PATTERN AND CHARACTERISTICS OF IMPACTED TEETH ASSOCIATED WITH JAW CYSTS AND TUMOURS AMONG PATIENTS ATTENDING THE UNIVERSITY OF NAIROBI DENTAL HOSPITAL

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2022

UNIVERSITY OF NAIROBI

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DEDICATION

In loving memory of Dr. Mandy Yolanda Sibanda-Dhlamini, this study and its findings is dedicated to patients, healthcare providers and partners who are affected by and/or are involved in the management of facial bones pathologies.

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ABBREVIATIONS AND ACRONYMS

AOT	Adenomatoid Odontogenic Tumour
CBCT	Cone Beam Computed Tomography
CEJ	Cemento-enamel Junction
CEOT	Calcifying Epithelial Odontogenic Tumour
CGCG	Central Giant Cell Granuloma
COF	Cemento-ossifying Fibroma
CT	Computed Tomography
IBM	Inferior Border of the Mandible
KNH	Kenyatta National Hospital
ERC	Ethics and Research Committee
NACOSTI	National Commission for Science, Technology and Innovation
NICE	National Institute of Clinical Excellence
OKC	Odontogenic Keratocyst
SIGN	Scottish Intercollegiate Guidelines Network
UoN	University of Nairobi
UONDH	University of Nairobi Dental Hospital
USA	United States of America

OPERATIONAL DEFINITIONS

Association	The concurrent occurrence of two or more features in the same anatomical site. In this study this refers to the concurrent presence of a jaw cyst/tumour and an impacted tooth in one and the same jaw region.
Complication	An unintended negative effect of a surgical intervention e.g. nerve injuries during disimpaction. It also refers to the sequelae of disease processes/entities, namely impacted teeth and jaw lesions in this study
Disimpaction	The extraction of an impacted tooth
Jaw pathologies	Diseases of the mandible and maxilla, manifesting radiologically as radiolucencies more than 3mm wide, radio-opacities and mixed lesions
Pathologies	Anatomical and physiological deviations of human tissue from the normal, which result in or characterise a disease
Pattern of impaction	The topographical presentation of an impacted tooth in relation to adjacent teeth, bone and soft tissues
Syndrome	A medical condition characterised by a constellation of symptoms concurrently occurring in different body regions/organs
Tooth impaction	The failure of a tooth to erupt to a functional height in the dental arch two years after its expected eruption age according to Schour and Massler dental eruption atlas
Tooth span	The number of teeth involved in a lesion

ABSTRACT

Background: The incidence of impacted teeth is rising globally. Besides dental hard tissue pathologies and pericoronitis, impacted teeth are also associated with destructive jaw cysts and tumours. Irrespective of these facts, non-molar tooth impactions and associated jaw pathologies are hardly published in Kenya.

Objectives: To determine the pattern and characteristics of impacted teeth associated with jaw cysts and tumours among patients attending the University of Nairobi Dental Hospital

Materials and method: This ten-year (January 2011 to December 2020) retrospective analytical study reviewed histopathology and dental pantomogram records of 354 patients (183 females and 171 males).

Data analysis: Data was analysed using SPSS version 28 and a p value < 0.05 was considered statistically significant. Frequencies, percentages and measures of central tendency were used to analyse data. The chi squared/Fisher's exact tests and the student t-test analyses were used for categorical and continuous data respectively.

Results: Of the 354 patients with jaw cysts/tumours, 358 lesions were identified of which 304 (84.9%) were developmental odontogenic lesions, 24 (6.7%) were inflammatory odontogenic and 30 (8.4%) were non-odontogenic in origin. In 52.3% of the developmental odontogenic lesions, 184 impacted teeth were observed. Of those teeth, mandibular third molars were the majority, contributing 21.2%. The next frequently impacted teeth associated with jaw cysts/tumours were the mandibular canines and maxillary canines contributing 17.4% and 16.8% of the teeth respectively. One-hundred and seventy two teeth (93.5%) had impaction depth below the cemento-enamel junction of the adjacent erupted tooth and 49.5% had mesioangular impaction. It was observed that lesion presentation was at least one decade earlier in the presence of impacted teeth. These three findings were statistically significant ($p<0.01$).

