating 180 degrees around the patient head. The x-ray beam is a narrow slit beam which is collimated vertically. This prevents radiation exposure to the unintended sites such as the eye. The beam is angled cranially which may cause distortion or magnification of the image. Correct patient positioning is important for quality diagnostic images. The patient usually stands, places their chin and forehead against the guides. The patient then holds the hand grips and bites the bite block. The tongue is raised to the hard palate and lips closed. Positioning lights are then used to confirm the vertical and horizontal alignment. The patient remains still for around 15 seconds of image acquisition. Patient cooperation is vital for a quality diagnostic panoramic image. Children younger than 5 years old and cognitively impaired patients are associated with higher rates of repetitions and poor image quality hence higher exposure to radiation. Panoramic radiography is also associated with motion, ghost and double image artifacts (Sams et al., 2021).

Dental caries is a multifactorial disease characterized by demineralization of the dental hard tissue (Nigel B. Pitts et al., 2017). Detection of dental caries by radiographs is suitable for advanced disease (Schwendicke et al., 2021). Clinical examination and intra oral radiography are important in the detection of dental caries. However, the two diagnostic tools are reported to be suboptimal in the detection of carious lesions (Dayo, Wolff, Syed, & Mupparapu, 2021). There is a good overall performance of visual caries detection (Gimenez et al., 2016). Bitewing radiography is the recommended technique for the detection of dental caries (Mystad, Svanæs, Larheim, & Gröndahl, 1995). Cone beam computed tomography (CBCT) was also

found to have a higher sensitivity than panoramic radiographs in the detection of dental caries (Walsh et al., 2022).

Panoramic radiography is also useful for the screening of some rare developmental and acquired anomalies around the mandibular and maxillary region. It is the initial screening tool for the assessment of condylar hyperplasia. Clinical examination is the assessment of choice for the diagnosis of exostoses. Panoramic radiography is also used confirm the diagnosis of exostoses. Panoramic radiography is also the imaging of choice for the visualization of calcified stylo hyoid ligament (D. K. White, Street, Jenkins, Clark, & Ford, 2003). The panoramic radiography is also the screening modality of choice for the assessment of naso-palatine duct cyst followed by Computed Tomography or Magnetic Resonance Imaging for further characterization of the lesions (D. K. White et al., 2003). Initial screening imaging tool for the diagnosis of stafne bone cavity is the panoramic radiography (Branstetter, Weissman, & Kaplan, 1999). However, Computed Tomography (CT) and magnetic resonance imaging (MRI) will characterize the lesion better than panoramic radiographs. Infectious bone process (Osteomyelitis) in the mandibular or maxillary region can be initially screened by panoramic radiography (Schuknecht, 2009). However, Computed Tomography and Magnetic Resonance Imaging are the modalities of choice in the assessment of the extent of the infection. Lateral oblique radiographs and panoramic radiography are modality of choice for the diagnosis of proliferative periostitis. Water's view radiographs and Computed Tomography is better than panoramic radiography in the diagnosis of antral pseudocyst (D. K. White et al., 2003).

A high quality panoramic radiograph can provide valuable clinical information for the diagnosis of dental pathologies (Parks & Williamson, 2002). A poor quality image

might require repetitions and the need for supplementary images. The poor quality images results from errors during patient positioning and image processing (K Horner, 1994). Unlike intra oral radiography, panoramic radiograph quality can be limited by tomographic blur, ghost artifact, superimposition and magnification of images (V. E. Rushton et al., 2001). Non diagnostic panoramic radiographs lead to misinterpretations, incorrect diagnosis, wrong treatment planning and additional radiation dose caused by unnecessary repetitions (K Horner, 1994). A report by Oakeshott, Kerry, & Williams (1994) recommends not less than 70% excellent films of panoramic radiographs in any imaging unit. A study by B. R. Choi et al., (2012) found 59% of panoramic radiographs with a normal or a higher level of image quality at a local dental clinic. Another study by Åkesson, Rohlin, Håkansson, Håkansson, & Näsström (1989) reported a lower image quality in panoramic radiographs from external clinics compared to the hospital done panoramic radiographs. However, patient positioning was not uniform in the above two studies. A study by Dhillon et al., (2012) also found 75.1% of panoramic radiographs to be diagnostically optimal.

1.2 Statement of the Problem

Radiation exposure is associated with a long-term risk of malignant neoplasm in the exposed person, as well as a low potential risk of hereditary diseases in their descendants (Teunen, 1998). A systematic review by Elmorabit & Ennibi (2021) reported that panoramic radiography can induce genotoxic and cytotoxic effects on epithelial cells with resultant cell death. The study also concluded that panoramic radiographs exposes patients to different kinds of health risks and therefore, should only be used when necessary and within the radiation protection guidelines. However, dental panoramic radiography is still the most frequently performed radiological procedure in the dental clinical procedure (Teunen, 1998).

A study by Pakbaznejad Esmaeili et al., (2016) reported that one fourth of panoramic radiography performed lacked proper referral. Another study by V. E. Rushton et al., (1999) found that 42% of dentists with panoramic radiography equipment carried out routine panoramic radiography on all new adult patients. The MTRH records and information department reported that 200 out 821 patients seen in the dental directorate are referred for a panoramic radiograph monthly (MTRH HMIS, 2020). Therefore, the diagnostic use of dental panoramic radiography needs to be justified. This study will therefore determine the correlation of panoramic and clinical findings of dental patients at MTRH (a tertiary hospital).

1.3 Research Question

What is the level of agreement between panoramic radiographic findings and clinical findings of dental patients referred for panoramic radiography at MTRH?

1.4 Aim and objectives of the study

The study was guided by both the general and specific objectives as follows:

1.4.1 General objective

To determine the correlation of panoramic radiographic findings and clinical findings among dental patients at Moi Teaching and Referral Hospital, Kenya

1.4.2 Specific objectives

i. To describe panoramic radiographic findings in patients with dental conditions referred for panoramic radiographs at MTRH
ii. To describe the clinical examination findings of dental patients referred for panoramic radiographs at MTRH
iii. To assess the level of agreement between panoramic radiograph and clinical examination findings in diagnosing dental conditions at MTRH

1.5 Justification

A systematic review by Elmorabit & Ennibi (2021) reported that use of panoramic radiography is associated with harmful genetic mutations to the exposed patients and their descendants. Another study by V. E. Rushton et al., (1999) also reported that indiscriminate use of dental panoramic radiography resulted in a negligible or extremely low yield for most of the patients. However, panoramic radiography is still frequently used in dental practice (Teunen, 1998). Therefore, the diagnostic benefits of using panoramic radiography should be weighed up against the potential detriment it might cause to the patient (K Horner, 2013)). A study by (J.-W. Choi, 2011) recommended further studies on panoramic radiography before its routine use in the national oral examination.

Two hundred patients (out of 821) at MTRH are referred monthly for OPGs (MTRH Health Records & Information Department, 2020). This study will therefore determine the correlation of panoramic findings and clinical findings at MTRH, Kenya. A high percent agreement between the two findings will advocate for the cautious and limited use of the imaging modality. This will therefore, prevent patients from unnecessary exposure to harmful radiation arising from panoramic radiography since a comprehensive clinical examination will be sufficient most the times.

1.6 Scope of the Study

This study was done to determine the correlation of panoramic radiographic findings and clinical findings of dental patients at MTRH, Kenya. The study was specifically conducted at the radiology and imaging directorate and the directorate of dentistry at Moi Teaching and Referral Hospital, Eldoret. The study focused on panoramic radiographs and clinical records of 93 patients. This study was conducted from August, 2019 to August, 2020.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Dental health conditions

Dental health is considered an essential part of overall health of an individual. Poor oral hygiene can lead to several conditions ranging from dental health diseases to heart disease, cancer, and diabetes. Dental cavities and gum disease are very common worldwide. Oral diseases are the most common non-communicable diseases (NCDs) causing several problems ranging from pain to death (Kassebaum et al., 2017). The Global Burden of Disease Study (2016) report estimated that oral diseases affected half of the world's population (3.58b). Severe periodontal (gum) disease, which may result in tooth loss, was estimated to be the 11th most prevalent disease globally (Jin et al., 2016).

Severe tooth loss and edentulism (no natural tooth) was ranked in the leading ten causes of Years Lived with Disability (YLD). In some Asian-Pacific countries, the incidence of oral cancer is within the top 3 of all cancers. Five percent of the total health expenditure and 20% of out-of-pocket health expenditure is associated with dental treatment in most high-income countries. The oral health care demands are beyond the capacities of the health care systems in most low-and middle-income countries (LMICs) (Needleman et al., 2018). The prevalence of oral diseases in most sub-Saharan countries has been increasing due to poor access to primary oral health care services, inadequate exposure to fluoride, heavy marketing of sugars, tobacco and alcohol (Petersen & Ogawa, 2016).

The State of Aging and Health in America (2007) report explained that dental health conditions are associated with pain, swollen or bleeding gums and loose teeth. However, it is important to understand the age related oral changes such as yellowing of teeth and reduced sensitivity which can mimic a serious dental condition (Jeannotte & Moore, 2007). A study by El Wazani, Dodd, & Milosevic (2012) reported that most of the patients with tooth wear presents to the hospital due to aesthetic reasons (59%) followed by sensitivity (40%), functional problems (17%) and pain (14%). Majority of the patients who presented with teeth wear are males, most of who presented with advanced disease. According to Al-omiri & Rcs (2007) majority of the patients with teeth wear are asymptomatic. They can also present with poor appearance and sensitivity of the teeth.

The most common presenting symptoms of dental abscess include fever, pain, edema, erythema, discharge and thermal hypersensitivity. The infection can spread along the fascial planes leading to severe airway obstruction. The patients can also present with xerostomia, neurological signs and halitosis. Older population is at risk of oral cancer, tooth loss, benign mucosal lesions and dental infections. Therefore, performing a focused oral examination and early referral of old patients can improve the prognosis of the dental diseases. Patients with oral diseases also present with discomfort, pain, disfigurement, tooth loss and even death (Colgan, 2001).

According to Chi, Neville, Krayer, & Gonsalves (2010) clinical oral examination can reveal findings suggestive of an underlying systemic disease. Therefore, early detection of periodontal inflammation and bleeding, mucosal changes and condition of the teeth can suggest an underlying systemic disease. Diseases such as crohn’s disease, anemia, lupus erythematosus and pemphigus vulgaris can be diagnosed early

through oral examination. Oral finding such as glossitis, mucosal pallor or oral candidiasis can be suggestive of anemia. Another study by Burge, Frith, Juniper, & Wojnarowska (1989) also explained that systemic lupus erythematosus could present with oral lesions such as white lesions, erythema and ulcerative lesions. A study by Chi et al. (2010) also reported that oral findings such as deep linear ulceration, muco-gingivitis diffuse mucosal swelling can be early findings of crohn's disease.

Dental abscesses commonly presents with swelling, tenderness and localized pain (Seow, 2003). Patients with oral squamous cell carcinoma present with dysphagia and odynophagia, local pain and burning sensation. Oral squamous cell carcinoma can also present as a non-healing ulceration and crust (Radfar & Sirois, 2003). A study by Capello (2008) reported that some of the most important dental clinical presentations include pain, bleeding, new growths, malocclusion, paresthesia and chewing problems. Chronic oral disease can lead to weight loss due to decreased oral intake. Facial examination is important to detect any masses, asymmetry and skin lesions.

A study of oral health in Kenya by Kaimenyi (2004) reported a 1-10% prevalence of periodontitis while that of ulcerative lesions was 0.12%. Cleft lip and palate were the most common birth defects while oral candidiasis was the most prevalent oral lesion among the HIV/AIDS patients. Another study of oral health status of rural Kenyan elderly population by Fukuda, Hayashi, Toda, Kaneko, & Wagaiyu (2021) concluded that poor oral health status affects the general health of the elderly population. Manji, Baelum, & Fejerskov (1988) reported dental caries and periodontal diseases as the most common causes of tooth loss in Kenya. Another study by Pengpid & Peltzer (2019) also reported a 13.7% prevalence of poor oral health in a Kenyan population.

A study by Kogi (2009) reported that the most common dental conditions in Kenya include dental caries, periodontal diseases, oral cancer and fluorosis.

The most common indications for panoramic radiography in the dental emergency department include mandibular trauma, dental pain, facial swelling, temporo mandibular pain and nonspecific facial pain (Sklavos, Beteramia, Delpachitra, & Kumar, 2019). The formation of tonsilloliths, tooth loss and periodontal bone loss is also associated with a normal ageing process (Gurbuz, Gungor, & Hatipoglu, 2021).

2.1.1 Dental caries (tooth decay)

Dental caries results when microbial bio-film (plaque) converts the free sugars contained in food substances into acids that disintegrate tooth enamel and dentine (Loesche, 1996). High intake of free sugars and deficient exposure of the tooth to fluoride cause the development of holes known as cavities. In advance disease the cavity results in the loss of the tooth and gum infection (Chenicheri, R, Ramachandran, Thomas, & Wood, 2017).

There is a high prevalence of dental caries worldwide. A study by Eigbobo & Etim (2015) observed 42.5% dental caries with occlusal surface being commonest occurrence site in a hospital based study in Nigeria. The overall pooled prevalence of dental caries was reported to be high in Eritrea (65%), followed by Sudan (57.8%) and a low prevalence in Tanzania (30.7%) (Teshome, Muche, & Girma, 2021). However, Simangwa, Åstrøm, Johansson, Minja, & Johansson (2019) reported a low prevalence (8.8%) of dental caries among masai population in rural Tanzania. Prevalence of caries was 37.5% in Nairobi west and 24% in Mathira west reported by Gathecha, Makokha, Wanzala, Omolo, & Smith (2012) in Nairobi, Kenya. Another

study by Masiga & M'Imunya (2013) reported a 65% prevalence of dental caries among HIV- infected children.

A study by Amrollahi, Shah, Seifi, & Tayebi (2016) reported that dental caries affect 90% of adult population in the United States. However, dental caries is a preventable disease which can also be treated or reversed if detected early (Cury & Tenuta, 2009). A study by Lira, Giraldi, Neves, & Feijoo (2014) concluded that radiography is a standard tool for complimentary diagnosis of dental problems that are difficult to detect via visual inspection. Proximal dental caries is often diagnosed by radiography since it is hard to be detected by clinical examination

According to An, An, & Choi (2007) the panoramic radiographs detectability of dental caries in the molar area is comparable to that of intraoral radiographs. The mean positive and negative predictive values of periapical, bitewing and panoramic radiographs for the detection of dental caries in molar area were nearly identical. 24.2% of dental caries was missed during dental clinical examination. Panoramic radiograph showed a 23.1% higher detectability of dental caries than clinical examination (M.-J. Shin et al., 2010).

A study by Feu, de Oliveira, de Oliveira Almeida, Kiyak, & Miguel (2010) reported that early detection of dental caries is important in dental patient's management. Bitewing radiography is the most widely used tool for caries detection with a diagnostic accuracy. However, bitewing radiography causes patients discomfort and high radiation dose due to need for image retakes (Qu, Li, Zhang, & Ma, 2011). Panoramic radiographs are widely used with a lower small radiation dose, better simplicity of application, less time required to perform and patients comfort than cone beam computed tomography (CBCT) (H. S. Shin et al., 2014). A study by Akkaya et

al. (2006) also explained that panoramic radiography was more effective for children, handicapped and elderly patients compared to intraoral radiography.

A study by Clark & Curzon (2004) reported that clinical examination identified significantly more carious occlusal surfaces than panoramic radiography. However, panoramic radiographs identified more carious approximal surfaces than clinical examination. It is important to gain needed expertise for the detection of dental caries on radiographs. Dental caries are sometimes difficult to visualize intra orally and diagnosis rely on radiographs (A. Haghanifar, 2022). A study by Galcerá Civera, Almerich Silla, Montiel Company, & Forner Navarro (2007) noted that the use of radiographic tools increase the number of caries diagnosed. The prevalence of approximal and occlusal dental caries increases when radiographs are used in addition to clinical examination (Hopcraft & Morgan, 2005).

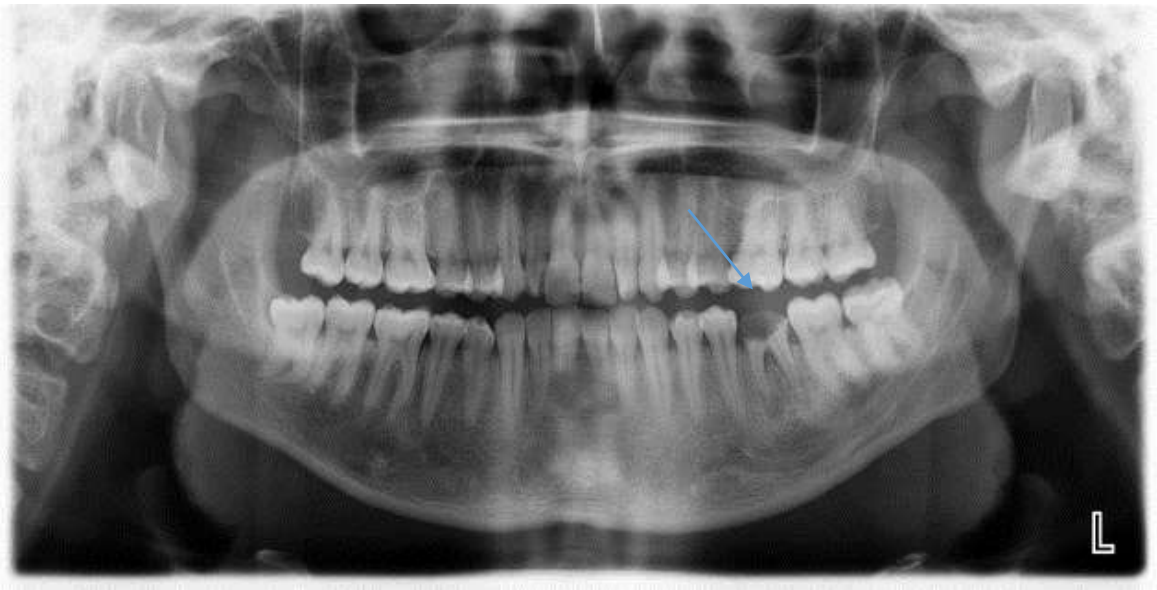

Figure 2.1 an example of a panoramic radiograph showing dental caries (Radiopaedia, 2019)

2.1.2 Tooth Impaction

An impacted tooth is one that fails to erupt into the dental arch within the expected developmental window. The tooth gets stuck under the gum and can be positioned against another tooth, bone or soft tissue (Friedman, 2007).

A study in Northern India reported a prevalence of 18.8% (tooth impaction), excluding third molars (Patil & Maheshwari, 2014). Another study in India by Prashaanthi N, Santhosh Kumar M P, & Shantha Sundari K K (2020) reported more impacted teeth in males (57.5%) than in females (42.6%) observed radiographically. Another study by Chu et al. (2003) reported 28.3% tooth impaction in a Hong Kong Chinese population with the most common being the mandibular third molars (82.5%) followed by maxillary third molars (15.6%) and maxillary canines (0.8%). However, a retrospective study in the Eastern province of Saudi Arabia reported a prevalence of 13.2% (tooth impaction) with maxillary canines (50.4%) being the most common teeth followed by upper second premolars (18.2%) and lower second premolars (12.2%) (Alamri, Alshahrani, Al-Madani, Shahin, & Nazir, 2020).