The most prevalent pathological entities associated with impacted teeth were dentigerous cysts (31.1%), ameloblastomas (26.8%), odontomes (15.9%) and odontogenic keratocysts (11.0%) but the overall most frequent jaw lesion irrespective of tooth eruption status was the ameloblastoma, observed in 123 (34.4%) cases. On radiographic appearance, 79.9% of all lesions and 75.6% of those with impacted teeth were

radiolucent. The posterior mandible beyond the canine was the most frequently affected site being involved in 95.1% of all cases.

Conclusion and recommendations: Deep dental impactions may be associated with jaw cysts and tumours therefore radiologic surveillance and clinical monitoring for all missing teeth, deep impactions and potential jaw lesions is recommended.

CHAPTER ONE: INTRODUCTION AND LITERATURE REVIEW

1.1 Introduction and background

Tooth eruption is the process whereby a tooth migrates occlusally from its follicle in the jaws into a functional position within the oral cavity for roles in mastication, speech and aesthetics[1,2]. Irrespective of the identified normal dentition set and eruption sequences, anomalies in tooth eruption are quite common and prevalences above 20% have been reported[3,4]. These anomalies impact negatively on the function and health of the dentition and the patient as a whole. Tooth impaction is a dental anomaly defined by the failure of adequate tooth eruption mainly due to a physical barrier or ectopic tooth position for at least two years after the expected eruption age[1, 2].

Tooth impaction can only be definitively confirmed or ruled out by imaging studies[5]. It follows then that the prevalence of tooth impaction in the general population is largely unknown because the random exposure of the population to radiation is unethical[2]. Most studies on impacted teeth are thus based on databases of patients attending oral healthcare institutions and often focus on one specific tooth especially the mandibular third molar. In a 1989 study, mandibular third molar impactions constituted 1.6% and 14.7% of all oral diagnosis clinic and oral surgery consultations at Kenyatta National Hospital respectively[6].

Due to resultant deranged dental arch form, impactions can lead to malocclusion, compromised masticatory function and poor aesthetics[2]. Impacted teeth have also been associated with pericoronitis, dental caries, adjacent tooth root resorption and bone cysts and tumours[7]. Among these pathologies, dental caries prevalence is high especially for impacted posterior teeth and when untreated, the radicular extension of the mandibular second and third molars below the mylohyoid muscle predisposes patients to Ludwig's angina[8]. In contrast, jaw pathologies have been noted to have a low prevalence, comprising about 2-6.2%

of associated pathologies in most studies but the incidence has been noted to increase with age[7]. When histopathological examination of the follicle is coupled to imaging studies, the incidence of jaw pathologies also increases[9]. Most impacted teeth are asymptomatic, raising the controversy of prophylactic versus therapeutic management of impacted teeth. Despite the controversy, impacted teeth management remains the commonest surgical procedure in oral surgery practice[10,11,12].

From literature, paucity of information on jaw pathologies associated with impacted teeth is apparent, more so on the African continent. Aside from the direct management of impacted teeth, the early diagnosis, prevention where possible and management of associated bone lesions is very important for both the surgeon and the patient. Jaw cysts and tumours result in bone destruction and their management can result in continuity defects, the reconstruction of which is still a challenge in many settings especially in Africa. This study aims to fill the information gap on the association between impacted teeth and jaw cysts and tumours in addition to providing evidence-based recommendations on the surveillance and management of impacted teeth and jaw lesions.

1.2 Literature review

1.2.1 Normal tooth eruption

The determinants of tooth eruption are multiple comprising genetic and environmental influences and these include race, sex, nutrition, diet, endocrine status etc.[13,14,15]. Schour and Massler introduced a dental eruption atlas in 1941 which has been used for dental age estimation over the years[16]. Recent studies have however shown precocious tooth eruption and an increased rate of tooth impaction[11, 13]. Amidst all these developments, lower third molar eruption remains unpredictable[17]. In Nigeria, the mandibular third molar eruption age is reported to be as low as 14 years in contrast to 24 years in the Greek population while in Kenya it has been reported to be around 18 years of age[18,19]. It follows that the utility of third molar eruption status in forensic dentistry currently lacks support and is complicated by dental impaction and agenesis. The eruption sequence is however distinct and maintained and the timespan from expected eruption age is used to distinguish between unerupted and impacted teeth[13].

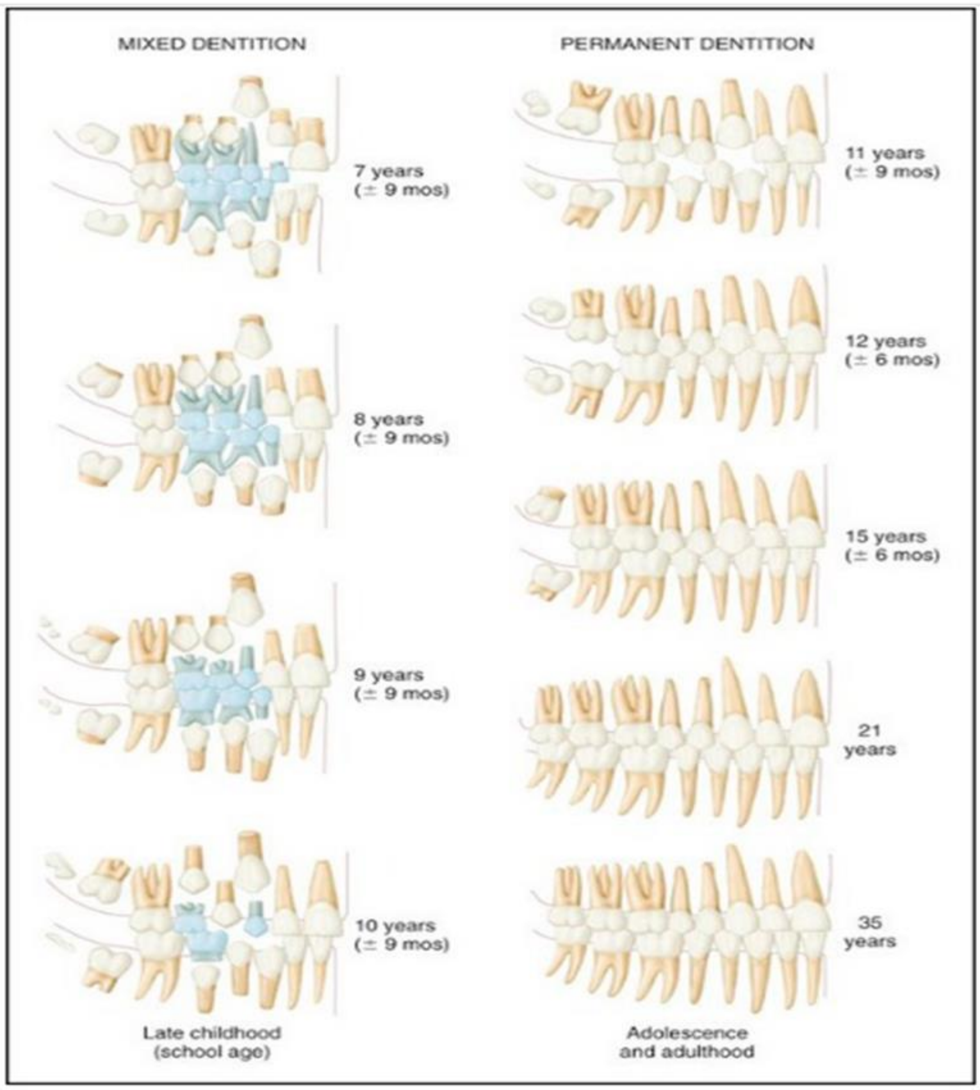

Figure 1: Schour and Massler tooth eruption atlas[16]

1.2.2 Theories of tooth eruption and tooth impaction

Multiple theories have been brought forward to explain tooth eruption. These include the root formation theory, periodontal ligament traction theory, the neuromuscular theory and the asymmetric bone remodeling theory among others[20,21]. With the observation of the eruption of rootless teeth, some theories have been refuted as sole determinants[20]. Tooth eruption is dependent on multiple factors and currently the asymmetric bone remodeling theory is widely accepted[20]. In support of the bone remodeling theory, disruptions of bone resorption e.g. osteopetrosis have been shown to be important factors in the occurrence of third molar impactions[17].

Five theories of tooth impaction were described by Durbeck in 1943[22]. The orthodontic theory states that interference with the downward and forward growth of the jaw results in limited space for tooth eruption. In contrast, the phylogenic theory recognises the evolutionary elimination of redundant structures as the reason for impaction. This is exemplified by the reduction in masticatory force requirements in refined diets which promotes the impaction of expendable teeth[22]. The other theories are the endocrinal and Mendelian theories which describe reduced jaw size due to deficient growth hormone and heredity respectively[22]. Durbeck also acknowledges that chronic infections can induce dense osteogenesis which can act as a mechanical barrier to erupting teeth and this is referred to as the pathological theory of tooth impaction[22]. Other researchers describe the growth and development theory which encompasses the orthodontic, Mendelian and pathological theories, while the evolution and phylogenic theories are equated[22,23,24].