In Africa, tooth impaction reported a high prevalence in most of the countries. A study by Ishwarkumar & Pillay (2019) reported a high prevalence (81%) of impacted third molars in a South African Indian population. The prevalence of tooth impaction in Dar es salaam was observed to be 21.3% with 14.5% of the lower third molar were impacted (Lema, 2002). A study by Mwaniki D (1996) reported an incidence of 15.8 per 1000 patients in a National Hospital in Kenya. There is seven times more common tooth impaction in the urban Nigerian Population (22.8%) than in the rural areas (3.1%) (Olasoji & Odusanya, 2000).

The causes of third molar impaction was mentioned to include: hereditary factors, lack of sufficient eruption force for third molars, reduced growth at the posterior region of the mandible and insufficient mesial movement of the dentition of modern men due to lack of interproximal attrition. Third molar impaction reported a high prevalence in high income countries (Lema, 2002).

A study by Katsnelson, Flick, Susarla, Tartakovsky, & Miloro (2010) reported that panoramic radiographs are useful for predicting the location of impacted maxillary canines and the subsequent surgical approach required for exposure and orthodontic appliance attachment. In a study in India, panoramic radiography was observed to being able to reliably determine the bucco-palatal position of the impacted canines when they lie in the middle and coronal zones (S. Kumar et al., 2015). A study by Margot et al. (2020) also reported that panoramic radiography was a valuable tool to decide between early intervention and regular follow-up of impacted canines. A study by Sudhakar, Patil, & Mahima (2009) reported the usefulness of panoramic radiographs in the localization of impacted permanent maxillary canines. Panoramic radiographs are reliable in the evaluation for impacted maxillary canines (Senisik, Karacin, Yildirim, & Cesur, 2019).

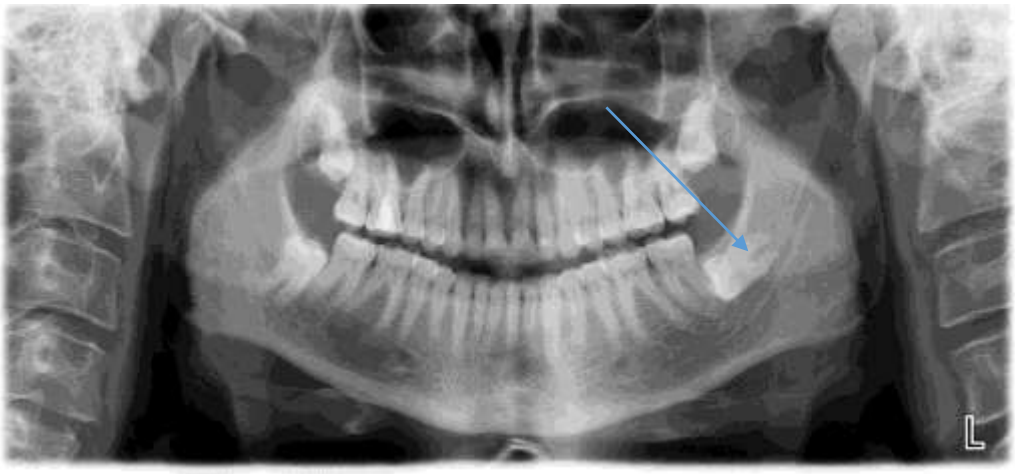

Figure 2.2 an example of a panoramic radiograph showing tooth impaction (Radiopaedia, 2021)

2.1.3 Periodontal disease

The periodontium supports the teeth within the jaw bones and provide sensory information relating to the function of chewing. The components of the periodontium include: the alveolar bone, cementum, the periodontal ligament, and the gingiva (gum) (Bortoluzzi et al., 2012). Acute and chronic periodontal disease is one of the most common health problems in humans. There is some aspect of deterioration of the periodontal tissues seen in almost all adults. The periodontal tissues are also subject to inflammatory, degenerative, dysplastic and neoplastic pathological changes. Periodontal diseases affect about 20-50% of global population, in both developing and developed world (Dumitrescu, 2016)

Panoramic radiographs play a key role in the diagnosis of periodontal diseases. It provides critical information regarding alveolar bone level, widening of periodontal ligament, crestal bone height and irregularity, and crown root ratio which cannot be found in clinical examination (Tugnait, Clerehugh, & Hirschmann, 2000). A study by J.-W. Choi (2011) also reported a higher detection rate of 31.9% for periodontal diseases by panoramic radiography than clinical examination. Detection of calculi deposition using screening panoramic radiograph was reported to be higher than that of clinical examination by 7.4% (An et al., 2007).

Periodontal diseases are prevalent both in high and low income countries affecting between 20% and 50% of the global population. Periodontal disease is associated with smoking, poor oral hygiene, diabetes mellitus, medication, age, hereditary and stresses. Diabetic patients had higher frequencies of inflamed buccal/lingual gingival units, gingival recessions and sites with attachment loss of ≥2 mm (Ryan, Carnu, & Kamer, 2003)

A study by A. Palmer (2013) reported 47.2% of adults aged 30 years and older have some form of periodontal disease in the United States with periodontal disease noted to be increasing with age. It is also noted that 70.1% of adult 65 years and older have periodontal disease. Another study by Nazir et al. (2020) who reviewed the global prevalence of periodontal disease reported that the distribution of periodontal disease increases with age. Periodontitis was the most common in older persons and in population from high-income countries. Prevalence of periodontal disease in coal mine workers in Turkey was high. Their distribution and severity is strongly influenced by risk factors and host susceptibility (Cengiz, Zengin, Içen, & Köktürk, 2018)

There is a high prevalence of periodontal disease in Turkish pregnant women and associated with advanced gestation, obesity and low income population (Vogt, Sallum, Cecatti, & Morais, 2012). The global prevalence and severity of dental caries has declined. However, the prevalence of periodontitis is still high (Frencken et al., 2017). A study by Nocini, Lippi, & Mattiuzzi (2020) reported that periodontal disease is the 12th prevalent pathology globally. There is an increased incidence, prevalence and disability–adjusted life years (DALYs) of periodontal disease during the last 30 years. The prevalence of aggressive and chronic periodontal disease is higher in Latin American population than in developed countries. Tobacco smoking, diabetes and poor oral hygiene are associated risk factors (Oppermann, 2007).

The prevalence of mild to moderate periodontitis was 26.2% while that of severe periodontitis was 19%. Urban population was reported to have the highest prevalence than their rural counterpart with a lower prevalence in the female than male Indian population (Janakiram, Mehta, & Venkitachalam, 2020). A study by Mankia et al.

(2019) also reported an increased prevalence of periodontal disease in patients with early rheumatoid arthritis.

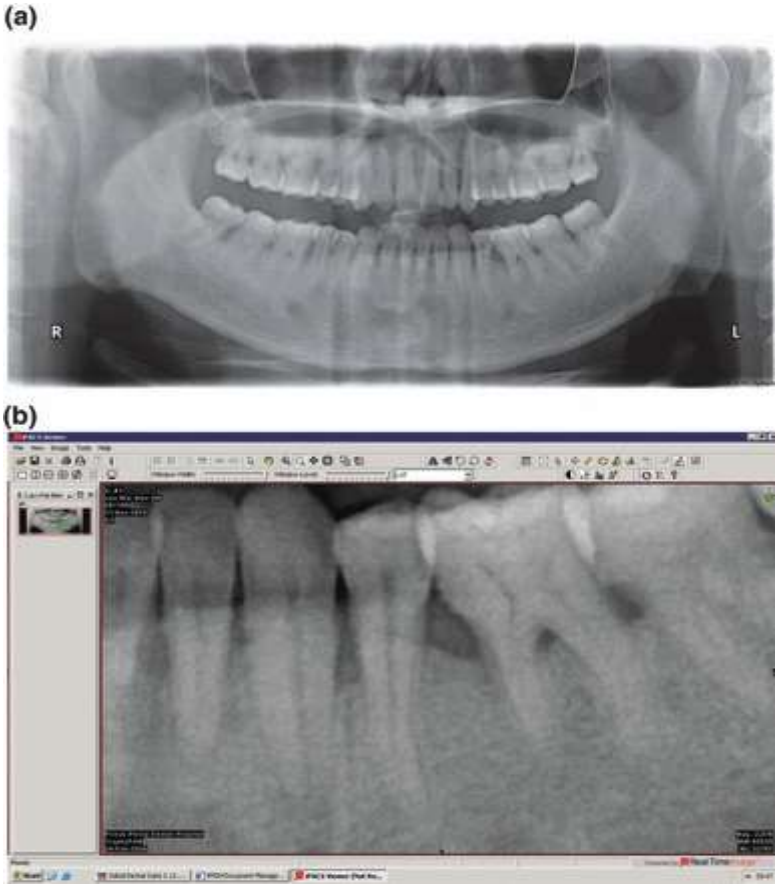

Figure 2.3 an example of a panoramic radiograph showing periodontal disease (Corbet & Lai, 2009)

2.1.4 Trauma of the Oro-facial Tissues

Maxillofacial trauma is becoming a leading medical problem in emergency departments worldwide because of increased industrialization and urbanization. Maxillofacial trauma may be fatal due to its proximity to the brain, the respiratory and digestive tracts. Panoramic radiographs can provide critical information in the diagnosis of fractures involving the maxilla and the mandible. Most fractures occur from motor vehicle accidents; other most frequent causes included assault, gunshot, and fall injuries. Maxillofacial fractures involved mostly the mandible, zygomatic

complex and the maxilla. Majority of the mandibular fractures occur at the parasymphysis, angle and the condyle (Elarabi & Bataineh, 2018).

A study by Markowitz, Sinow, Kawamoto Jr, Shewmake, & Khoumehr (1999) reported that radiographs significantly diagnosed more angle fractures than axial or coronal computed tomography (CT) views (100% vs. 60%). The study noted that fractures are easily missed on panoramic radiographs when there is no displacement. Panoramic radiography is the modality of choice in clinically stable and cooperative patients with fractures of the mandible. However, coronal computed tomography (CT) is recommended whenever panoramic radiography is equivocal. Another study by Moilanen (1984) reported 64% fractures of the middle third of the facial skeleton. However, the use of panoramic radiographs alone was reported inadequate for the detection of multiple fractures outside mandible. Panoramic radiography was considered useful prior to maxillofacial surgery in the evaluation of fractures of the mandibular angle and body, and in suspected jaw fractures. However, panoramic radiography is not very reliable in the evaluation of temporo-mandibular and condylar trauma. It is only second to computed tomography scan in the assessment of maxillary fractures. Computed tomography scan gives better definition of changes involving the alveolar bone and teeth (Keith Horner, 2012).

The most common (60-70%) maxillofacial fractures observed in emergency rooms are mandibular fractures. They usually present with loss of mandibular function and malocclusion. However, there is variation of epidemiology of maxillofacial fractures based on socio-economic status and geographical differences. Computer tomography is the tool of choice for maxillofacial fractures since panoramic radiography is limited to isolated lesions. The maxillofacial fractures are usually caused by road traffic

accidents (40-42%) followed by assaults, falls, sports and work related injuries. Mandibular fractures are classified as: Horizontal branch, angle, symphysis/parasymphysis, ramus and condylar fractures (Nardi et al., 2020).

A study by Albassal, Al-Khanati, & Harfouch (2021) reported that panoramic radiography is the most sensitive and informative tool in the detection mandibular fractures. However, it has some limitations in the detection of condylar fractures. A thorough clinical examination prior to panoramic radiography followed by computed tomography scan was recommended for an equivocal symptomatic patient. Another study by Schubert (2002) concluded that proper diagnosis of mandibular fractures is important for proper treatment of the fractures. Panoramic radiography is the standard tool for the evaluation of mandibular fractures. Panoramic views are usually combined with postero-anterior or reverse Towne's views for a higher yield. However, new multi-slice computed tomography scans offer better resolution and multi-planar evaluation of mandibular fractures compared to panoramic radiography.

According to Howson, Rajaram, Maranzano, & Clark (2015) panoramic radiography is the most useful tool for the evaluation of mandibular fractures. It is less prone to positional errors hence less retakes of the radiography. Therefore, panoramic radiography is most of the in line with ALARA (As Low as Reasonably Achievable) principle of radiation exposure. A study in India by Tejasvi et al. (2016) reported that significant numbers of fractures go undetected. However, use of panoramic radiography was still reported to improve detectability of mandibular fractures. Both panoramic digital radiography and panoramic inverted digital radiography were observed to be reliable in the detection of maxillofacial fractures with no significant difference in their diagnostic accuracy.

Diagnostic imaging provides additional information in the detection of maxillofacial fractures in trauma patients. A study by Scarfe (2005) concluded that diagnostic imaging is influenced by political, economic, social and technological factors at different levels of service provision. Another study in a Kenyan Hospital by Kihara, Ochola, Wagaiyu, & Chindia (2020) also noted the importance of using panoramic radiography in the examination of mandibular fractures. The combination approach was noted to reduce the number of retakes hence low radiation dose to patients. A study in Korea by Son, Yoon, Kwon, An, & Lee (2021) concluded that mandibular fractures are the most common injuries encountered in the maxillofacial region. They suggested the use of Cone Beam Computed Tomography (CBCT) and panoramic radiographs for the diagnosis of such fractures. A detection tool called YOLO-based deep learning tool was suggested to improve diagnostic accuracy of panoramic radiography.

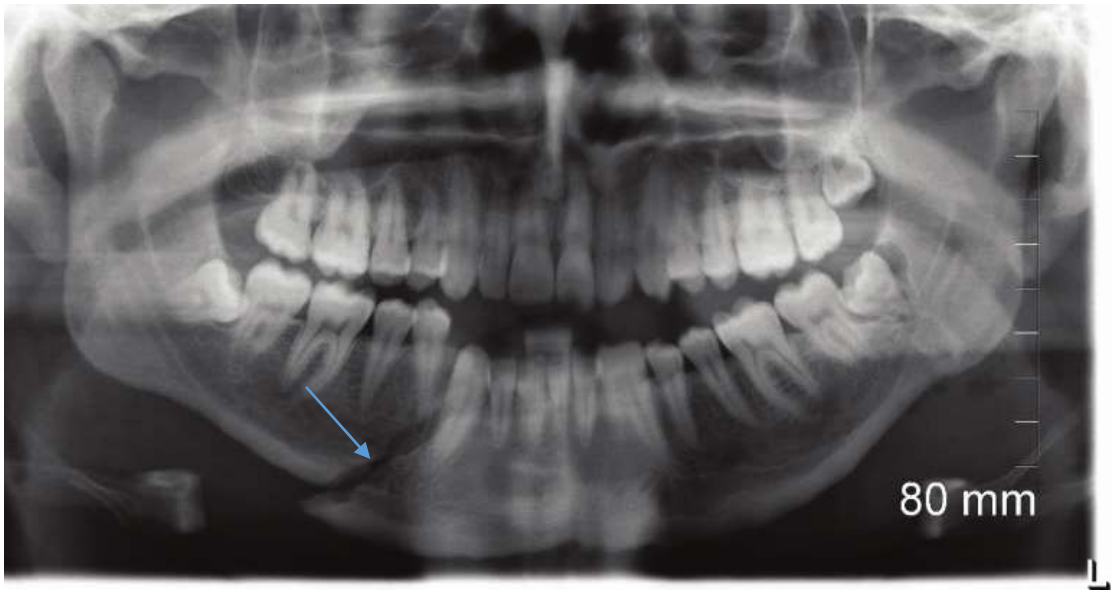

Figure 2.4 an example of a panoramic radiograph showing mandibular fracture (Radiopaedia, 2019)

2.1.5 Periapical lesions

Periapical lesions occur in the region surrounding the root of a tooth. Most of the periapical lesions results from necrotic pulp and occurs within the alveolar bone. Majority of periapical lesions are cysts or granulomas. A statistically significant difference in radiographic and clinical diagnosis of periapical cysts has been reported, with an overall diagnostic accuracy of panoramic radiography found to be 54.3% (Gbadebo SO, Akinyamoju AO, 2014). Dentists make wrong diagnosis clinically in 43% of the time. Wrong diagnosis are made by periodontists(41.2%), endodontists (42.2%), general dentists (42.2%) and maxillofacial surgeons 42.8% of the time (Sreedharan, Govinda, Krishnan, Krishna, & Reports, 2012)

Panoramic radiography was found to have low reliability in the diagnosis in the diagnosis of periapical cysts. Therefore, pathological confirmation is highly recommended after surgical removal of periapical cysts. The most common periapical pathology encountered by endodontist is apical periodontitis which results from infiltration by microbes from deep dental caries into dental pulp. However, apical periodontitis can also be as a result of trauma. Sometimes apical periodontitis can be self-limiting; however, it can complicate to form periapical cyst, abscess, granuloma or scar. Most of these lesions are radiographically indistinguishable. Histopathological examination is the gold standard for the diagnosis of periapical lesions (Paula-Silva, Wu, Leonardo, Bezerra da Silva, & Wesselink, 2009).

Periapical lesions are commonly visualized using periapical and panoramic radiographs. Ultrasonography is used as an alternative modality in the diagnosis of periapical lesions in the anterior teeth (Arslan, Demir, Berker Yıldız, & Yaşar, 2020). Treatment failure can be diagnosed radiographically or sometimes clinically due to

pain. A study by (Saatchi, 2007) concluded that periapical diseases can produce an acute or chronic inflammation of the periapical tissue. The disease is 90% of the time a complication of deep dental caries or as a result of injuries, dental procedures, teeth grinding and abrasion. Another study by (Sigurdsson, 2003) also explained that chronic apical periodontitis is as a result of necrosis of the pulp usually asymptomatic, but can course pain or tenderness on percussion. Chronic disease is diagnosed as periapical radiolucency radiographically.

According to Ridao-Sacie, Segura-Egea, Fernández-Palacín, Bullón-Fernández, & Ríos-Santos (2007) the radiolucency on radiographs is as a result of chronic inflammatory process. A study by Naturales et al. (2018) reported that the main aim of endodontic treatment is to aid the reparation process through proliferation and differentiation of cells to replace damaged cells following inflammation. The reparation process following periapical disease does not restore anatomy to its original form. Another study by Wesselink (2002) observed that the healing process of periapical disease had a variable course. It usually takes between 6 months to several years for healing to be appreciated radiographically. A study by Zhang et al. (2015) also reported a significant reduction of periapical lesions 2 years after endodontic treatment.

A study by Alqaied (2012) reported that a combination of clinical, radiographic and histopathological findings is useful for the detection of periapical lesions. However, some lesions might easily mimic infections and necrosis of the periapical lesions. He added that 90.4% of the periapical lesions are related to apical periodontitis. Periapical granulomas (51.5%) are the most detected lesion in the region followed by periapical cysts (2.08%). Another study by Gbadebo SO, Akinyamoju AO (2014)

reported that periapical lesions are the most pathological conditions affecting the alveolar bone with granulomas (68.3%) being majority of the periapical lesions. They also concluded that specimen should be submitted for histopathological evaluation following surgical procedures to enhance diagnostic accuracy.

A study by Al khasawnah et al. (2018) observed that calcium hydroxide iodoform silicon oil paste is effective in the non-surgical clinical management of periapical lesions. It results in short healing time with avoidance of tooth extraction. Another study by Lorduy, Marrugo, Aguilar, & Ariza (2018) concluded that majority of dental surgical procedures are for the treatment of periapical pathologies. Therefore it is important for dental practitioners to understand the epidemiology of periapical lesions. A study by Bergenholtz, Kvist, Bergenholtz, & Kvist (2009) also reported that in dental clinics, the diagnosis of apical periodontitis is done both clinically and radiographically. However, histo-pathological examination is the gold standard examination of periapical lesions. Cone Beam Computed Tomography offers are multiplanar examination and better resolution than conventional radiography. However, it needs more time for interpretation and more radiation dose for the exposed patient is a big concern.

A study by Bansal, Kamboj, Narwal, & Devi (2022) reported that the presence of periapical disease influences the success or failure of non-surgical endodontic treatment of teeth. However, early detection of the disease can change the success rate of the dental implants. In another study by Rosenberg et al. (2010) it was found that it is difficult to distinguish a cyst from a granuloma radiographically. However, differentiating a cyst from granuloma does not alter the rate of healing post treatment. Another study by García, Sempere, Diago, & Bowen (2007) also observed that

majority of intra-radicular infections are produced by apical periodontitis. The infection usually persists for a long time as a post endodontic periapical lesion following cleansing and filling of canal. Chronic inflammation of the periapical lesion is the most common pathology affecting the alveolar bone of the jaws. Periapical granuloma, radicular cysts and scars are the main histological sites of the periapical lesions. The granuloma was observed as the most common followed by cysts and scars.

A study by Siddiqui et al. (2019) recommended the use of Resolvin (RvD2) in the treatment of periapical periodontitis. The treatment resolved inflammation and promotes calcification in the apex of the tooth and consequently healing of the periapical lesion. Another study by Karamifar (2020) reported that periapical surgeries are the treatment of choice for periapical lesions. The procedures include: surgeries, abscess drainage, corrective surgeries and root removal. They reported that around 10 to 15% of endodontic treatment results in the persistent or recurrence of the disease. Failure of the procedure is associated with pain on mastication, draining fistula and increase in size of the radiolucency. Surgery is therefore indicated for such cases where endodontic treatment has failed.

A study by Chapman et al. (2013) periapical lucencies are usually incidentally found on head and neck imaging. Majority of the lucencies are caused by apical periodontitis. The advance disease can spread to the orbits, sinuses, deep fascial spaces of the neck and intracranial regions. Although majority of the periapical lesions are due to apical periodontitis, some are caused by non-infectious causes as seen on radiographs and Cone Beam Computed Tomography. There is improvement in the morbidity and mortality with early detection and prompt treatment of the

periapical disease. Another study by Peters & Frcd (2003) the most common pathological periapical lesions within the alveolar bone are those resulting from the necrotic dental pulp. Majority of the periapical lesions are cysts, abscesses and granulomas. Periapical tissue is sent for histo-pathological review if there are concerns about the clinical diagnosis.

Two periapical radiographs were needed to supplement the findings of clinical examination and panoramic radiography for a high diagnostic yield. There is an increase in the diagnostic use of panoramic radiography for the dental patients in the Great Britain, the USA and in Sweden. However, periapical radiography was reported to be superior to panoramic radiography in the examination of maxillary premolar and mandibular region. However, the two modalities were comparable in the assessment of marginal bone loss (Rohlin & Åkerblom, 1992).

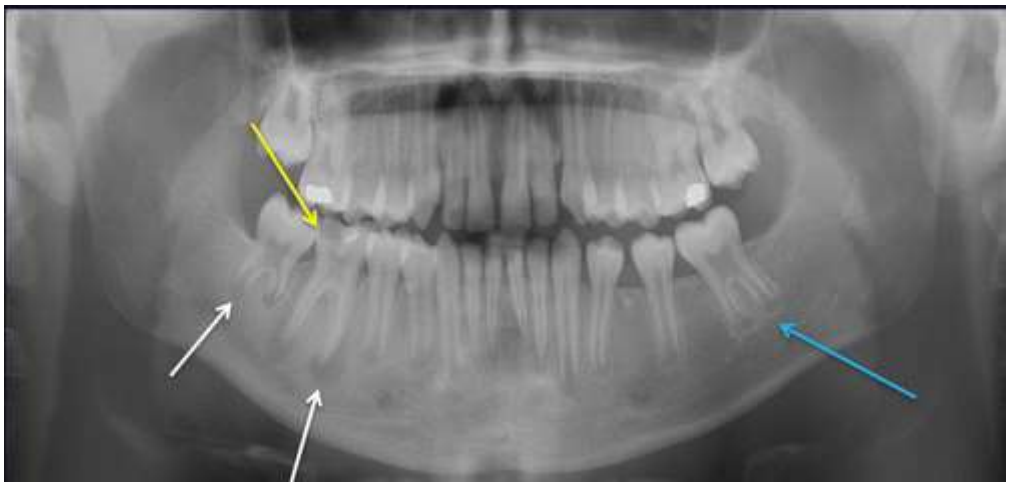

Figure 2.5 an example of a periapical abscess (white arrow) (Source: Sams, Dietsche, Swenson, DuPont & Ayyala, 2021)

2.1.6 Temporo-mandibular joint disorders

The Temporomandibuar joint (TMJ) is a hinge joint that connects the jaw to the temporal bone of the skull anterior to the ear. Temporomandibular disorders (TMDs) are complex group of neuromuscular and musculoskeletal conditions involving TMJ and surrounding structures. Up to 15% of the population is affected by TMDs with majority falling between 20 and 40 years of age. TMD is simply classified as being intra and extra articular disorder (Gauer & Semidey, 2015). A study by Gonçalves et al. (2011) reported that patients with TMDs commonly presents with jaw dysfunction and pain, headache, earache and facial pain. TMD is the commonest cause of non-dental pain in the orofacial region. The most common syndrome associated with TMD includes disk derangement disorder, osteoarthritis, myofacial pain disorder, autoimmune disorder, trauma, dislocation and neoplasia.

The prevalence of temporo mandibular disorders globally is 10% with age range from 20 to 40 years (Ohrbach & Sharma, 2021). The most common cause of non odontogenic pain in the oro facial region is the tempo mandibular disorders. The patient usually presents with associated symptoms such as headaches, tooth aches and otalgia. TMJ sounds during restriction of mandibular movements and jaw function is part of the signs and symptoms. Temporo mandibular disorders include subluxation, degenerative joint disease and disk displacement disease (Ahmad & Schiffman, 2016). There is a higher prevalence of temporo mandibular disorders in patients with malocclusion (Manfredini et al., 2016). There is insufficient evidence to support the relationship between temporo mandibular disorders and orthodontic interventions (Luther, Layton, & Mcdonald, 2016). Internal derangements of temporo mandibular joint may cause facial asymmetry. Panoramic radiography can demonstrate condylar changes such as condyle flattening, vertical ramus asymmetry and osteophyte

formation (Westesson, Eriksson, & Kurita, 1989). A study by Wang et al. (2013) reported increased temporo mandibular joints osteoarthritis in adolescents receiving orthodontic treatment. Clinical examination should include assessment of TMJ sounds, deviation of mouth opening, joint tenderness and pain during movements (Malik, Singh, George, Kakkar, & Vaid, 2020).

A study by J. Palmer & Durham (2021) reported that TMD is associated with several triggers which include social, environmental, biological, emotional and cognitive factors. There is a twofold increase in TMD in patients suffering from depression. Female smokers younger than 30 years were associated with an increased risk of temporo mandibular disorders. Another study by Okeson & de Kanter (1996) reported 50% of TMD is associated with musculoskeletal conditions.The most common intraarticular TMD is articular disk displacement. There are several conditions which can present with pain hence mimic TMD; these include dental caries, abscesses, oral lesions, muscle over use, trauma/dislocation and maxillary sinusitis (Cooper & Kleinberg, 2007)). The diagnosis of TMD is mainly by history & physical examination. Panoramic radiography is the initial imaging study. However, MRI is the modality of choice for comprehensive examination. MRI is associated with 20% false positive findings in asymptomatic patients (Rawlani et al., 2018). A study by Nascimento et al. (2019) observed that injection of local anesthetic by physicians or dentists to anesthetize the auricotemporal nerve region will aid in diagnosis of TMD. Another study by Ribeiro, von Meusel, Gaviolli, Silveira, & Cericato (2018) explained that treatment of TMD involves a multidisciplinary approach to achieve complete resolution of the disorder. Surgical approach is an option for patients who did not respond to conservative treatment.

A study by Gauer & Semidey (2015) concluded that non pharmacological management of TMD is crucial for alleviation of symptoms. Another study by Hodges (1990) concluded that the most common morbidity associated TMJ syndrome is pain. Fourty six percent (46%) of patients with TMJ syndrome presented with headache, neck pain or sinus while 48% presented with ear pain. Conservative treatment was successful in the management of TMJ syndromes in 75% of the time. Comprehensive medical history and physical exam is important in the evaluation of all patients with head and neck pain or ear pain. Intractable TMJ pain can be prevented through early diagnosis and treatment of the TMJ syndrome. Patients who fail to respond to conservative management require surgery.

A study by Mz, Sj, Rjm, Sloan, & Am (2009) noted that TMJ syndrome was the most common temporo mandibular disorders. Myofacial pain dysfunction, myofacial pain dysfunction syndrome, craniomandibular dysfunction and facial arthromyalgia are some of the synonyms often used for the TMJ syndrome. The study concluded that there is no statistically significant difference in the effectiveness of active treatments and stabilization splint therapy.

A study by Murphy, MacBarb, Wong, & Athanasiou (2013) also reported that MRI had a key role in trauma of TMJ due to its ability to diagnose soft tissue injuries well. A study by (Kaya et al., 2010) reported that ultrasonography is useful in the evaluation of suspected cases of inflammation or internal derangements. However due to its operator dependency, it entails a high degree of inter-observer variability. Arthrography has been replaced with MRI due to its many associated complications.

The management of patents with temporo mandibular disorders (TMD) involves a multidisciplinary approach with treatment tailored towards individual patient's needs (Dimitroulis, 2018). Patients usually presents with pain in the muscles of mastication, exacerbated by lengthy dental examination and procedures. Most of the patients with mild TMD require jaw rest and soft diet. About 70% of general population suffers from a form of TMD. However, about 75% of them are asymptomatic. Only 5% with symptomatic disease actually seek treatment, majority being female. Majority of TMD occur in early adulthood (Ahmad & Schiffman, 2016).

A study by Ahmad & Schiffman (2016) reported that 90% of TMD patients require non-surgical treatment. The most common TMD are osteoarthritis, myofacial dysfunction and internal derangement. The most prevalent of the TMD is myofacial dysfunction and pain. Another study Ghurye & McMillan (2015) also reported that myofacial pain and dysfunction is a muscular disorder caused by oral parafunctional habits and sometimes related to psychogenic disorders. A study by Forssell, Altergren, Bakke, Bjornland, & Jääskeäinen (2016) also concluded that internal derangement is a TMD where the articular disk is abnormally positioned resulting in clicking and restriction of normal range of movement.

Osteoarthritis is a degenerative disorder affecting the articular cartilage commonly seen in older patients. The causes of TMD include psychogenic, trauma and malocclusion. Genetic predisposition has also been reported as a cause of TMD. Majority of patients with TMD presents with pain followed by clicking noises in the joint especially in asymptomatic patient. Restricted jaw function causes difficulties in daily activities of patients. Other less common symptoms in patients with TMD include neck and shoulder pain, headache, earache and tinnitus (Dimitroulis, 2018)

A study by Ahmad & Schiffman (2016) also noted that correct diagnoses involve history taking, clinical examination and appropriate imaging to confirm the diagnosis of TMD. High level OPG is considered as important initial investigation of TMD. It is useful in detection of degenerative, traumatic and pathological disorders in mandibular condyle. MRI, however, is the tool of choice in diagnosis of internal derangement of TMJ. Another study by Larheim, Abrahamsson, Kristensen, & Arvidsson (2015) reported that Cone Beam Computer Tomography is frequently used due to its high resolution and multiplanar options in the diagnosis of condylar pathologies. A study by Song, Lee, Huh, & Park (2020) reported that osteoarthritis is a degenerative disorder causing bony changes and inflammatory conditions. It causes cartilage destruction since the catabolic process overpowers anabolic chondrocytes. Patients with osteoarthritis of TMJ present osteophytes, sclerosis, sub-chondral bone cysts, joint mice and joint space reduction.

A study of Mani, Raghavan, Birur, Gurudath, & Keerthi (2018) that due to high level of superimposition, it is difficult to evaluate the condyle on panoramic radiography especially if the lesions on the superior surface of the condyle of more than 2.3 mm diameter or more than 4.5 mm depth. Computer Tomography allows evaluation of bony structures on multiplanar dimensions. Age and gender is a key factor for the prognosis of TMJ osteoarthritis (Tanaka, Detamore, & Mercuri, 2008). Accurate prognosis of TMJ osteoarthritis requires long term assessment of bony changes using clinical and radiographic findings. Resolution of destructive changes observed in 42% of the total evaluated patients with TMD (Lei, Yap, Li, Liu, & Fu, 2020). The overall aim of TMD management is to improve jaw function and pain alleviation (Liu & Steinkeler, 2013).

Figure 2.6 an example of a bilateral low condylar fracture (Oliver et al., 2003)

2.1.7 Mandibular lesions

Oral cancer includes cancers of the lip and all sub-sites of the oral cavity, and oropharynx. The age-adjusted incidence of oral cancer in the world is estimated at 4 instances/100 000 persons. However, Oral cancer is more common in men, older people, and those in poor socio-economic condition. In some Asian-Pacific countries, the incidence of oral cancer ranks among the three top cancers (Kruse, Bredell, & Grätz, 2011). An analysis of 30 million health insurance records by found that the period prevalence of malignant intraosseous lesions detected by panoramic radiographs were 5 cases/million/year and that of benign lesions were 100 cases/million/year. However, more studies on panoramic radiograph detection of tumors were recommended (Zeichner, Ruttimannn, & Webber, 1987)

A study by Gohel (2006) reported that mandibular lesions are classified into odontogenic and non odontogenic in origin with a varying degree of destructive potential. The most common benign cystic lesions include radicular (periapical) cyst, follicular (dentigerous) cyst and odontogenic keratocyst. The benign solid tumors

include ameloblastoma, odontomas, ossifying fibromas and periapical cemental dysplasia. The malignant mandibular tumors include squamous cell carcinoma, osteosarcomas and metastatic tumors from distant primaries. Other tumors of vascular origin such as hemangiomas and arteriovenous malformations can also affect the mandible. Due to similarities in imaging appearances it is important to understand the secondary findings, such as age, prevalence, location within the mandible, cystic or solid appearance, border contour and its effect on adjacent structures, to narrow down the differential diagnosis. Another study by Devenney-Cakir et al. (2011) also mentioned that true mandibular cysts develop secondary to trauma, surgery, inflammatory and developmental factors stimulating epithelial cells adjacent to a tooth. They are well defined lucent lesions next to the tooth with a varying degree of peripheral sclerosis.

Periapical (radicular) cyst is the most common odontogenic cyst resulting from apical periodontitis. Radiographically, radicular cyst appear as a lucent lesion with sclerotic border. However, it is difficult to distinguish between a granuloma and a radicular cyst based on radiographs (Yoshiura, Weber, Runnels, & Scrivani, 2003). Follicular (Dentigerous) cyst is the most common developmental odontogenic cyst forming around the crown of unerupted tooth. It appears as a well-defined radiolucent lesion attached to an unerupted tooth. It can become so large, unlike radicular cyst, often distorting the roots of adjacent teeth and remodel the mandible (JS, MK, PN, & GL, 1999). Odontogenic keratocyst are located mainly in the body and ramus of the mandible. They are destructive lesions with the potential to recur. They develop from the dental lamina and are usually multiloculated and associated with Gorlin Goltz syndrome. Residual cysts are rare inflammatory cysts which are usually preceded by a

radicular cyst in the jaws. They are located in the apical area or adjacent to an extracted tooth (Titinchi & Morkel, 2020).

Stafne cyst (static bone cavity) is a well-defined fat filled radiolucent pseudo cyst within a cortical defect on the medial aspect of the posterior mandible. Simple bone cyst is a result of the trauma leading to intramedullary hemorrhage and subsequent resorption. They have poorly defined borders in the posterior marrow space of the mandible with a characteristic scalloped superior margin extending between the roots and adjacent teeth (JS et al., 1999).

Odontoma is the most common harmatomatous odontogenic tumor of the mandible. It consists of dentine and enamel, and is associated with an impacted tooth in 50% of cases. It is initially radiolucent with small calcification. Later, it forms a radiopaque center with a lucent rim. Ameloblastoma develop from enamel forming cells occurring in the posterior mandible. It is associated with a follicular cyst or impacted tooth. It is a slow growing expansile radiolucent lesion with a "soap bubble" appearance (George & Kamboj, 2012)

Odontogenic myxoma is a rare tumor with indistinguishable imaging characteristics to ameloblastoma. It was also reported that majority of mandibular lesions have a cystic radiographic appearance (JS et al., 1999). A study by Avril et al. (2014) reported that panoramic radiograph can demonstrate variety of odontogenic and non odontogenic mandibular lesions with a varying degree of malignant potential. Imaging has a role in both diagnosis and monitoring treatment response. Panoramic radiography is often used for imaging of mandibular lesions due to low radiation and easy access. A digital panoramic radiography further decreases radiation dose in identifying radiolucencies, radiopaque and mixed pattern mandibular lesions. Another

study by JS et al. (1999), however, reported that panoramic radiograph being a two dimensional projection have a limited use for the examination of the margins and extension of the lesion. Therefore, the use of Computed Tomography (CT), Cone Beam Computed Tomography (CBCT), Magnetic Resonance Imaging, Positron Emission Tomography/Computed Tomography (PET/CT) or with MRI (PET/MRI) can overcome the limitations of the two dimensional radiography.

Diffusion weighted imaging (DWI) sequence of MRI plays an important role in the diagnosis of tumor with high cellularity, infections and inflammatory conditions. Low ADC (Apparent diffusion coefficient) values demonstrate poorly differentiated lesions whereas higher ADC values are seen in well differentiated tumors (Subhawong, Jacobs, & Fayad, 2014). Positron emission tomography/Computed Tomography (PET/CT) is not used routinely in the imaging of the mandibular lesion (Varoquaux et al., 2013). However, PET/CT plays important role in the staging of malignant tumors invading the mandible. It can also detect distant metastasis in other organs. A study by Avril et al. (2014) also reported that knowing the imaging characteristics is key to narrow differential of mandibular radiolucent lesions. Important lesion characteristics include prevalence, Age of manifestations, specific location, and relationship to dental structures will also help in the diagnosis of mandibular lesions.