1.2.3 Aetiology and epidemiology of impacted permanent teeth

On the basis of failure of a tooth to adequately emerge intraorally into the dental arch, some researchers further qualify impaction if a tooth's normal eruption age is past, with the tooth having at least two-thirds root formation[25]. The expected eruption age marks the difference between unerupted teeth which are defined as being within normal limits of eruption age and impacted ones which will be post eruption age[26]. Some studies specify two years post-eruption age as the demarcation between impacted and unerupted teeth[1,2].

A myriad of factors are implicated in the development of tooth impaction and these can be local or systemic. Local factors such as the presence of physical barriers along the path of tooth eruption tend to have a greater contribution to impaction as opposed to systemic factors[27]. Recognised risk factors for tooth impaction include premature loss of deciduous teeth, inadequate arch space exemplified by limited resorption of the mandibular ramus; mechanical impediments and malpositioned tooth buds [2,15,17,24,28]. Mechanical impediments include overlying thick bone or soft tissues, supernumerary teeth, cystic and neoplastic lesions[15,24,25,26]. In contrast to mechanical impediments, malpositioned tooth buds are mostly associated with oro-facial clefts[15]. Other identified risk factors include dentoalveolar trauma, root dilacerations, radiation and endocrinal deficiencies[15,29,30]. Some studies have suggested a role for refined diet in the development of tooth impaction as evidenced by the increasing incidence of tooth impaction especially in the developed world[5,13,14]. Rarely tooth impactions can be multiple and in this form are usually syndromic, associated with Gardner's syndrome, cleidocranial dysostosis, osteopetrosis, progeria, Crouzon and Apert syndromes[30,31].

Dental impactions generally do not have gender predilection, are rare in the deciduous dentition and are on the rise[11, 31]. The teeth which are prone to impaction are the ones which erupt last in the eruption sequence e.g. the canines and third molars[28]. The most frequently impacted teeth in descending order are the third molars, maxillary canines, mandibular premolars and mandibular canines[10,11,15,24,31]. Maxillary canine impaction among the Japanese has been noted to be around 0.27% of the population and around 2.4% for Italians[27]. The canine moves a long distance to its normal occlusal position hence the predisposition to impaction[1]. Unilateral canine impactions are more common than bilateral ones with reported ratios ranging from 2-3:1[1,15]. This predilection for unilaterality of canine impaction has been used to support environmental aetiologies as opposed to genetic ones.

1.2.4 Classification of impacted teeth

Multiple classifications for impacted teeth are documented in literature and are frequently designed for specific tooth types, mostly the third molars and maxillary canines (Appendix 1). Classifications are used for ease and accuracy of communication and also to predict the surgical difficulty of managing impacted teeth[32]. General classification according to composition of overlying tissue includes soft tissue, partial bony and total bony impaction[14,20,33]. For mandibular third molars, the Pell and Gregory classification comprises the tooth's relative distance from the anterior border of the mandibular ramus and the depth from the occlusal plane while, the Winter's classification is according to the tooth's angulation[14,25]. Impaction angulation patterns include vertical, mesioangular, distoangular, horizontal, transverse and other uncommon dental inclinations[14]. In most mandibular third molar impactions, retromolar space size is inversely related to the depth of the tooth and multiple studies have reported mesioangular impaction as the most prevalent impaction pattern for mandibular third molars[6,29,34]. The pattern of tooth impaction has been reported to have a bearing on the associated pathologies with jaw lesions being more common in deeper impactions and vertically impacted teeth[17,18].

Impacted maxillary canines have been classified according to Archer and ideally require orthogonal imaging views or cone beam computed tomography (CBCT) for determination of the tooth's anteroposterior position[32]. Five classes are identified: class I is for palatally impacted teeth, class II for bucally impacted and class III for teeth with both palatal and buccal positioning. Classes IV and V describe impaction in the alveolar process and edentulous maxilla respectively[35]. No descriptions pertaining to proximity to vital structures are given. Other impacted canine tooth classifications include Yamamoto's classification which is comprised of seven classes and is preferred in some literature[36]. The classes include vertical, mesioangular, distoangular, horizontal with mesial crown, horizontal with distal crown, inverted and labiopalatal impaction[36].

Besides third molars and maxillary canines, impactions of other tooth types have not been specifically classified. In 2019, Orafi from the University of Benghazi proposed a universal quantitative classification called the SPAND classification. It records the eruption space size, impaction depth, angulation, proximity of tooth roots to vital structures and distance from the nasopalatine canal (for upper anterior teeth)[32]. The collated scores are postulated to be directly proportional to the degree of difficulty of surgical management of impacted teeth.

1.2.5 Diagnosis of impacted teeth

Most patients present with impacted tooth complaints in their second and third decades of life[6]. A thorough history, clinical examination and appropriate imaging are essential for accurate diagnosis. This will also enable the establishment of the possible aetiology/risk factors and associated pathologies; and evaluation of difficulty of management. Late presentation to health institutions is common and can result in greater morbidity especially for patients with associated jaw pathologies. In some cases however, impacted teeth are found incidentally on imaging[31, 37,38].

1.2.6 Clinical history and features

Common signs and symptoms include retained deciduous teeth or missing permanent teeth, dental caries, pericoronitis and diffuse locoregional pain. Retained deciduous teeth can be due to a lack of push force from succedaneous teeth due to their absence, malpositioning, impaction or poor development[24,28,39]. In few instances, symptoms related to impacted 3rd molars have been cited to delay the diagnosis of malignancies[27,39].

The rapid painless expansion of bony swellings, fractures and facial disfigurement has been observed in children, especially due to the presence of dentigerous cysts[39]. Jaw pathology progression is however slower in the adults[40]. When large cysts are present, buccal cortical plate expansion can be evident with eggshell crackling, resultant facial asymmetry and deflected teeth[18,39,40,41]. Rarely patients can present with complete edentulism of one of the jaws as a result of multiple impacted teeth and this finding is mainly noted in syndromic cases[30]. Syndromic cases will present with additional abnormalities in other body regions for example absent clavicles in cleidocranial dysplasia[30].

1.2.7 Imaging

Dental panoramic radiography is the basic view for diagnosis of impacted teeth but magnification and distortion effects are some of its disadvantages[10,25]. For supplementation of radiographic detail, intraoral periapical radiographs may also be taken. In contrast to conventional radiography, computed tomography (CT) and cone-beam computed tomography (CBCT) have higher resolution and minimal image distortion but pose the risk of increased radiation dose[10,29,39]. High resolution imaging is crucial in outlining the relationship between impacted tooth roots and vital structures like the mandibular canal, mental foramen and the maxillary sinus[29]. However in the absence of high resolution imaging, the Rood and Shehab criteria can be used with panoramic images to assess the proximity of third molar roots to the mandibular canal[42]. For the confirmation of buccolingual direction of impacted teeth, orthogonal views and the tube shift technique are used[28].

In one study, the incidental finding of complete tooth impaction was made on radiography in about 5% of the patients[31]. Besides the diagnosis of an impacted tooth and its proximity to vital structures, other crucial information from imaging studies includes transmigration of impacted teeth, root resorption of adjacent teeth, caries and radiographically detectable bone pathology[17,27,43]. Panoramic radiography unfortunately has low sensitivity to bone destruction in early jaw pathologies[43].

1.2.8 Pathologies associated with impacted teeth

Pathologies associated with impacted teeth include soft-tissue pathology, dental hard tissue and bony pathologies[43]. In one American study with middle aged participants, at least 98% of the study sample had either caries or periodontal disease while Mwaniki found caries in 46.4% of impacted teeth in a Kenyan study population[6,43]. Thus caries is a common finding in partially erupted impacted teeth.

Pain

Pain is one of the commonest symptoms of impacted teeth and can be due to radicular encroachment onto nerves, caries, pericoronitis, root resorption and pressure effects of the impacted tooth and jaw pathologies[31,34,43]. In most cases the pain is usually spontaneous, referred and generalised[32].

Pericoronitis

Pericoronitis occurs in partially-erupted teeth and is characterised by inflammation of the overlying operculum. It is primarily triggered by the accumulation of food debris underneath the redundant gingiva[44]. Studies show that pericoronitis predisposes the patient to cardiovascular diseases[45]. Management by operculectomy is not effective in the long term and extraction is the definitive management[43].