Figure 2.7 an example of a panoramic radiograph showing ameloblastoma in the right angle of the mandible (Source: (Sams et al., 2021)

2.1.8 Missing teeth

Congenitally missing teeth negatively affects individual dental aesthetic, occlusion and the function of mastication. The absence of teeth is described as "hypodontia", the absence of six or more teeth, "oligodontia" and the complete absence of teeth is "anodontia" (Al-Ani, Antoun, Thomson, Merriman, & Farella, 2017). A study by Silva Meza (2003) reported that the prevalence of congenitally missing teeth (CMT) was 27% when all teeth are included. However, the prevalence reduced to 2.7% when the third molars were excluded. The study also concluded that CMT occurrence in the permanent dentition often affects the third molars followed by maxillary lateral incisors and then mandibular second premolars.

A study by Goya, Tanaka, Maeda, & Akimoto (2008) reported that the prevalence of congenitally missing teeth in a Turkish population was 9.4%. However, this study contrasted with Silva Meza (2003) by reporting the most common CMT being mandibular second premolar. There were no first molars missing in any of the patients

studied. The prevalence of oligodontia was found to be 1.4% with a slight male preponderance. A cohort study in Turkey by Sari (2014) found prevalence of CMT in the overall population of 30.64% when missing third molar were included. The prevalence of CMT was less (6.77%) when third molar were excluded with higher prevalence in females. The study observed the third molars to be the most commonly absent teeth followed by maxillary lateral incisors and mandibular second premolars. Majority of the missing third molars were found in the maxillary region (55.7%).

A study by Khalaf, Miskelly, Voge, & Macfarlane (2014) found the global prevalence of hypodontia to be 6.4%. Africa had the highest hypodontia prevalence (13.4%) followed by Europe (7%), Asia (6.3%), Australia (6.3%), North America (5%) and Latin America and Caribbean (4.4%). The most common affected teeth were mandibular second premolars followed by maxillary lateral incisors and maxillary second premolars. However, third molars were not included in the study. Mild hypodontia was the commonest (81.6%) followed by moderate hypodontia (14.3%) and severe hypodontia (3.1%). Another study by Endo, Ozoe, Kubota, Akiyama, & Shimooka (2006) reported the prevalence of hypodontia (excluding the third premolars) in Japanese orthodontic patients to be 8.5%. The most commonly missed teeth mandibular second premolars, followed by the mandibular and maxillary lateral incisors.

The prevalence of CMT in a Saudi Arabian population was observed to be 2.6%. The mandibular second premolar were the most frequently absent teeth (Salama & Abdel-Megid, 1994). A study by Kılıc et al. (2021) in Turkey concluded that artificial intelligence approach was effective in numbering and detection of teeth on panoramic radiographs. Another study by Jasim (2020) in Iraq reported a prevalence of CMT of

10.37%. The most common missing teeth were maxillary lateral incisors (4.81%), followed by the mandibular second premolar (4.3%), mandibular lateral incisors (0.5%), maxillary central incisors (0.5%) and maxillary second premolars (0.25%). A cross-sectional study in Kenya reported the most common absent teeth were lower molars followed by upper molars (Volchansky, Cleaton-Jones, Evans, & Shackleton, 2016). Dental caries was the commonest cause of the absent teeth (52.6%), followed by periodontal disease (27.6%) and traditional extractions (12.3%). Treatment (2.2%) and trauma (2%) also contributed to the causes of missing teeth. Another study by Mccord & Smales (2013) reported that missing teeth are usually replaced due to physical, psychological, functional and social reasons. Fixed prosthesis is more preferred by patients than removal prosthesis. The average number of teeth decreases with age. Panoramic radiography is essential to identifying retained roots and conditions that may interfere with treatment of missing teeth.

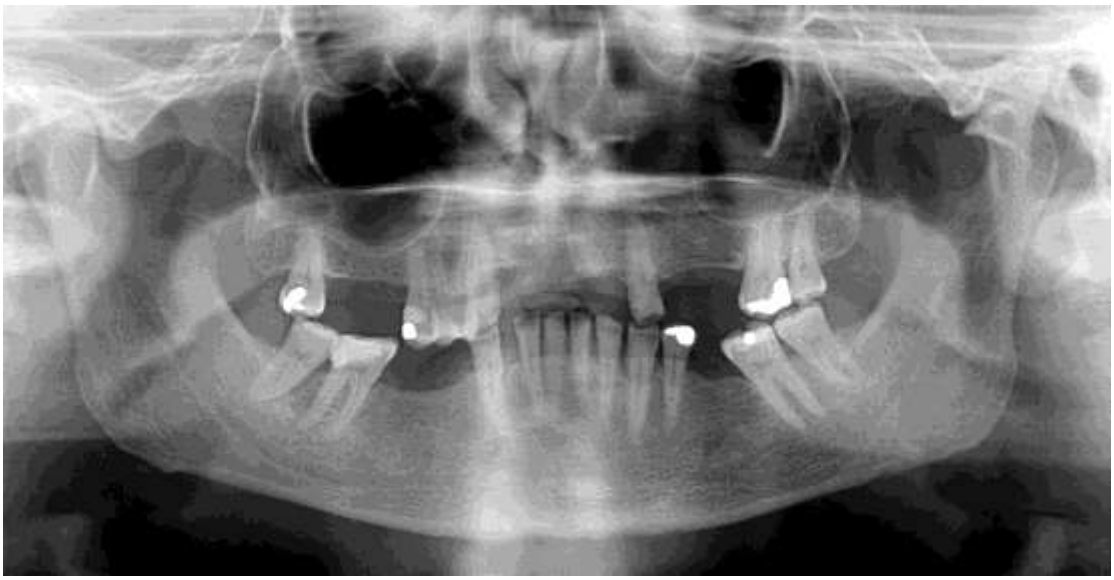

Figure 2.8 an example of a panoramic radiograph showing missing teeth (Radiopaedia, 2019)

2.1.9 Malpositioned teeth

Malpositioned teeth involve change in the position of one or more teeth in a normally aligned jaw. There are several causes of malpositioned teeth which include odontomas, cysts, trauma, ectopic tooth germ, supernumerary teeth and local bony pathologies. Treatment depends on severity of the teeth malocclusion,treatment options and patient's compliance which can include removal of overcrowding teeth, braces or reshaping of teeth (Moresca, 2018). A cross-sectional study of jaw and tooth abnormalities on panoramic radiograph by Cholitgul & Drummond (2000) reported that the most common abnormalities detected were malpositioned teeth, missing teeth and teeth with hypoplastic appearance. The New Zealand study further recommends the use of panoramic radiography in the examination of dental development.

A study by Chaushu, Chaushu, & Becker (1999) concluded that panoramic radiography is useful in detecting the position of unerupted maxillary canines using canine vertical restriction and the canine-incisor index. Malpositoned teeth are very detrimental to the health of an individual and can cause excessive wear, poor chewing function, esthetic issues and malocclusion which can lead to temporomandibular problems. However, the association between malocclusion and TMJ problems is still controversial (Marchesi, Bellini, Sardella, Fornarelli, & Zefi, 2022). Another study by Sockalingam, Shuhud, & Zakaria (2020) also reported that rotated malpositioned teeth correction is most often challenging for pediatric patients. Early intervention helps to avoid harmful effects and reduce the chances of a complex orthodontic treatment. The success of treatment depends on not only the severity of malpositioned teeth but also the availability of bone and space and patient's compliance to treatment. The study also recommended simple sectional orthodontic wire appliances and 2×4 orthodontic appliances for derotation of malpositioned teeth.

There is a great dilemma to dentists who manage malpositioned teeth. Simple malpositioning of teeth can be managed by simple methods such as tongue blade, wooden spatula, or a glass ionomer cement plane. However, for severely rotated or malpositioned teeth requires improvisation in the alignment methods to achieve effective correction of the malpositioned teeth (Zou, Meng, Law, Rao, & Zhou, 2018). (Abuaffan & Salih, 2015) in Sudan concluded that the health of periodontal tissue was negatively affected by malpositioning of teeth. Therefore, overall oral health of patients requires a multi-disciplinary approach that includes orthodontic and periodontal care in the management of oral conditions.

The early treatment of malpositioned teeth helps in the prevention of periodontal disease. Orthodontic treatment should be part of periodontal rehabilitation programs. Malpositioned teeth can be present in as early as in deciduous teeth dentition. Therefore, pediatric dentists and orthodontists should correct tooth positioning early to avoid malocclusion that may progress into permanent dentition (Zou et al., 2018). A study in north Jordan on school children by Alhaija, Al-Khateeb, & Al-Nimri (2005) reported that malocclusion alone will not result in periodontal disease. Malocclusion coupled with poor oral hygiene precedes periodontal disease. Tooth malpositioning of different types can result in early tooth loss due to formation of periodontal pockets on the mesial surface of the tooth. Early identification of malpositioned teeth results in the alignment of teeth to avoid occlusal trauma and subsequent periodontal disease (Hallmon, 1999) .

A study by Gusmão, Deschamps, & Queiroz (2011) emphasized on the need for orthodontic interventions for patients with periodontal diseases. Therefore, multi-disciplinary approach including periodontics, orthodontics, restorative dentistry and implant dentistry is necessary to respond to overall patient's dental health needs. Developmental anomalies are disturbances of eruption path and position of teeth (Klein et al., 2013).

Infraocclusion involved a tooth that is positioned below the occlusal plane. Primary molar infraocclusion affects 14% of children aged 8 to 9 years. It is observed twice as much in the mandible as in the maxilla with mandible second premolars being the most affected teeth. Genetic factors play a role in the development of infraocclusion. It is almost impossible to move infraoccluded primary molars into normal occlusion by orthodontic treatment (Jenkins & Nichol, 2008). A study by (Celenza (2012) reported that orthodontic treatment is a key tool in the correction of periodontal defects. Another study by Bollen, Cunha-Cruz, Bakko, Huang, & Hujoel (2008) emphasized on the need for careful examination of periodontal status of patients seeking orthodontic treatment especially the older ones. Overbite and upper arch severity was reported to be increased with age and increase in periodontal problems. A study by Ando & Sato (2014) also reported that root flattening of malpositioned teeth is effective for achieving complete root coverage of patients.

Figure 2.9 an example of a panoramic radiograph showing displaced third molar (Radiopaedia, 2019)

2.1.10 Nasal congestion

The term maxillary sinusitis has been replaced by Rhinosinusitis by the American Academy of otolaryngology. This is because of contiguous anatomy of the nose and paranasal sinuses (frontal, ethmoidal, maxillary and sphenoid sinuses)(Osguthorpe & Hadley, 1999). Rhinosinusitis has both major and minor signs and symptoms which helps in the diagnosis. The major signs include facial pain, pressure, facial congestion, nasal obstruction, paranasal drainage, hyposmia and fever. The minor signs include dental pain, halitosis, headache, fatigue cough and ear pain. The diagnosis is made through identification of a major sign and minor signs (Kretzschmar & Kretzschmar, 2003).

Maxillary sinusitis has an odontogenic etiology in 10 to 12% of cases. The maxillary posterior teeth have a close proximity to the maxillary sinus. Once the schneiderian membrane integrity is violated by a periapical dental infection or dental surgery procedure, infection spreads into maxillary sinus. In patients with dental or jaw pain with maxillary sinusitis an odontogenic source should be considered. Panoramic

radiograph is good in providing a bilateral view of maxillary sinus. Symptomatic patients with unilateral opacification of the maxillary sinus on panoramic radiograph should raise a suspicion of maxillary sinusitis. A referral to a maxillofacial surgeon or an otorhinolaryngologist should be considered if a dental origin cannot be confirmed. Computed tomography is a useful complimentary imaging to confirm the diagnosis (Malina-altzinger, Damerau, Grätz, & Stadlinger, 2015).

Cone beam comtuted tomography (CBCT) was reported to be more reliable in the evaluation of maxillary sinusitis than panoramic radiography (Tadinada et al., 2015). False-positive unilateral opacification of maxillary sinus seen on panoramic radiograph, were however, found to be normal on Computed tomography. (Osguthorpe & Carolina, 2001) discovered a 66.4% agreement between panoramic radiography and computed tomography in the diagnosis of maxillary sinusitis. A study by Noffke, Raubenheimer, & Chabikuli (2015) reported that detection of radio-opacity on panoramic radiograph results in consideration of many differentials. The use of Computed tomography would help in reaching specific diagnosis.

There is significant superimposition of anterior and posterior walls of the maxillary sinuses (Ohba & Katayama, 1975). Panoramic radiography is better in the detection of radiopaque lesions compared to periapical and occlusal techniques. However, panoramic radiography is not good in the detection of lucent lesion and can also wrongly identify the position of the defect. Computed tomography is still the most accurate in the diagnosis of maxillary pathologies. Panoramic radiography is also better than Water's view in the detection of cystic maxillary sinus lesions. However, a study by Shahbazian & Jacobs (2012) concluded that the two modalities could supplement each other in the diagnosis of the maxillary sinus pathologies.

Panoramic radiography provides sufficient information for the diagnosis of maxillary sinusitis. However, examination of the maxillary sinus by panoramic radiography is examiner dependent (Malina-altzinger et al., 2015). A study by Maciel, Lopes, Mara, Tucunduva, & Simpione (2020) in Brazil concluded that Cone Beam Computed Tomography had a better visualization of maxillary sinus involvement, alveolar bone and infectious focus compared to 2D x-rays. Another study by Felisati et al. (2013) reported that odontogenic maxillary sinusitis could occur secondary to inflammation, infection or odontogenic trauma due to maxillary sinus proximity to the roots of the upper molar teeth. A study by Simuntis, Kubilius, & Vaitkus (2014) reported that 30 to 40% of chronic maxillary sinusitis are odontogenic in etiology. Odontogenic causes include dental caries, periodontal diseases, odontogenic cysts and endo-antral syndrome. The clinical features of odontogenic maxillary sinusitis include headache, pain, facial tenderness, nasal secretion and nasal congestion (Maciel et al., 2020).

Panoramic radiography is adequate imaging for the evaluation of the maxillary sinus. However, certain findings on panoramic radiographs may be based on an examiner dependent assessment. Cone Beam Computed Tomography provided additional information compared to panoramic radiography especially for the preoperative assessment of patients (Malina-altzinger et al., 2015). Precise examination of the maxillary sinus is mandatory. Therefore, clinical examination, panoramic radiography and cone beam computed tomography should be performed (Bornstein & Vaughn, 2014). Millions of sinus lift operations have been done with the guidance of panoramic radiography; however, due to superimposition of structures on panoramic radiography, precise assessment can be difficult on a 2D imaging. Therefore maxillary pathology detected clinical and panoramic radiography examination should

be followed by Cone Beam Computed Tomography for precise examination (Neugebauer, Ritter, & Mischkowski, 2010).

A study by Dhillon et al. (2012) reported that in addition to the challenges of positioning errors compromising the quality of images associated with panoramic radiography, there are challenges associated with inter and intra examiner variation in the interpretation of 2D radiographs. Another study by Rodriguez, Aquino, Graziano, Pelegrine, & Lupi (2017) reported that the second most common lesions in the maxillary sinus region are the antral pseudo cysts. A study by Mathew, Sholapurkar, & Pai (2009) added that the cysts develop as a result of retention of mucous produced by mucous glands on the lining of maxillary sinus. A study by Giotakis & Weber (2013) described the cysts appear on panoramic radiography as a dome shaped radiopaque lesions attached to the sinus walls. They can be unilateral or bilateral and mostly originate from the sinus floor with a slow growth. A study by Maria (2017) reported that there is a strong association between antral pseudo cyst allergic, inflammation, trauma, pollution and humidity. A study by Arai, Tammisalo, Iwai, Hashimoto, & Shinoda (1999) reported that Cone Beam Computed Tomography findings include septal deviation and the obstruction of the meatal ostium.

Imaging of the maxillary sinus is often done using panoramic radiography, Computed Tomography and Magnetic Resonance Imaging. Computed Tomography and Magnetic resonance imaging is only indicated when there are symptoms of maxillary pathology (Farman & Nortjé, 2002). Advanced disease is associated with poor prognosis. Some of the maxillary sinus can produce few signs and symptoms.

Therefore panoramic radiograph can be the initial imaging tool for the detection of maxillary sinus pathology. However, it cannot exclusively rule out pathology (Mathew et al., 2009).

Maxillary sinus disease is very frequent on panoramic radiograph. It is therefore mandatory for a radiologist and dentist to understand the Radiographic features of maxillary sinus pathologies and normal variants. Not all antral mucosal thickening or mucous retention cyst warrant patient referral to an Ear Nose and Throat specialist nor ignoring early features of malignancy (Neugebauer et al., 2010).

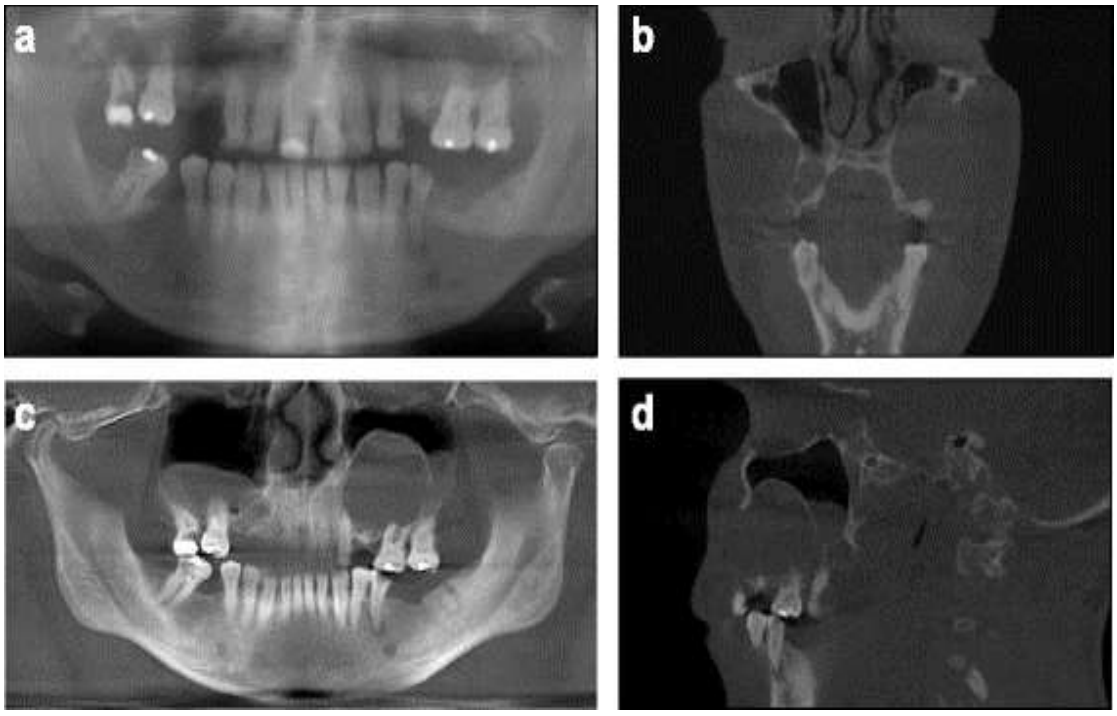

Figure 2.10 :an example of a panoramic radiograph showing maxillary bone cyst extending to the sinus (Altzinger, Damerau, Gratz & Stadlinger, 2015)

2.2.1 Patterns of panoramic radiograph findings

Panoramic radiography is a radiologic technique which shows the jaws and surrounding structures. It is often used to assess several conditions such as: un-erupted third molars, orthodontic abnormalities, tooth development, developmental abnormalities, trauma, and large lesions. The panoramic radiograph enables viewing of a large area of both the maxilla and mandible on a single film (Park, 2014).

There are few studies which have been done on the area of dealing with the diversity of dental patterns for forensic identification (A. Kumar, Ghosh, & Logani, 2014). Radiographs are useful in forensic odontology because they reveal details and provide reliable and objective information. In particular, panoramic radiography is a useful technique for forensic identification (Bhateja, 2015).

The main advantages of panoramic radiography are the convenience and short time it takes for imaging. It is also widely accepted by patients and, it is a safe imaging modality due to its low radiation dosage to patients. Panoramic radiographs cover a wide area of dental arches and their associated structures. A panoramic radiograph has also proven its excellence in imaging patients with trismus or trauma, because it does not require the opening of the mouth as in other techniques(Langland, Langlais, & Preece, 2002). It is rated highly as an imaging modality due to its excellence in projecting diverse structures on a single film (de Oliveira Capote, de Almeida Gonçalves, Gonçalves, & Gonçalves, 2015).

For more than half a century, panoramic radiography has been an essential diagnostic tool in dentistry. However, it is limited by superimposition of anatomic structures and geometric distortions (Paatero, 1949). A study by Wyatt et al. (1995) reported that panoramic radiographs are routinely used in almost all dental specialties for overall

screening. A study by Pakbaznejad Esmaeili (2017) noted that orthodontists seem to request a panoramic radiograph and a lateral cephalogram for initial treatment planning. It provides additional information about tooth eruption state, angulation of teeth, and overall dental, periodontal and condylar condition on top of clinical evaluation findings. OPG is also used as a follow up for orthodontic treatment progress and visualize treatment outcome and progress of the detected wisdom tooth.

When compared with panoramic radiography, Cone beam computed tomography (CBCT) has been found to offer more information for specific orthodontic comprehensive care such as of canine impaction, root resorption, supernumerary teeth and airway related problems. However, the radiation burden by CBCT remains a major concern, especially in children (Mazrani, McHugh, & Marsden, 2007). (Beshtawi, 2017) also concluded that reformatted panoramic views from some CBCT scans have been found to offer equal diagnostic quality compared with digital panoramic images. It was also reported by (Jada & Kuijpers-jagtman, 2012) that there is little evidence from the literature that indicates whether CBCT has better diagnostic potential than a conventional panoramic radiograph.

A study by El-khateeb, Arnout, & Hifnawy (2015) also observed 34.5% of dental patients in western Saudi Arabia to have Tooth impaction on panoramic radiographs. Another study by Rs & Gn (2018) reported 28% tooth impaction on panoramic radiographs. A retrospective study of dental patients by Alamri et al. (2020) observed 13.2% of tooth impaction on in Saudi Arabia on panoramic radiographs. A study in Brazil, however, found only 3% of reviewed patients' panoramic radiographs had tooth impaction (Luis et al., 2014).

A study by Dar-odeh et al. (2010) in Jordan observed 17.4% of patients with periodontitis on panoramic radiographs. A cross sectional study done in India by (Rs & Gn, 2018) also observed 17% of periodontitis on panoramic radiographs. A study in Romania reported a very high prevalence of periodontitis (65.8%) of dental patients by panoramic radiographs (Hategan et al., 2019). Bitewing and panoramic radiography are preferred to periapical images for crestal bone assessment.(Gedik, Marakoglu, & Demirer, 2008).

However, panoramic radiographs provide a challenge in interpretation due to overlapping of certain anatomical structures in the image, magnification and mild distortion of the quality of the image. Some objects located beyond the focal area cannot be viewed and thus some artifacts can easily be misinterpreted. These limitations are felt more when details of anatomical structures and accurate measurements are needed(de Oliveira Capote et al., 2015).

Panoramic radiography provides an extensive view of the jaws, teeth and numerous other structures within a single image. It is a very a reliable source tool for victim identification following disasters such as aircraft crash and terrorist attack (Perez, 2015). However, there is a discrepancy between dentist and expert assessment in the interpretation of OPG as reported by (V. E. Rushton et al., 2001). They reported an agreement of 37.1% (dental caries), 69.9% periapical lesions and 52% (periodontal bone loss) between dentist and expert assessment of panoramic radiographs.

Radiographs are recommended for a complete dental examination of patients(Kaur, Sheikh, & Pallagatti, 2012). Panoramic radiography provides an overview of the hard tissue structures of the facial region (Sk & Rk, 2015). Panoramic radiographs supplements and verifies important findings which were observed clinically

(Meireles, Costa, & Rocha, 2008). However there should be more value than the potential risks associated with x-rays (Demir & Akkas, 2019). A study by Freitag & Seidel (1972) also reported that OPG enables the early diagnosis of tooth and jaw pathologies. It also has a role in the pretreatment examination in the dental practice. The long-term cost of dental treatment is reduced by the use of dental panoramic radiography (V. E. Rushton & Horner, 1996). However, a study by Drage & Brown, (2001) questioned the routine use of x-rays in dental assessments. There is a small difference between x-ray findings and clinical findings in the assessment of dental patients. Therefore, routine use of x-rays results in unnecessary exposure to radiation.

The European guidelines on Radiation in dental radiography reported that panoramic radiography can be used in adult patients for a limited number of dental conditions (Martínez Beneyto, Alcaráz Baños, Pérez Lajarín, & Rushton, 2007). A study by concluded that there is no enough evidence to advocate the use of supplementary panoramic radiography for the provision of valuable and additional information during dental examination. Reliable acquisition of clinical information during the first (check-up) examination in dental practice is sufficient without additional panoramic radiographs. Orthopantomography also revealed additional clinically unclear findings (M. N. Rushton & Rushton, 2012). The sensitivity of panoramic radiographs in the detection of dental caries is 60% while that of periodontal disease is 85%. However the study combined both bitewing and panoramic radiographs (Douglass, 2011).

A pretreatment radiographic assessment allows the identification of possible pathologies that may influence the orthodontic treatment planning. A 50% prevalence rate of incidental findings out of 410 patients done panoramic radiography compared to what they were observed clinically (Vaseemuddin, Sciences, & Sciences, 2016).

Panoramic radiography provides critical information during planning and progress evaluation for most of oral surgical procedures (Cral, Quirino, & Rubira-bullen, 2018). Clinical examination and panoramic radiography supplement each other in the orthodontic diagnosis and treatment plan. The radiographs provide essential information on jaws pathologies and teeth eruption. Panoramic radiographs interpretation can reveal findings un related to the patient's complaint and the reason for the panoramic radiograph examination. The incidental findings on panoramic radiograph may indicate pathologies that require dental or medical interventions. The incidental findings on panoramic radiographs include osteosclerosis, odontoma, dentigerous cysts, alveolar bone resorption and apical endodontic lesion (Bondemark, Jeppsson, Lindh-Ingildsen, & Rangne, 2006).

A study by Vaiciulis, Cristine, Cavalcanti, & Chilvarquer (2020) reported non articular incidental findings on dental panoramic radiographs such as bone loss, maxillary sinus opacification, dental caries and peri apical lesions in patient with temporo mandibular disorders. The study also incidentally observed altered position of teeth and tooth impaction on panoramic radiographs. Periapical lesions with or without endodontic treatment were the endodontic changes incidentally reported on the radiographs.

Panoramic radiography has also been found useful in the assessment of dental pathologies in the pediatric group. A study in Turkey by Bekiroglu, Mete, Ozbay, Yalcinkaya, & Kargul (2015) reported 1.14% radicular cysts and 1.52% impacted tooth in children aged 4 to 12 years on panoramic radiography. Panoramic radiography can be utilized for the assessment of tooth development, growths and traumatic injuries; pediatric dentists prefer panoramic radiography because it is

noninvasive and readily tolerated by most children especially those with high caries risk and mixed dentition (de Marsillac, Andrade, de Oliveira Fonseca, Marcal, & Santos, 2013). Panoramic radiography also provides comprehensive information about erupted and unerupted teeth, and jaw anomalies. It also discovered incidental findings in the oral and maxillofacial region (Yonetsu, Yuasa, & Kanda, 1997).

A study by Pekiner, Borahan, Gümrü, & Aytugar (2011) reported 16.7% impacted teeth, 12.5% missing teeth and 9.7% follicular cysts and 11.1% fractures on panoramic radiographs. Another study by Cholitgul & Drummond (2000) reported 21% dental anomalies on panoramic radiographs. The most common anomalies was found to be malpositioned teeth, misshaped teeth and hypoplastic teeth on children and adolescents. The study also concluded that panoramic radiography is sufficient to detect and confirm dental anomalies. A study by Asaumi et al. (2008) also discovered 59.1% missing teeth and only one (1) odontoma, radicular cyst and impacted tooth on panoramic radiographs. Another study by S. Haghanifar et al. (2019) discovered 40.8% dental anomalies on dental panoramic radiography in Iran. The most common anomalies reported were dilacerations, tooth impaction (8.3%), taurodontism and supernumerary teeth. A study on 152 children aged 5 to 15 years reported most of the findings on clinical examination and panoramic radiographs were supernumerary teeth(Rajab & Hamdan, 2002). A study on Estonial school children aged 14 to 17 years reported 14% missing teeth and 3% supernumerary teeth on panoramic radiographs (Farman, 2007). There was a higher incidence of missing teeth on girls than boys with more of them in the mandible than maxillary arch using panoramic radiography (Zuhal, I, & Ertürk, 2005) . A study by Bruce, Manning-Cox, Stanback-Fryer, Banks, & Gilliam (1994) discovered 4.4% missing teeth and 1.5% supernumerary teeth on panoramic radiographs of black children.

A study by Bäckman & Wahlin (2001) detected more than one abnormality in 8% and only one abnormality in 18% of 7 year old Caucasian children by clinical examination and panoramic radiographs. Another study by Sharma & Singh (2012) discovered more supernumerary teeth on boys than girls on panoramic radiographs. Another cross-sectional study in Iran by Imanimoghaddam, Tohidi, Yazdi, Nikbakhsh, & Goudarzi (2021) reported incidental findings in 85% of the reviewed panoramic radiographs. The most common incidental findings include intra osseous, followed by dental anomalies, soft tissue calcifications, maxillary sinusitis & Temporo mandibular joint pathologies. Rarefying osteitis is the most common intra osseous finding while tooth impaction and missing teeth were the most common dental anomalies detected incidentally on panoramic radiography. Mucosal thickening and articular eminence pneumatization are the most common sinus and temporo mandibular joint incidental findings respectively.

Panoramic radiography is useful for the assessment of jaw bone involvement by oral squamous cell carcinoma. The oral squamous cell carcinoma involves the jaw bone in 12-56% of cases. The changes on dental panoramic radiography denoting bone involvement is altered trabecular pattern and smooth borders of the jaw. The study concluded that panoramic radiography is useful in the detection of jaw bone involvement by oral malignancy and also in treatment planning (Chaudhary & Lecturer, 2020).

Dental emergency department utilize panoramic radiography for the assessment of mandibular trauma and odontogenic infections. However, reporting errors, artefacts and superimposition of structures pose a challenge to the clinicians who read panoramic radiographs in the emergency department (Sklavos et al., 2019). Therefore,

dental panoramic radiography cannot be solely relied on for a comprehensive dental diagnosis (Maupom, 2014). The clinician interpreting a panoramic radiograph film should first account for the normal structures on the film. The entire mandible should be systematically examined from the left side to the right side of the image. The mid face and the maxilla are then assessed followed by the entire dentition and supporting structures (Sklavos et al., 2019).

Fractures are usually detected as a radiolucent line on panoramic radiographs. A clinician should have a high index of suspicion for a second and third fracture of the mandible after detecting the first one. Radiographic and clinical correlation is important in the making of diagnosis of maxillomandibular trauma on panoramic radiographs. However, the two dimensional panoramic radiographs may lead to missed diagnosis of mandibular fractures. Computered tomography is the imaging modality of choice in the diagnosis of trauma to the condyle and sub condylar area. A discontinuity in the cortical bone denotes a radiographic diagnosis of mandibular fracture (Markowitz et al., 1999). There is also some distortion of the images outside the focal trough on panoramic radiographs (Akadiri & Adeyemo, 2005).

Radiographs are useful for the examination of periodontal disease. Periapical radiographs are used to examine the bone trabecular pattern and density, periodontal ligament, root divergencies, size of root trunk and the presence of peri apical lesions (Kim, Obst, Zehaczek, & Geenen, 2008). Bitewing radiographs are indicated for the assessment of alveolar crest and cementum- enamel junction area(Hausmann, Allen, & Clerehugh, 1991). Bitewing and periapical radiographs are useful for the detection and monitoring of marginal bone levels. Panoramic radiography is usually indicated when it is difficult to perform intra oral radiography. However, the distortions in the

panoramic radiographs make precise evaluation difficult for the clinicians (Takeshita, Iwaki, Da Silva, & Tonin, 2014). Computed Tomography allow for a three dimensional visualization of images. However, high radiation dose and cost limit its use in dentistry. Periapical and bitewings radiography are the most indicated modalities for the detection of changes in the periodontal tissues (V. Kumar, Arora, & Udupa, 2014).

Panoramic radiography is the imaging modality of choice for the detection of impacted third molar. Panoramic radiography is also used preoperatively to assess for the inferior alveolar nerve injury associated with third molar surgery. Inferior alveolar nerve injury on panoramic radiographs is detected using signs such as darkening of the root, interruption of the white line, deflected roots, narrowing of the root and the diversion of the inferior alveolar canal. The study concluded that panoramic findings and the presence of the inferior alveolar nerve injuries are positively and significantly related (Palma-Carrió, García-Mira, Larrazabal-Morón, & Peñarrocha-Diago, 2010). A study by Jerjes et al. (2006) also found a positive relationship between panoramic radiograph findings and the presence of injury to the inferior alveolar nerve.

Panoramic radiography is useful for the assessment of pathological calcifications such as tonsilloliths. Tonsilloliths were reported in 16.4% of the panoramic radiographs in a Turkish study (Gurbuz et al., 2021). However, another study by (Aoun, Nasseh, Diab, & Bacho, 2018) reported a lower prevalence of tonsilloliths (7.2%) on panoramic radiographs. Other studies by Oda et al. (2013) & Bamgbose, Ruprecht, Hellstein, Timmons, & Qian, 2014) also found a lower prevalence of 7.3% and 8.14% of tonsilloliths respectively on panoramic radiographs. The difference was explained by the variations in panoramic radiography equipment, sample size and racial

differences. Magnifications, distortions and superimposition of structures on panoramic radiographs lead to some misdiagnosis of the tonsilloliths. However, digital panoramic radiography improved the image quality through the adjustment of brightness and contrast of the images(Ram, Siar, Ismail, & Prepageran, 2004). Computed tomography was found to be better than panoramic radiography for the detection of tonsilloliths (Takahashi et al., 2018).

A study by Bitar, Herman, Einstein, York, & Dahman (2002) reported odontogenic cysts on panoramic radiographs in a patient with basal cell nevus syndrome. However, computed tomography was used to confirm the diagnosis of the cysts. Another study by Ahsan-Mohammed, Clarkson, & Carmichael (2019) reported dense bone islands, carotid artery calcifications and osteoporosis incidentally discovered on panoramic radiographs.

A study by Garoff, Ahlqvist, J, & Johansson (2016) reported that panoramic radiography can detect carotid artery calcifications in relation to carotid stenosis. Carotid artery calcification detected on panoramic radiographs indicates significant (>50%) carotid artery stenosis. A study by Moshfeghi, Taheri, Bahemmat, & Ebrahim (2014) reported that carotid artery calcifications seen on panoramic radiographs are associated with increased risk of cerebrovascular events such as stroke. Therefore, panoramic radiography can be used to screen for patients at risk for stroke. However, dental researchers differ on the use of panoramic radiography for the detection of carotid artery stenosis (Mupparapu & Kim, 2007). Conventional angiography or the digital subtraction angiography is the gold standard for the assessment of carotid artery (U-king-Im, Young & Gillard, 2009). Panoramic radiographs depict part of the neck in addition to the teeth and jaws (Bentzon, Otsuka, Virmani, & Falk, 2014).

Adequate Interpretation of panoramic radiograph for the assessment of carotid artery calcification involves excluding other calcifications in the area. These include tonsilloliths, sialoliths, calcified lymph nodes, calcified stylo hyoid ligament and calcified superior horn of the thyroid cartilage. Frontal radiographs (antero- posterior projections) are used to confirm carotid artery calcification and for differentiating it from other calcifications occurring in the carotid region (Friedlander, 2000). The prevalence of carotid artery calcification on panoramic radiograph is reported to be 2-5%. The risks increases in post-menopausal women, diabetes mellitus type 2 and dilated cardiomyopathy. Carotid artery calcifications are incidentally seen on panoramic radiographs performed for other indications. Ipsilateral carotid artery calcification is identified in 70% of patients with significant carotid artery stenosis (Moshfeghi et al., 2014). The size and shape is usually described during interpretation of panoramic radiographs. However, computed tomography has better yield in the quantification of carotid artery calcification due to distortions associated with panoramic radiography. Panoramic radiograph also don't show the full extent of the carotid artery unlike computed tomography (Nandalur et al., 2010). A study by Garoff et al. (2016) reported that carotid artery calcifications are incidentally detected in 7% of panoramic radiographs performed for odontological reasons.

A study by Cederhag, Lundegren, Alstergren, Shi, & Hellén-halme (2020) in Sweden concluded that panoramic radiography is useful for the assessment of third molar before surgical removal. Other incidental findings are also found on panoramic radiographs in the assessment of the third molars. A study by Atieh (2010) reported that panoramic radiography is useful for the assessment for the relationship between roots and the inferior alveolar nerve. The panoramic radiographs were also considered adequate to demonstrate the relationship between third molar and the inferior alveolar

nerve. Panoramic radiography is commonly used for such purpose owing to its lower radiation dose, shorter examination time and cost effectiveness (Bell & Rodgers, 2003). Incidental findings such as osteosclerosis and radiolucencies were reported on panoramic radiographs of adult patients (Yonetsu et al., 1997). A study by Macdonald (2020) reported at least one incidental finding on 32.1% of panoramic radiographs for new patients. Another study by Garoff et al. (2016) also found 57% incidental findings on panoramic radiographs.