Dental caries

Maintaining good oral hygiene of partially erupted teeth is difficult[31]. The mesioangular impaction of third molars is the commonest type of impaction and it poses a high caries risk for the adjacent second molars[25,31]. Caries of both the impacted tooth and the adjacent one are common and complicated by difficulty of restoration due to tooth malpositioning[43]. In a study by Mwaniki in Kenya, 62.4% of patients with impacted third molars had mesio-angular impaction and caries was the commonest reason for tooth extraction[6].

Dental root resorption

Root resorption of adjacent teeth can manifest as pain, tooth mobility and migration and is a result of pressure from the impacted tooth or associated jaw pathologies. The apical one third of the root is the most frequently affected and with chronic impaction, the abutting crown of the impacted tooth can also be resorbed[46,47]. This predisposes the patient to tooth loss.

Odontogenic cysts and tumours

The development of odontogenic cysts and tumours

Odontogenic cysts and tumours arise from the embryonic rests of tooth germs[26,48]. The tooth germ is composed of the dental follicle which surrounds the enamel organ and the dental papilla. From these tissues, cell rests of Seres, the reduced enamel epithelium, epithelial cell rests of Malassez and the Hertwig epithelial root sheath have been identified as sources of cysts and tumour development[48]. Thus the presence of odontogenic embryonic rests in impacted tooth settings is a risk factor for the development of cysts and tumours.

Impacted teeth and odontogenic cysts and tumours

Impacted tooth involvement in odontogenic cysts and tumours is recognised though the prevalence is variable and different study methodologies make data comparison difficult[9,18,25,26]. Associated follicle disease is however underdiagnosed because pericoronal tissues are rarely submitted for histology[43]. Radiographic evaluation alone is inadequate for an accurate diagnosis of pathologic changes in embryonic tissue rests, making histology the gold standard in diagnosis[9,11,26,43]. In some studies over 20% of patients who had no cortical bone expansion had histopathologic confirmation of the presence of a dentigerous cyst[17,18]. These lesions result in bone and dental radicular resorption; and encroach onto adjacent structures e.g. neurovascular bundles and the maxillary sinuses especially when they become large enough[49,50]. Some studies have reported the preponderance of the knife-edge radicular resorption pattern in ameloblastoma lesions to the point of being pathognomonic[51]. Other complications include facial asymmetry, tooth displacements, malocclusion and pathological fractures[50].

Most jaw lesions are in the mandible and the commonest ones are dentigerous cysts, odontogenic keratocysts and ameloblastomas[7,14,26]. In Kenya, ameloblastoma and keratocystic odontogenic tumour (currently recognised as a cyst) are noted to be the commonest odontogenic tumours but their involvement with impacted teeth is not documented[52]. The modal age for cysts and tumours is often higher in males than females and this has been attributed to the earlier development of females and pro-cyst hormonal influences[26]. When associated with impacted teeth, jaw pathologies are more common in the 2nd and 3rd decades of life and pathological significance has been noted to increase with age[7,9,18,37,43]. Predilections for the male gender and the mandible have been shown for cysts and tumours[9,11,26,37,41,48]. This has been attributed to higher tobacco use and alcohol intake among males[7]. The prevalence has also been shown to be higher in Africans (1.26-5.6%) and Asians and some studies have shown an earlier age at presentation for locally aggressive lesions in patients from developing countries[48,52,53].

1.2.9 Impacted tooth management protocol controversy

The controversy of prophylactic extraction as opposed to therapeutic management of impacted teeth has been longstanding over the years. Proponents for extraction only in the presence of pathology include the National Institute of Clinical Excellence (NICE) and the Scottish Intercollegiate Guidelines Network (SIGN)[7,11]. Some studies however suggest that the risk of cyst and tumour development justifies the risk of prophylactic extraction[7]. The longer impacted teeth are retained, the greater the chance of development of dental caries and bone pathology at an age where intervention complication rates may be high[7]. With increased life expectancy, the rate of bone pathologies might be predicted to increase thus a cost-benefit analysis should be done during treatment plannning[11]. Tooth position should also aid in decision-making on prophylactic extraction as opposed to watchful waiting[17].