2.2.2 Patterns of panoramic radiograph and dental clinical findings

Panoramic radiography has been used as a routine screening tool for dental patients because it demonstrates the entire dentition, alveolar bone, temporo-mandibular joints, and adjacent structures on a single film (V. E. Rushton et al., 2001). Panoramic examination can play a big role in the detection of caries on dental examination. The detectability of proximal surface dental caries from panoramic examination was found to be significantly higher than that from clinical examination. When clinical examination was combined with panoramic radiograph the additional detection of caries was found to be: 26.7% in occlusal, 48.2% in proximal, 33.3% in bucco-lingual surface, and 38.3% totally (J.-W. Choi, 2011). A study by An et al. (2007) reported that panoramic examination discovered 24.2% of dental caries which had not been discovered in clinical examination. However, the rate of carious lesion which had been detected only in clinical examination was 5.2% in a study in Lithuana on children Machiulskiene, Nyvad, & Baelum (1999) reported that panoramic radiography showed a higher detection rate of 23.1% for dental caries than clinical examination.

A study by Shin et al. (2010) also reported a higher detection rate of 31.9% for periodontal diseases with panoramic radiographs than clinical examination. Another study by J.-W. Choi (2011) also found that 62.6% of calculi deposition in screening panoramic radiographs compared to only 7.4% by clinical examinations. Panoramic radiographs with intraoral Polaroid photographs are useful in the detection of periodontal disease. Therefore, supplementing clinical exams with the radiographic examination increase the overall number of periodontal disease detected based on these studies (Galal, 1985)

Panoramic radiographs reveal several useful information regarding maxillofacial fractures. The fractures may occur alone or in combination with other fractures of the body. The patterns of the fractures vary: with the mechanism of injury, magnitude and direction of impact force and anatomy of the injured site (Bakardjiev & Pechalova, 2007). Age and gender of the patients have been reported as important factors that affect the occurrence of maxillofacial trauma (van den Bergh, Karagozoglu, Heymans, & Forouzanfar, 2012). The highest incidence is observed in patients aged 21 to 30 years, and the lowest incidence is in patients aged more than 60 years and less than 5 years old while the male to female ratio is 4:1 worldwide (Zhou, Ongodia, Liu, Yang, & Li, 2013). The common sites of maxillofacial fractures include: the mandible, zygomatic complex and the maxilla. The mandibular fractures occur mostly at the parasymphysis menti, angle, or condyle (Elarabi & Bataineh, 2018).

Radiographs are very helpful for detecting dental diseases such as peri-apical lesions, impacted or missing teeth, maxillary sinus anomalies, and condylar changes, which cannot be easily seen in clinical examination. Panoramic radiograph was found to be the most effective in detecting impacted teeth and other miscellaneous findings

because of its greater area of coverage (An et al., 2007). In a study by M.-J. Shin et al. (2010) there were: 33.6% impacted teeth, 11.6% maxillary sinus abnormalities, 2.1% condylar abnormalities, 24.5% dental anomalies, and 14.1% miscellaneous abnormalities seen in panoramic examinations. A study by Lee & Kang (2005) also found 11.9% periapical radiolucencies, 10.8% retained roots, and 2.0% impacted teeth in screening with panoramic radiographs. Another study by V. E. Rushton et al. (2001) in screening panoramic radiographs, also reported 40.2% peri-apical lesions, 17.3% retained roots, 35.6% unerupted teeth, 14.0% maxillary antra abnormalities, and 20.1% of other abnormalities.

It was however, concluded that routine screening of tumors of head and neck with panoramic radiography could not be justified due to risk of radiation exposure. It is doubtful how many tumors and cysts will be detected in panoramic radiography, however, further research in is needed (Zeichner et al., 1987).

A study by Bruno, De Stefani, Balasso, Mazzoleni, & Gracco (2017) in Italy reported that elongated styloid process on panoramic radiographic is usually asymptomatic, but can also be associated with eagle's syndrome. The styloid process is elongate if it is longer than 30mm. The eagle's syndrome is characterized by neck and orofacial pain during mouth opening, deglution and head rotation. The study concluded on the importance of awareness of such findings to the dentists. Another study by Bondemark et al. (2006) observed the most frequent incidental findings on panoramic radiographs were maxillary sinusitis, periapical inflammatory lesions and idiopathic sclerosis of the alveolar bone. (Macdonald, 2020) also observed impacted teeth (24%) as the most common incidental finding on digital panoramic radiographs followed by idiopathic sclerosis (6%), tonsillitis (3%) and antral pseudocyst (1%).

A study by Ortiz, Silva, Ortiz, Lizárraga, & Ruiz (2017) in Mexico reported that the most common incidental findings on panoramic radiographs include maxillary sinus pathology (31.5%), nostril pathology (32.04%), opaque lesions (4.13%) and root retentions (32.29%). In another study by Ghassemzadeh, Sbricoli, Frigo, & Bacci (2021) the most common incidental panoramic findings were reported to be intra-osseous pathology, dental abnormalities, soft tissue calcifications, maxillary sinusitis and Pathologies of the TMJ. A study by Cral et al. (2018) also reported impacted teeth as the most common incidental finding on panoramic radiographs followed by supernumerary teeth and osteosclerosis for both pre and post treatment orthodontic groups.

The prevalence of incidental findings on panoramic radiographs was 88.12% with the most frequent finding being maxillary sinusitis (25.8%) (Plaza, Ruiz, Cifuentes, & Villalobos, 2018). A study by Ghassemzadeh et al. (2021) reported sclerotic bone islands, calcifications of the carotid artery and osteoporosis as the most common incidentally found pathologies on panoramic radiographs. Another study by Cristina et al. (2021) also observed condylar hypoplasia, lytic bone lesions and dentigerous cysts as incidental findings on panoramic radiographs.

A study by Cederhag, Lundegren, Alstergren, & Shi (2020) reported that the most common incidental findings on panoramic radiographs were apical lucencies, idiopathic sclerosis and tooth fragments. Another study Ghassemzadeh, Sbricoli, Frigo, & Bacci (2020) observed that the prevalence of incidental findings on panoramic radiographs was 48.2%. A study by Senye (2015) also observed 62.6% incidental findings on panoramic radiographs with hypodontia and impacted teeth as the most common of the findings. A study in India reported the most common

incidental finding on panoramic radiograph was maxillary sinus opacification followed by impaction of the maxillary canines. Non-odontogenic aetiology should be considered in patients presenting with an orofacial pain. Other reported incidental findings include carotid artery calcification, calcified sub mandibular lymph node, tonsillolith and retention cyst/polyp. The study concluded the need for panoramic radiographs to be reviewed by senior surgeons with experience in radio-diagnosis to improve detection of pathologies (Syam & Maheswari, 2019).

The most common incidentally found pathology on dental radiography was idiopathic osteosclerosis followed supernumerary teeth, sinusitis and calcifications (Goyal, Padda, & Kaur, 2016). Incidental findings were also reported in cone beam computed tomography done on patients for other indications. A study in Turkey reported that the prevalence of incidental findings on cone beam computed tomography was 92.8%, with the most common findings including airway pathologies, impacted teeth, TMJ pathologies and endodontic lesions (Çaglayan & Tozoglu, 2012). Another study by Drage, Rogers, Greenall, & Playle (2013) also reported retained deciduous roots and periapical disease on orthodontic patients as incidental findings on cone beam computed tomography (CBCT). However, majority of the incidental findings do not affect orthodontic treatment planning.

A study by Monsarrat, Galibourg, Nasr, Telmon, & Maret (2019) reported a 60% prevalence of incidental findings on dental radiology. They include airway pathologies, sinusitis and carotid artery calcification. Another study by Trias, Llopis-Perez, & Pérez (2016) concluded that patients with down syndrome need and orthodontic and periodical dental supervision so as to prevent or control subsequent oral problems. There were more dental anomalies observed clinically and on

panoramic radiographs in the Down syndrome group than the control group. A study by Barghan, Arashlow, & Nair (2016) reported incidental findings on Cone Beam Computed Tomography which include soft tissue calcifications, intracranial calcifications, cervical vertebrae, external carotid artery calcifications and calcified tendonitis. A study by Khasawneh et al. (2020) also observed 28.7% incidental findings on maxillofacial computed tomography most of which were thyroid nodules. A study by Aghdasi, Valizadeh, Amin-Tavakoli, & Bakhshandeh (2012) reported a 5% prevalence of tonsiloliths on panoramic radiographs. A retrospective study in Iran reported 21.1% incidental findings on Cone Beam Computed Tomography of the TMJ which includes: soft tissue calcifications, erosion of the condyle and articular eminence (Mehdizadeh, Rezaei, & Moghadam, 2020)

CHAPTER THREE

3.0 METHODOLOGY

3.1 Research Design

This was a cross sectional research design which was conducted at the Radiology and Imaging department and Dental department of Moi Teaching and Referral Hospital.

3.2 Study Site

MTRH is located in Eldoret town, serving the residents from the Western Kenya Region to parts of Eastern Uganda and Southern Sudan. MTRH is a tertiary (level 6) national health facility which serves as a teaching hospital for Moi University School of Medicine, Public health, Nursing, Dentistry and the Institute of Bio-informatics. MTRH serves residents of 23 counties in Kenya with a catchment population of approximately 13 million persons.

The study was conducted at the Radiology and Imaging department and the Dental department at MTRH. The Radiology department provides a comprehensive range of imaging services, including both routine and specialized procedures. The department offers services such as Interventional radiology, general X-rays, Magnetic Resonance Imaging, Special X-rays, CT –scans as well as Ultra- Sound. In 2018, there were 2640 panoramic radiographs done at the radiology department. Clinical dental findings were obtained from the patients' records at the dental clinic, MTRH.

3.3 Study Population

The study population consisted of all patients with dental health conditions referred for a panoramic radiograph at the Radiology and Imaging department, MTRH between September, 2019 and June, 2020.

3.4 Eligibility Criteria

3.4.1 Inclusion Criteria

1. Patients referred for panoramic radiographs at the radiology and imaging department, MTRH.

3.4.2 Exclusion Criteria

1. Patients referred from other health facilities or dental clinics outside MTRH
2. Self-referring patients

3.5 Sample and Sampling Techniques

3.5.1 Sample Size Determination

The main objective of the study was to determine the correlation of panoramic radiographic findings and clinical findings of dental patients with dental health conditions. The researcher used total raw (percent) agreement calculated as a proportion to compare the two. A similar study done by Moll et al, (2013) found an agreement between clinical and radiograph findings of 93.6%. In order to be 95% sure that the proportion of agreement is within plus or minus 5% of 93.6% assumed to be the population value, a sample size was calculated using a sample size formula as described by Lemeshow et al, (1990) as follows:

$$n = \frac{Z^2_{1-\alpha/2} P(1-P)}{d^2}$$

Where,

n= minimum sample size required

$Z^2_{1-\alpha/2}$= Critical value for standard normal distribution at α-level of significance (α=0.05, $Z_{1-\alpha/2}$=1.96).

p =proportion of agreement between clinical and radiographic findings taken as 93.6% from a study done by Moll et al, (2013).

d =Margin of error (d=0.05)

$$n = \frac{(1.96)^2 \times 0.936(1-0.936)}{(0.05)^2} = 92.05$$

$$n = 93$$

3.5.2 Sampling Technique

Systematic sampling was used to select study sample. Based on the MTRH data (2018), the estimated numbers of panoramic radiographs done for a ten month period are 2000. Therefore, the sampling interval was estimated as follows:

$$\mathrm{K}^{th}\ \text{number} = \frac{\text{Total 10 month radiographs}}{\text{Sample size}}$$

$$\mathrm{K}^{th}\ \text{number} = \frac{2000}{93} = 21$$

Therefore, every 21st consenting patient was reviewed starting from the second patient (identified using lottery method). The data was collected from September, 2020 to June, 2021.

3.6 Data Collection

3.6.1 Data Collection Instruments

A structured chart review form was used to collect data from the panoramic radiographs and patients medical record.

3.6.2 Study Procedures

The panoramic radiography was performed by the radiographer on duty with the help of the investigator at the department of radiology and imaging at MTRH. The two research assistants were qualified radiographers who went through intensive training prior to data collection. The participants were informed about the study and consent sought after the OPG procedure to avoid coercion in signing of the consent.

A digital panoramic radiograph machine (Dimax4-ceph) was used in line with MTRH protocols. The procedure was explained and equipment shown to the patient to reduce anxiety. The patient was asked to place all metal objects such as hairpins, earrings and necklaces on the counter to avoid artifacts. Lead apron was provided to the patient to protect unexposed areas of the body from radiation. The unit was reset and patient asked to sit uprightly facing the machine. Using sterile gloves, the bite block was place in the bite block stick.

The patient was asked to place his/her chin on the chin rest and asked to bite into the grooves of the bite block. Using the positioning lights, the patient's head was well positioned and asked to close the lips, swallow and raise the tongue to the roof of the mouth. When unit status turned green, the patient was asked to breathe normally, remain still while OPG room was cleared ready for exposure. After exposure, the images were automatically saved in the computer.

After signing of the informed consent and assent forms, participants' data was collected. Demographic data was recorded in the chart review form. Data of panoramic radiographs findings was recorded first on the chart review form after the researcher reviewing images and consulting with a dentist and a radiologist. In case of variation in the two diagnoses, a second dentist was consulted to confirm the finding. The researcher, dentist and radiologist were masked of clinical findings when the OPG findings were recorded. Corresponding clinical dental examination findings of the patient was sought from the electronic clinical notes available at dental department and recorded in the forms after the panoramic radiographs findings were recorded. The clinical findings were recorded by a dentist on duty. The same electronic tool was used for recording clinical findings to ensure standardization. In case of missing electronic data, like in the case of post-operative patients, clinical data was sought from the physical patients' files.

3.7 Validity

3.7.1 Validity

Face validity was used to assess whether or not the study measures what it is supposed to measure. The chart review form was considered suitable after being validated by the author, a senior dentist and a senior radiologist

3.8 Quality Control

All panoramic radiogaphy was done at MTRH using the same digital panoramic radiography machine (Dimax4-ceph) for internal quality control. This was done when the patient was sent for the radiograph. The radiograph was done by a qualified radiographer on duty and the investigator based on a standardized protocol of MTRH. The panoramic radiograph was then reviewed by the researcher, a senior radiologist and a senior dentist.

3.9 Data management and analysis

3.9.1 Data Management

Data was collected using a structured chart review form. The data collected was checked for completeness and consistency on a daily basis by the researcher. In case of incomplete or inconsistent data, efforts were made to amend using documented data in the patients file or saved panoramic radiographs. The collected data was coded and transferred to a computer database using double entry to ensure accuracy of the data is maintained. The review forms were stored under lock and key in drawers while the softcopy of the data was secured in computer through a password.

3.9.2 Analysis

Data was imported into STATA 16, where coding, cleaning and analysis was done. Descriptive statistics were done to explore and summarize the data. For categorical variables such as gender, occupation and education level, data was summarized as frequencies and proportions and reported in tables and bar graphs. For numerical variable such as age, data was summarized as median and corresponding interquartile ranges and reported as tables and bar graphs. Cross tabulation was done to compare clinical examination and panoramic radiograph findings where percent agreement was reported as proportions. Chi-square test was used for statistical testing.

3.10 Limitations of the Study

The study faced the following challenges:

- There was no long-term storage of the digital panoramic radiographs in the department. This was addressed by saving the digital data in CDs and external hard disc for future reference
- The study was hospital based, therefore could not be generalized to the entire population

- The clinical records were recorded by different observers (dentist on duty). However, a standard electronic tool was used to record the data to ensure standardization and that no clinical data was missed by the clinician.

3.11 Ethical Considerations

To ensure that the study adhered to research ethical standards, the information collected from respondents was treated with utmost confidentiality and the respondents' names were hidden. Personal integrity was strictly observed when conducting the research by being objective and avoiding misrepresentation of results.

Participants were provided with all the information regarding the purpose, risk, benefits of the procedure and the study. Only consented patients were included in the study. Consent and assent forms were signed by participants or guardians prior to the data collection. All consenting participants were issued with a copy of the consent form.

Radiation protection guidelines were strictly adhered to. They include: ALARA principle (as low as reasonably acceptable dose), lead shielding for all patients, only patients indicated for the radiographs were exposed, among others. The research assistants were thoroughly trained to ensure participants safety and all ethical guidelines were adhered to. Ethical approval was also obtained from the IREC and hospital administration prior to conducting the research. The results of the research will be presented to the hospital's management and the university's department of Radiology and Imaging for use. It will also be available for academic reference in the College of Health Sciences Resource Centre. The study will be published in a peer reviewed journal and presented to my sponsors (Tana River County)

CHAPTER FOUR

RESULTS

The results are based on 93 patients with dental health condition seen at MTRH and referred for a panoramic radiograph at the radiology and imaging department between September, 2019 and June, 2020. The age of the study participants ranged from 5 to 73 years with a median age of 27.5 (IQR 13.5, 41.5). The peak age was 10-19 years followed by 30-39 years. Table 1 present the socio-demographic characteristics of the participants

Table 4.1: Socio-Demographic Characteristics

	Overall (N=93)
Age (years)	
N-Miss	1
Median (IQR)	27.5 (13.5, 41.5)
Range	5 – 73
Age Group	
0 – 9	13 (14.13%)
10 – 19	23 (25%)
20 – 29	14 (15.2%)
30 – 39	16 (17.4%)
40 – 49	12 (13%)
50 – 59	8 (8.7%)
60+	6 (6.5%)
Gender	
Male	47 (50.5%)
Female	46 (49.5%)
Occupation	
N-Miss	3
Employed	10 (11.1%)
Business	19 (21.1%)
Farmer/Unemployed/Retired	25 (27.8%)
Student	36 (40.0%)
Education level	
N-Miss	2
Nursery	8 (8.8%)
Primary	31 (34.1%)
Secondary	35 (38.5%)
Tertiary	17 (18.7%)

Participants were equally distributed in number between gender categories. Most (40%) of the patients were students followed by farmers (27.8%), and about 43% had nursery and primary level of education.

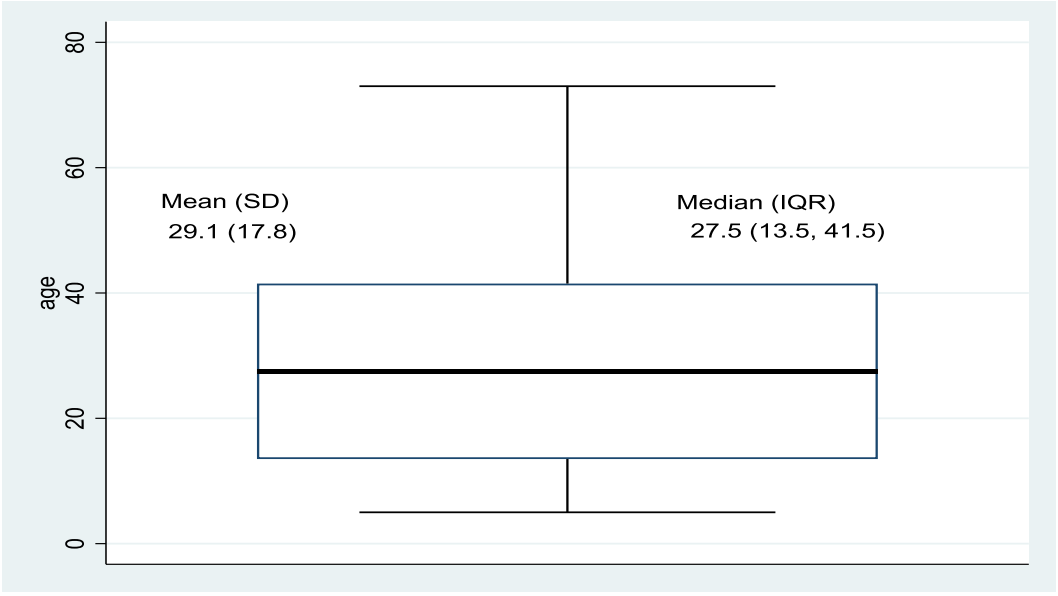

Figure 4.1: Age distribution

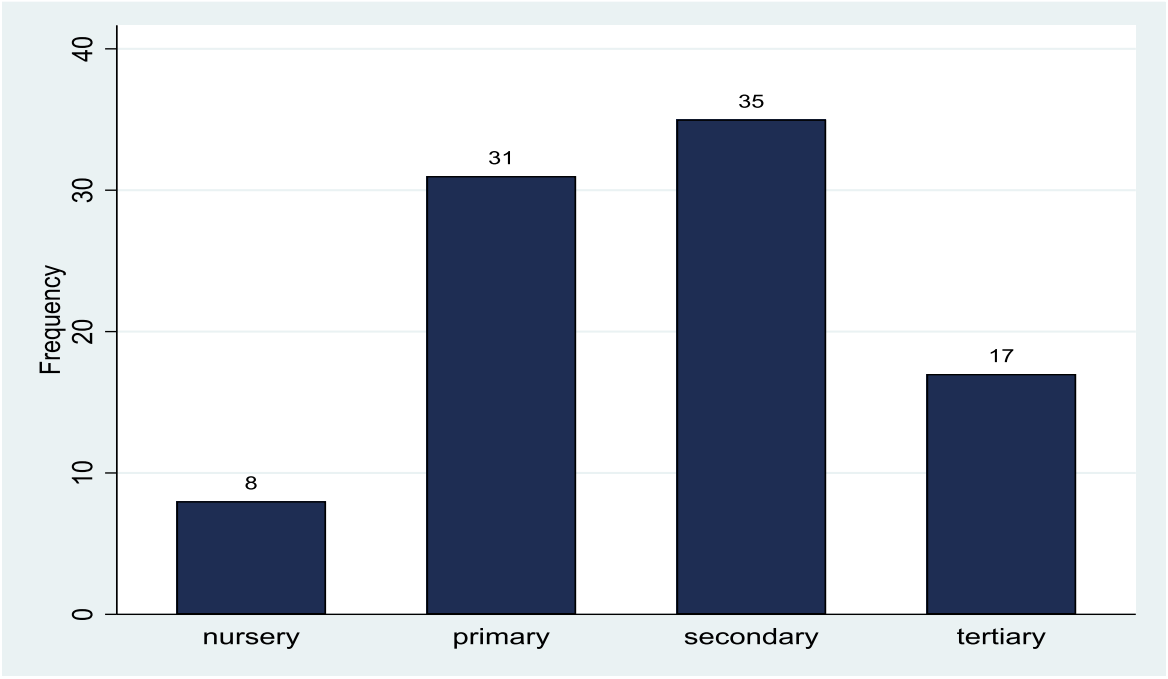

Figure 4.2: Education level

Table 4.2: Signs and symptoms

	Overall (N=93)
Clinical signs and symptoms	
Pain	79 (52.0%)
Swelling	34 (22.0%)
Bleeding gums	21 (14.0%)
Loose teeth	16 (10.0%)
Missing teeth	1 (1.0%)
Mal-positioned tooth	1 (1.0%)

Most of the participants presented with Pain (52.0%) followed by swelling (22.0%) and bleeding gums (14.0%). Only 10% of the participants presented with loose teeth (17.2%). Missing teeth and mal-positioned tooth was in 2.0% of the participants.

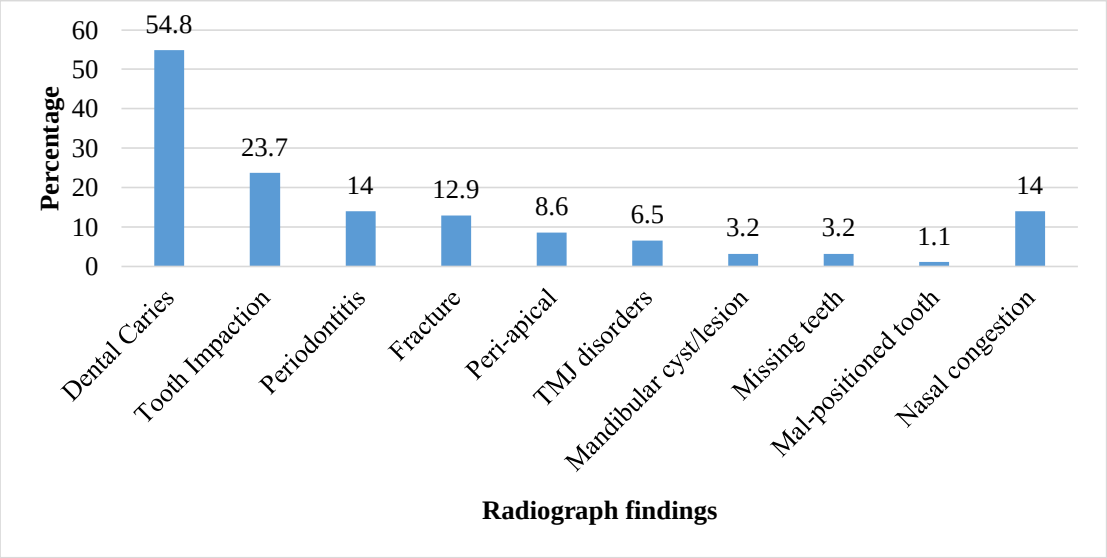

Figure 4.3: Panoramic radiograph findings

As per the panoramic radiograph, half (54.8%) of the patients had dental caries, 23.7% had tooth impaction while nasal congestion and periodontitis were diagnosed in 14% each.

Table 4.3: Clinical examination findings

	Overall (N=93)
Clinical diagnosis	
Dental caries	47 (50.5%)
Tooth impaction	18 (19.4%)
Periodontitis	15 (16.1%)
Fractures	10 (10.7%)
Periapical lesions	6 (6.4%)
TMJ disorders	6 (6.5%)
Mal-positioned tooth/Displaced teeth	2 (2.2%)
Missing tooth	1 (1.1%)
Soft tissue mass	1 (1.1%)

Clinically, dental caries was identified in 50.5% of the patients while tooth impaction, periodontitis and fractures were identified in 19.4%, 16.1% and 10.7% respectively.

Table 4.4: Agreement between radiograph and clinical examination findings

	Overall (N=93)
Diagnosis	
Dental Caries	83 (89.3%)
Tooth Impaction	89 (95.7%)
Mandibular cyst/lesion	90 (96.8%)
Periodontitis	91 (97.8%)
Fracture	91 (97.8%)
Periapical pathology	91 (97.8%)
TMJ disorders	91 (97.8%)
Missing teeth	91 (97.8%)
Soft tissue mass	92 (98.9%)
Mal-positioned tooth	92 (98.9%)

Dental caries had a total row agreement of 89.3% while tooth impaction and mandibular lesion had 95.7% and 96.8% respectively. The overall total row

agreement between clinical examination and radiograph findings was 75.3% (70/93) with a p value of less than 0.001.

Table 4.5: Summary of agreement between clinical and panoramic findings

Diagnosis	Radiology	Clinical	Agreement Level	p-value
Dental Caries	51	47	83	<0.001c
Tooth Impaction	22	18	89	<0.001f
Periodontitis	13	15	91	<0.001f
Fracture	12	10	91	<0.001f
Peri-apical pathology	8	6	91	<0.001f
TMJ disorders	6	6	91	<0.001f
Missing teeth	3	1	91	<0.001f
Mal-positioned tooth	1	2	92	<0.001f

[c] Chi Square test
[f] Fisher's Exact test

There was a statistical significant agreement between clinical and panoramic findings in all the diagnosis made with p value less than 0.001.

SAMPLE IMAGES

Image 1: 68 year old with multiple dental caries

Images 2: 35 year old with body of the mandible fracture post-operative

Image 3: 73 year old with periodontitis and missing teeth

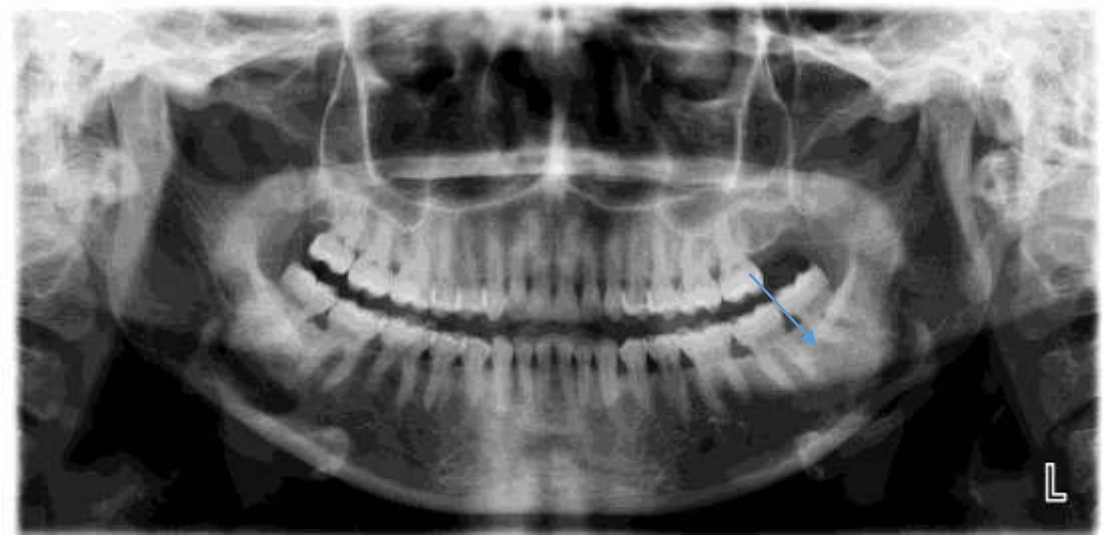

Image 4: 35 year old with periapical pathology

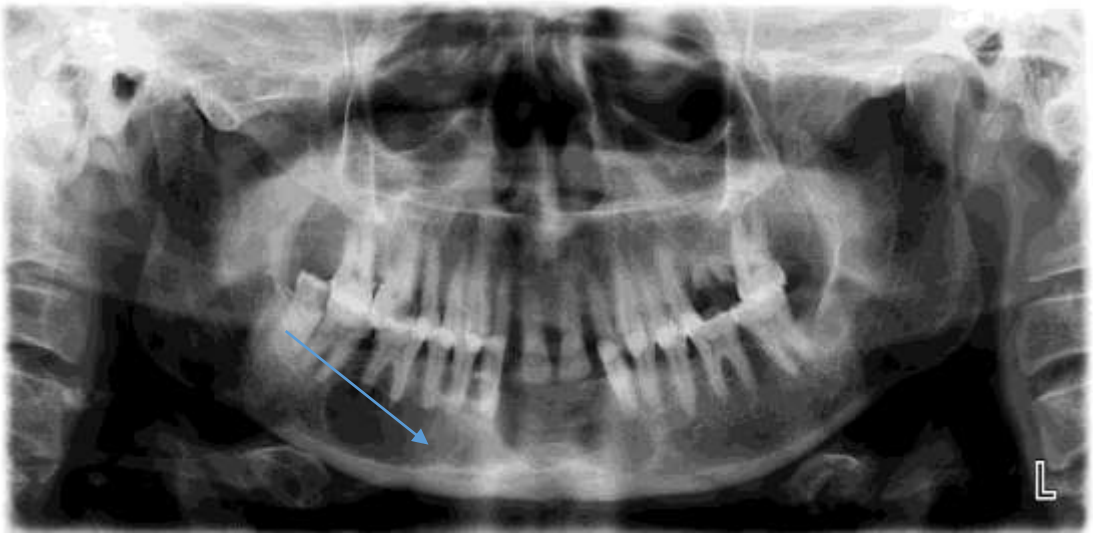

Image 5: 73 year old with multiple cystic lesions in the mandible

Image 6: 25 year old with dental caries

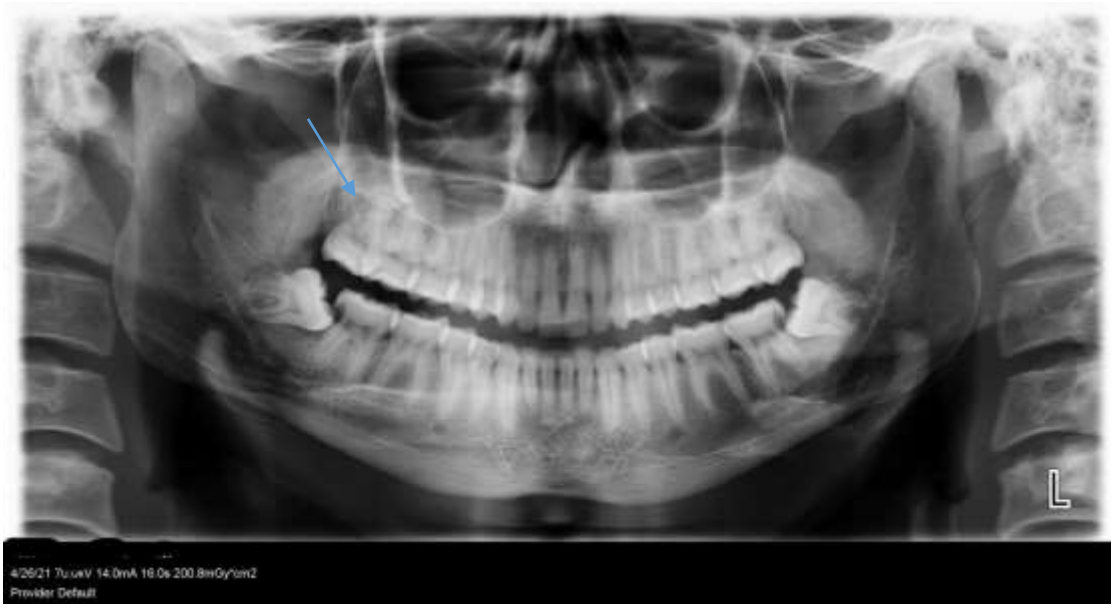

Image 7: 29 year old with bilateral tooth impaction

CHAPTER FIVE

5.0 DISCUSSION

5.1 Introduction

The purpose of this study was to determine the correlation of panoramic radiographic findings and clinical findings among dental patients at Moi Teaching and Referral Hospital, Kenya. Dental panoramic radiography is a simplified extra-oral procedure which visualizes the entire maxilla-mandibular region on a single film. In this way, clinical findings can be verified and supplemented by the panoramic radiographs.

5.2 Demographic Characteristics

The age of patients in this study ranged from 5-73 years with a mean age of 27.5. The peak age was 10-19 followed by 30-39 years. In a study done by (Moll et al., 2013) found majority of the participants to be in age bracket of 25-35 years. The wide range of age shows that dental conditions affect all age groups.

5.3 Signs and symptoms

A total of 79(52.0%) of patients presented with pain followed by swelling 34 (22.0%) and bleeding gums 21 (14.0%). Only 16 (10%) presented with loose teeth and 1 (1.1%) with missing teeth or mal-positioned teeth. The findings of study disagree with (Epstein et al., 2001) who discovered 75% of the patients presented with facial pain. However, the study on focused on patients with temporo mandibular disorders (TMD)

5.4 Panoramic radiograph findings

The bulk of the participants had dental caries 51(54.8%) followed by tooth impaction 22 (23.7%) and periodontitis 13 (14%) on panoramic radiographs. Nasal congestion 13(14%) and mandibular lesions 3(3.2%) were only seen by panoramic radiographs. The findings agree with a Korean study which reported a higher detection rate of

23.1% for dental caries, impacted tooth (33.6%) and TMJ disorders on panoramic radiographs than by clinical examination (M.-J. Shin et al., 2010)

The findings disagree with M.J. Shin et al (2010) also who found a 31.6% higher detection rate of periodontal disease on panoramic radiographs than on clinical exam. A study by Machado & Morgado (2020) in Portugal who found higher periodontitis (60% to 79% mild to moderate) and 66% severe on panoramic radiographs. The difference can be explained by a higher sample size (1064), population based study and a higher x-ray quality used. Another study by Do, Ogada, & Rj2(018) reported a lower percentage of tooth impaction discovered on panoramic radiographs. However, the study compared the panoramic findings and clinical findings of edentulous patients.

The findings disagree with a study Epstein et al. (2001)) who discovered 43.6% tooth impaction on panoramic radiographs. The higher percentage can be explained by the study focusing on patients with facial pain and jaw dysfunction. A study in Korea discovered 11.9% of peri apical pathologies and 2% impacted tooth on panoramic radiographs (Lee & Kang, 2005). Another study in Germany also reported contrasting findings of missing teeth on panoramic radiographs (11.5%). However, the above studies had difference in diagnostic threshold, observers and population. There is paucity of data locally comparing the two diagnostic tools (Moll et al., 2013)

5.5 Clinical dental findings

A total of 47(50.5%) had a clinical diagnosis of dental caries followed by tooth impaction 18(19.4%) and periodontitis 15(16.1%). Fractures 10 (10.7%), periapical lesions 6 (6.4%) and temporo mandibular lesions 6 (6.4%) were also discovered clinically. The findings disagree with An et al (2007) who detected only 5.2% dental caries clinically

A study in Germany reported a contrasting prevalence of missing teeth on clinical examination (11.4%). The difference can be explained different observers and diagnostic thresholds (Moll et al., 2013). Another study by Rohlin & Åkerblom (1992) reported 12.1% of periapical lesions discovered clinically. The difference can be explained by variations in the observers.

5.6 Agreement between radiographic findings and clinical examination findings

There was less dental caries 47 (50.5%) observed clinically compared to panoramic radiograph examination 51 (54.8%) with an agreement of 83(89.3%). Panoramic radiographs also diagnosed more tooth impaction 22(23.7%) compared to clinical diagnosis 18 (19.4%) with an agreement of 89(95.7%). However, more periodontitis was diagnosed clinically 15 (16.1%) than with panoramic radiographs 13 (14%) with an agreement of 91% (P–value<0.01). Mandibular lesions 3 (3.2%) and Nasal congestions 13 (14%) were only discovered radiographically.