1.2.10 Management of jaw pathologies

Early management of jaw pathologies minimises the severity of jaw destruction. Treatment modalities for cysts include enucleation, decompression and marsupialisation[39,49,50]. In addition, chemical cautery with Carnoy's solution can be employed to eliminate daughter cysts especially in the management of odontogenic keratocysts[50]. In contrast, the treatment for tumours and large cysts with cortical bone destruction is mainly bone resection with wide margins and adjuvant radiotherapy for radiosensitive malignancies[37,48]. The preservation of vital structures where possible is crucial and includes the lateralisation of nerves in benign lesions[53]. Attendant complications of surgery include bone continuity defects, facial disfigurement and malocclusion and these have been reported to be more common in rural patients and those presenting with large tumours[37].

1.3 Statement of the research problem

Jaw resection surgery is a common procedure in the management of long-standing cysts and tumours. In current practice, this surgery is costly and is associated with inadequate reconstruction and multiple complications often requiring reoperation. While jaw cyst and tumour development is largely unpredictable, some studies have shown that the probability of a diagnosis of jaw cyst or tumour being made increases with the presence of impacted teeth and the depth of impaction[17,54]. It was however unknown if these assertions are true in the Kenyan context. This knowledge gap precluded the development of evidence-based surveillance and management protocols for both impacted teeth and jaw cysts and tumours.

1.4 Study justification

Despite impacted teeth reportedly being associated with grave loco-regional pathologies, this association is hardly published in Kenya. This study sought to investigate the pattern and characteristics of impacted teeth associated with jaw cysts/tumours at the University of Nairobi Dental Hospital (UONDH). Consequently, level 3 impacted teeth were noted to be more frequently associated with jaw pathologies in comparison to other dental impaction depths. This finding is hoped to enable the development of evidence-based surveillance and management protocols for both impacted teeth and jaw cysts/tumours. Protocol implementation is hoped to translate to early jaw lesion diagnosis when impacted teeth are investigated, reduced costs and improved management outcomes inclusive of the patient's quality of life.

1.5 Research question

What is the pattern of impacted teeth associated with jaw cysts/tumours and the characteristics of the jaw cysts and tumours among patients attending the UONDH?

1.6 Study objectives

1.6.1 Broad objective

To determine the pattern of impacted teeth associated with jaw cysts and tumours and the characteristics of the jaw cysts and tumours among patients attending the University of Nairobi Dental Hospital

1.6.2 Specific objectives

1. To determine the radiographic pattern of impacted teeth associated with jaw cysts and tumours among patients with jaw cysts and tumours attending the UONDH
2. To determine the histological characteristics of jaw cysts and tumours associated with impacted teeth among patients attending the UONDH
3. To determine the radiographic characteristics of jaw cysts and tumours associated with impacted teeth among patients attending the UONDH

1.7 Variables

Table 1: Study variables

	Variable	Measurement criteria
Demographics	Age	Number of years
	Gender	Male/Female
Impacted tooth	Impacted tooth/teeth	None, mandibular or maxillary incisors, canine, premolar, molars
	Impaction pattern	SPAND classifications, Pell and Gregory + Winter
	Site	Mandibular ramus, angle, body, parasymphysis, premaxilla or posterior maxilla
Jaw cyst/tumour	Histopathology diagnosis	WHO classification
	Radiologic appearance	Radiolucent, radiopaque, mixed
	Site	Mandibular ramus, angle, body, parasymphysis, anterior maxilla or posterior maxilla
	Cyst/tumour size	Tooth span (number of teeth involved in lesion)

CHAPTER TWO: MATERIALS AND METHOD

2.1 Study design

The study was a retrospective analytical study.

2.2 Study setting and duration

The study setting was the UoN Dental Hospital Histopathology laboratory, Radiology and Minor Oral Surgery units. The hospital was completed in 1996 and across the different units served an average of 4000 new patients per year in addition to regular clients.

[55]

Figure 2: Study setting map

Patients were sent for primary diagnostic imaging in the radiology department which was equipped with one dental pantomogram machine, Kodak 9000 Extraoral Sytem model and two Belmont Phot X II radiograph machines for intraoral radiographs. All dental pantomogram digital images were simultaneously stored electronically in the server which was connected to the pantomogram machine. Any additional images for enhanced diagnostic quality and pre-operative planning were outsourced during the ten year study period. Following medical imaging and biopsying or surgery, specimens were sent to the histopathology laboratory for histological evaluation. Approximately 400 histopathology specimens were processed and evaluated annually from both internal and external clinics/health institutions. The department was equipped with all the basic histopathology equipment inclusive of a microtome, water bath, automatic tissue processor, hot air oven and several light microscopes. Haematoxylin and eosin staining was routinely done and some special stains were also available. Data collection started after study approval by the KNH-UoN ERC and was completed within one year.