The overall total percent agreement between panoramic radiograph examinations and clinical examinations was 70/93 (75.3%) (P–value <0.01). The results agree with a similar study in Germany by Moll et al. (2013) who also found a high agreement(93.6%) between dental panoramic radiographs findings and clinical findings. However, the German study used a relatively higher sample size and studied

only male soldiers aged between 25 years and 35years. The findings are also in agreement with a study by Hopcraft & Morgan (2005) in Melboune, Australia who found a high agreement, 93% to 97% of inter-proximal caries between clinical findings. However, the study included bitewing radiographs in addition to panoramic radiographs. In addition to that, only young adult population between 17 and 30 years of age were studied. More dental caries were reported clinically than on panoramic radiographs in the Melboune study. A study by Galcerá Civera et al. (2007) reported that both digital and conventional radiographic techniques increases the detection of dental caries compared to conventional clinical examination.. However, the study focused on low risk population. Proper analysis of the risks and benefits should be weighed up (Moll et al., 2013). The findings were also in agreement with a cross-sectional study by Naik (2020) in India who reported a high agreement between panoramic findings and clinical findings from a sample size of 130. The agreement of dental caries was 99%, periodontal bone loss (94%) and TMJ disorders (84%). The study also found 11% dental pathologies incidentally on panoramic radiographs only.

The findings also agree with a Kenyan study by Do et al. (2018) who found 83% agreement between panoramic radiograph findings and clinical findings of 163 edentulous patients. However, the agreement of the two findings was mainly on the location of the pathologies rather on diagnosis. The study also concluded that clinicians are able to detect most of the pathologies without radiographic investigations. A review of literature in Korea concluded that panoramic radiography will increase the efficacy of examination of dental patients. However, evaluation of cost, benefit and operation time was suggested in further studies. Clinical detectability of dental caries was lower than that of panoramic radiographs. It was statistical significant (J.-W. Choi, 2011). The results are in agreement with Nakagawa, Ishii, &

Nomura (2007) who found more tooth impaction and dental caries on panoramic radiographs than clinical examination findings. Another Korean study by M.-J. Shin et al. (2010) also discovered 23.1% more dental caries and 31.9% periodontal disease on panoramic radiographs than on clinical examination.

The findings of this study disagrees with a similar study by Molander, Ahlqwist, Grondahl, & Hollender (1993) & Valachovic, Douglass, & Ph (1986) who reported a relatively lower agreement between panoramic radiograph findings and clinical findings of dental patients of 47% and 54% respectively. The lower agreement can be explained by the current technical advancement in dental radiology. A German study also found 130 more carious lesions clinically than on panoramic radiographs in 170 patients out a sample of 275 (Moll et al., 2013) . Therefore, panoramic radiography is not a good diagnostic imaging tool for the detection of dental caries. A posterior bitewing radiograph is the preferred tool (V. E. Rushton et al., 2001). A study by Epstein et al. (2001) concluded that clinical examination is more relevant for the diagnosis of temporo mandibular disorders (TMD) and for the indication of additional imaging modalities than panoramic radiography in patients with facial pain and temporo mandibular disorders. In 70% of patients, panoramic radiography was found to be in adequate in the diagnosis of periapical lesions (Rohlin & Åkerblom, 1992).

Panoramic radiographs reported significant number of incidental findings compared to clinical examination. The findings are comparable to Vaseemuddin et al. (2016) who reported 10% of incidental Sino nasal pathology. The results also compares well with Donizeth-rodrigues, Silveira, & Alencar (2012) who found more nasal congestion (25%) on panoramic examination compared to routine dental clinical examination (0%). The findings were comparable with V. E. Rushton et al. (2001)

who found 34.3% more dental pathology on panoramic radiograph than clinical examination. Panoramic radiographs also found 33% more dental diseases on panoramic radiographs than clinical examination (Chaffin, Hennessy, & Cripps, 2004). However, the study compared clinical examination findings and panoramic radiograph findings of United States of America soldiers on entry screening. A similar study by in Korea was also in agreement (M.-J. Shin et al., 2010).

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

1. The most common panoramic radiograph finding at MTRH is dental caries followed by tooth impaction and periodontitis
2. The most common clinical examination finding at MTRH is dental caries followed by tooth impaction and periodontitis
3. The level of agreement between panoramic radiograph findings and clinical examination findings for dental conditions at MTRH was high (75.3%) and statistically significant.
4. Notably, radiographs did reveal slightly more cases for more of the condition than had been diagnosed clinically, with the exception of periodontitis. Incidentally, some dental and non-dental conditions were only discovered following radiographic examination

6.2 Recommendations

The agreement between panoramic findings and clinical findings in the diagnosis of dental health conditions is high with total percent agreement of 75.3%. Therefore clinicians are able to detect most of the pathologies without panoramic radiographic investigations. The following recommendations are made:

- There should be limited use of panoramic radiography as a supplementary diagnostic tool at MTRH to minimize unnecessary radiation exposure and cost of dental care to the patients
- MTRH to continuously invest in comprehensive dental clinical examination through recruitment, trainings and career progression to maintain a high level of clinical expertise hence reduce over reliance of radiography for diagnosis
- Panoramic radiography should be indicated in specific cases, were necessary, such as when additional findings are suspected and during pretreatment assessment, and based on clinical decisions by a qualified dentists
- The hospital administration to consider introducing standard operating procedures (SOPs) on the use of panoramic radiography by the dentists in the dental directorate

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APPENDICES

Appendix I: Consent Form

MOI UNIVERSITY
DEPARTMENT OF RADIOLOGY AND IMAGING

CONSENT FORM

This Informed Consent Form is for patients with dental conditions referred for panoramic radiographs, and who I am inviting to participate in research. The Topic of my research proposal is "**The pattern of panoramic radiograph findings in correlation to clinical findings of patients with dental health conditions at Moi Teaching and Referral Hospital, Kenya.**"

My name is Abdullatif Muhaji Badru bearing a registration number- **SM/PGR/02/2018**. I am currently pursuing a Master Degree in of Medicine in Radiology and Imaging at Moi University, School of Medicine. I kindly invite you to be part of this research by reading this form and ask any questions you may have before agreeing to participate in the study.

Purpose: This study will seek to determine the pattern of panoramic radiograph findings in correlation to clinical findings of patients with dental health conditions at Moi Teaching and Referral Hospital, Kenya.

Procedure: Patients presenting with dental health problems and for whom consent has been given will be included in the study. A data collection form will be used to collect demographic information, information regarding dental clinical information and radiological findings of panoramic radiographs. Data collection will be done by filing in of questionnaires. Information gathered will be treated with utmost confidentiality. Radiographs data will be saved in CDs and flash disks and discussed with two radiologists and a dentist.

Benefits: There will be no direct benefits of participating in this study. Study subjects will be accorded same quality of management as non-study subjects.

Risks: There are no anticipated risks to the participants attributable to this study.

Confidentiality: All information obtained in this study will be treated with utmost confidentiality and shall not be divulged to any unauthorized person

Rights to Refuse: Participation in this study is voluntary, there is freedom of refusal to take part or withdraw at any time. This study has been approved by the Institutional Research and Ethics Committee (IREC) of Moi University/Moi Teaching and Referral Hospital

I have read the foregoing information, or it has been read to me. I have had the opportunity to ask questions about it and any questions that I have asked have been answered to my satisfaction. I consent voluntarily to participate as a participant in this research.

Sign or make a mark if you agree to take part in the study

Patient: ……Investigator:…….. Date……

(For patients under 18 years)

Name of Guardian/ Parent giving consent……

Signature/*Sahihi*…… Or/*Ama*Thumb print *(Left)/Alamayakidole*

Gumba (kushoto)

Date/*Tarehe*……

Name of the person taking consent……

(Jina la anayetoaidhini

Signature/*Sahihi*…..... Date/*Tarehe* ……

Swahili Version

Mpelelezi: Jinalangu ni Abdullatif Muhaji Badru. Mimi ni daktari aliye hitimu na kusajiliwa na bodi ya Kenya ya Madaktari na Madaktari wa meno. Kwasasa natafuta shahada yauzamili katika Radiology na Imaging katika Chuo Kikuu cha Moi. Ningependa kukusajili katika utafiti wangu ambao ni wakujifunza majibu ya "***kuamua mfano wa matokeo ya radiografia ya panoramic kuhusiana na matokeo ya kliniki ya wagonjwa wenye hali ya afya ya meno katika Hospitali ya Mafunzo na yarufaa ya Moi, Kenya."***

Kusudi: Utafiti huu utajaribu kuamua mfano wa matokeo ya radiografia ya panoramic kuhusiana na matokeo ya kliniki ya wagonjwa wenye hali ya afya ya meno katika Hospitali ya Mafunzo na yarufaa ya Moi, Kenya.

Utaratibu: Wagonjwa wanao wasili na matatizo ya afya ya meno na ambao idhini wamepeana watapitia tathmini "Panoramic". Fomu ya kukusanya data itatumika kukusanya taarifa zaidi yawatu, habari kuhusu mazingira yakuumiza na matokeo ya radiological. Mkusanyiko wa data utafanywa na mahojiano na kufungua ndani ya maswali. Habari zilizokusanywa zitatambuliwa kwa usiri mkubwa.

Faida: Hakutakuwa na manufaa yamojakwamoja yakushiriki katika utafiti huu. Masomo ya kujifunza yatapewa ubora wausimamizi kama masomo yasiyo yakujifunza.

Hatari: Hakuna hatari inayotarajiwa kwa washiriki inayo tokana na utafitihuu.

Usiri: Taarifa zote zitakazopatikana katika somo hili zitatambuliwa kwa usiri mkubwa na hazita funuliwa kwa mtu yeyote asiye idhinishwa.

Haki ya kukataa: Kushiriki katika utafiti huu ni kwa hiari, kuna uhuru wa kukataa kushiriki au kujiondoa wakati wowote. Utafitihuu umeidhinishwa na Kamati yaUtafiti na Maadili yaTaasisi (IREC) ya Hospitali ya Moi na ya Chuo Kikuu cha Moi na Mafunzo ya Rufaa.

Kusaini au kuweka alama kama unakubali kushiriki katika utafiti Mgonjwa: ..... Mpelelezi: ..... Tarehe: .....

Walio chini ya Miaka 18

Jina la Mzazi au mlezi

Sahihi ……Tarehe…….

Jina la anaye chukua idhini

Sahihi….. ***.....*** *Tarehe ……*

Appendix II: Chart Review Form

MOI UNIVERSITY
DEPARTMENT OF RADIOLOGY AND IMAGING

CHART REVIEW FORM FOR THE STUDY

SECTION A

BACKGROUND INFORMATION

1. Gender Male [ ] Female [ ]

2. Date of birth Year.....Month..... Date.....

3. Occupation

Health Worker [ ] Farmer [ ] Fisher [ ]

Pastoralists [ ] Business man/woman [ ]

Other [ ]

4. Level of education

Primary [ ] Secondary [ ] Tertiary [ ] Other [ ]

SECTION B

PANORAMIC RADIOGRAPH FINDINGS

1. What are the radiograph findings?

   Dental caries YES [ ] NO [ ]

   Tooth impaction YES [ ] NO [ ]

   Periodontitis YES [ ] NO [ ]

   Peri-apical Pathology YES [ ] NO [ ]

   Fractures YES [ ] NO [ ]

   TMJ disorders YES [ ] NO [ ]

   Others [ ]

   If others, please specify

   them……

SECTION B

DENTAL CLINICAL FINDINGS

1. What is/are the clinical presentation?

   Pain YES [ ] NO [ ]

   Swelling YES [ ] NO [ ]

   Bleeding gums YES [ ] NO [ ]

Loose teeth YES [ ] NO [ ]

Others [ ]

If others, please specify

……

What is the working diagnosis based on clinical examination?

Dental caries YES [ ] NO [ ]

Tooth impaction YES [ ] NO [ ]

Periodontitis YES [ ] NO [ ]

Peri apical Pathology YES [ ] NO [ ]

Fractures YES [ ] NO [ ]

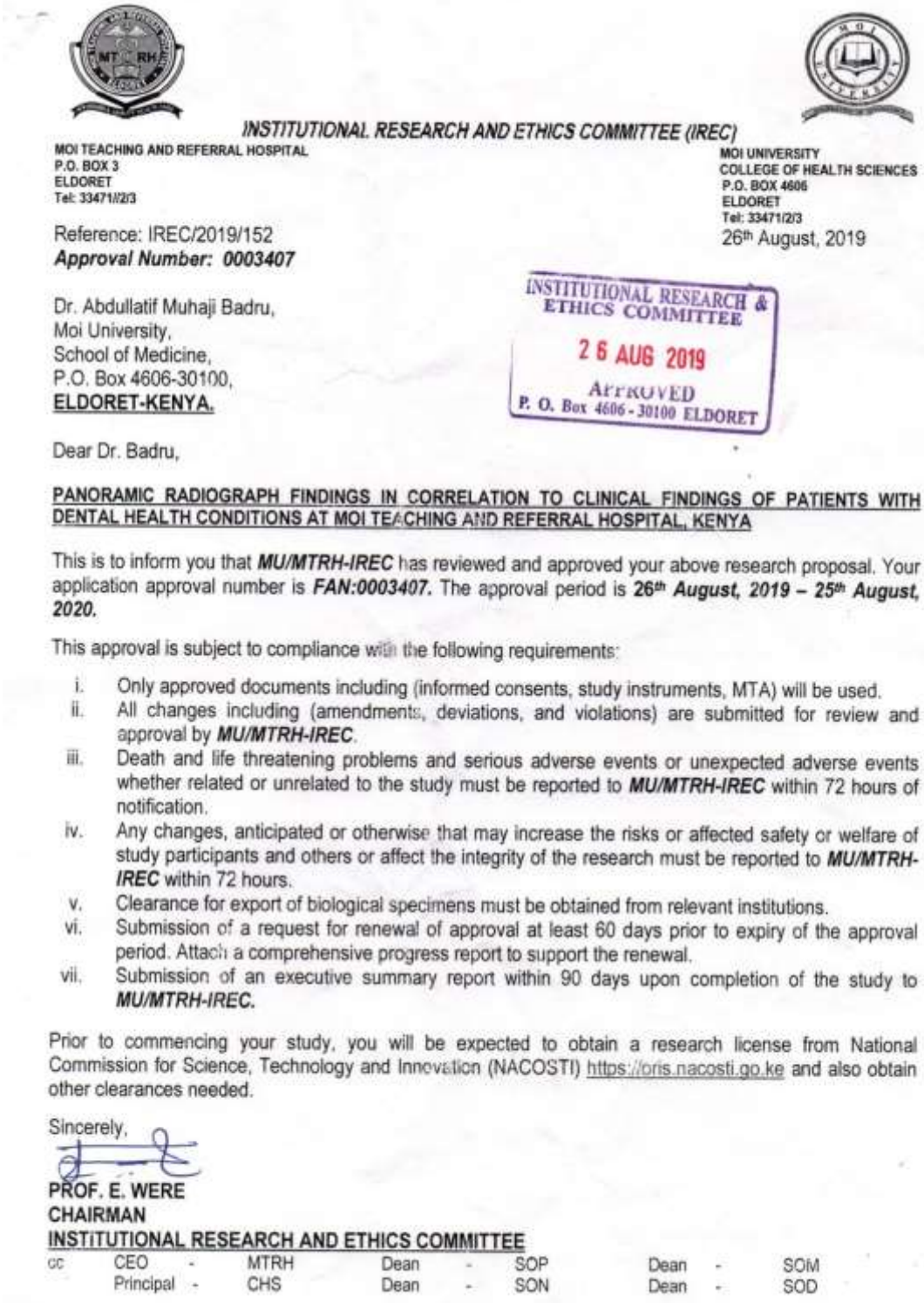
TMJ disorders YES [ ] NO [ ]

Others [ ]

If others, please

specify……

Appendix III: IREC Approval



INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE (IREC)

MOI TEACHING AND REFERRAL HOSPITAL
P.O. BOX 3
ELDORET
Tel: 33471/2/3

MOI UNIVERSITY
COLLEGE OF HEALTH SCIENCES
P.O. BOX 4606
ELDORET
Tel: 33471/2/3

Reference: IREC/2019/152
Approval Number: 0003407

26th August, 2019

INSTITUTIONAL RESEARCH & ETHICS COMMITTEE
26 AUG 2019
APPROVED
P. O. Box 4606 - 30100 ELDORET

Dr. Abdullatif Muhaji Badru,
Moi University,
School of Medicine,
P.O. Box 4606-30100,
ELDORET-KENYA.

Dear Dr. Badru,

PANORAMIC RADIOGRAPH FINDINGS IN CORRELATION TO CLINICAL FINDINGS OF PATIENTS WITH DENTAL HEALTH CONDITIONS AT MOI TEACHING AND REFERRAL HOSPITAL, KENYA

This is to inform you that ***MU/MTRH-IREC*** has reviewed and approved your above research proposal. Your application approval number is ***FAN:0003407.*** The approval period is ***26th August, 2019 – 25th August, 2020.***

This approval is subject to compliance with the following requirements:

i. Only approved documents including (informed consents, study instruments, MTA) will be used.
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by ***MU/MTRH-IREC***.
iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to ***MU/MTRH-IREC*** within 72 hours of notification.
iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to ***MU/MTRH-IREC*** within 72 hours.
v. Clearance for export of biological specimens must be obtained from relevant institutions.
vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
vii. Submission of an executive summary report within 90 days upon completion of the study to ***MU/MTRH-IREC.***

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://oris.nacosti.go.ke and also obtain other clearances needed.

Sincerely,

PROF. E. WERE
CHAIRMAN
INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE

cc CEO - MTRH Dean - SOP Dean - SOM
Principal - CHS Dean - SON Dean - SOD

Appendix IV:Hospital Approval (MTRH)

An ISO 9001:2015 Certified Hospital

MOI TEACHING AND REFERRAL HOSPITAL

Telephone :(+254)053-2033471/2/3/4
Mobile: 722-201277/0722-209795/0734-600401/0734-683361
Fax: 053-2061749
Email: ceo@mtrh.go.ke/directorsofficemtrh@gmail.com

Nandi Road
P.O. Box 3 – 30100
ELDORET, KENYA

Ref: ELD/MTRH/R&P/10/2/V.2/2010

30th August, 2019

Dr. Abdullatif Muhaji Badru,
Moi University,
School of Medicine,
P.O. Box 4606-30100,
ELDORET-KENYA.

APPROVAL TO CONDUCT RESEARCH AT MTRH

Upon obtaining approval from the Institutional Research and Ethics Committee (IREC) to conduct your research proposal titled:-

"Panoramic Radiograph Findings in Correlation to Clinical Findings of Patients with Dental Health Conditions at Moi Teaching and Referral Hospital, Kenya".

You are hereby permitted to commence your investigation at Moi Teaching and Referral Hospital.

MOI TEACHING AND REFERRAL HOSPITAL
CEO
APPROVED
30 AUG 2019

DR. WILSON K. ARUASA, *MBS*
CHIEF EXECUTIVE OFFICER
MOI TEACHING AND REFERRAL HOSPITAL

cc - Senior Director, (CS)
- Director of Nursing Services (DNS)
- HOD, HRISM