2.3 Study population

The study population was all patients with histopathological confirmation of jaw cysts and tumours at the UoN Dental Hospital.

2.4 Sample size determination

In a Brazilian study done from 2013 to 2014, 16.43% of radiologically detectable jaw lesions had associated impacted teeth[56]. For the determination of the minimum sample size for statistical inference, Cochrane formula ($n = Z^2 \times P \times (1-P)/d^2$) was used[57]; where,

n_0 = sample size for unknown large population

Z = statistic value for a desired level of confidence

P = expected prevalence or proportion

d = precision

$n_0 = (1.96)^2 \text{ x } (0.1643) \text{ x } (0.8357)/ (0.05)^2$

$n_0 = 211$

Assuming that biopsies for all radiologically demonstrable jaw cysts and tumours were sent for histopathology during the study period, patients diagnosed with jaw cysts and tumours were approximated to be 668 from the histopathology records (334 from 2011 to 2015). Adjusting for a finite population in Cochrane's formula,

$n = n_0/(1+(n_0\text{-}1/\text{population}))$

n= 211/(1+(211-1)/668))

n= 161 to nearest whole number

Thus 161 patient records were considered the minimum sample size.

2.5 Sampling method

Purposive sampling was done and all patients who met the inclusion criteria were included in this study.

2.6 Inclusion criteria

1. Patients attended to at the UONDH with a histopathological diagnosis of jaw cyst or tumour

2. Patients attended to from January 2011 to December 2020

3. Patients with diagnostically acceptable dental panoramic images

2.7 Exclusion criteria

1. Patients with concurrent traumatic injuries
2. Bone cysts/tumours which were an extension of soft tissue pathology
3. Patients with known metabolic bone disease
4. Patients with known metastatic bone disease/malignancy other than that of jaw bones

2.8 Data collection

Identification of study participants was done using histopathology records and an electronic radiographs database. Data was collected by the principal investigator and one research assistant using the approved checklist (Appendix 2) and the impaction classification reference provided (Appendix 1).

The research assistant was an undergraduate student from the UoN Faculty of Health Sciences and was trained by the principal investigator on how to use the study checklist for data collection from histopathology records. Evaluation of radiographs was done by the principal investigator who received extra training from two of the supervisors who have a wide range of experience in the interpretation of dental and maxillofacial radiographs. 10% of the radiographs were reviewed by a maxillofacial radiologist so as to determine the inter-examiner agreement using the Cohen Kappa statistic which excludes agreement by chance. A kappa value of 83% (very good/almost perfect) was obtained. Specialist opinion was sought from a dental and maxillofacial radiologist where necessary.

2.9 Data management

All patient data was de-identified before electronic capturing into Microsoft Excel spreadsheet. Data was cleaned and checked for validity and completion daily during the data collection period.

2.10 Data analysis

SPSS version 28 was used to analyse the cleaned data. Categorical data was presented using frequencies and percentages while measures of central tendency were used for continuous data. The chi squared/Fisher's exact tests and t-test bivariate analysis were used for categorical and continuous data respectively and a p value less than 0.05 was considered statistically significant. Where at least one cell count was less than 5, Fisher's exact test was employed. Tables, graphs and pie charts were used to present findings where appropriate.

2.11 Ethical considerations

Under the prevailing ERC guidelines during the time of the study, patient consent for use of clinical records for research purposes was not pre-requisite and intention of permission to access patients' records was granted by the Executive Chairperson of the UoN Department of Dental Sciences (Appendix 3) pending study approval. Study approval was granted by the KNH-UoN ERC with the registration number P696/08/2021 (Appendix 4) and a research license for the study was obtained from NACOSTI (NACOSTI/P/22/1619) (Appendix 5). Patient confidentiality was maintained by elimination of patient identifiers. The study methodology posed no harm to the patients whose records were used and the study outcomes are hoped to benefit all without prejudice.

2.12 Study results dissemination plan

Study results will be disseminated to the study institution, that is the University of Nairobi's Department of Dental Sciences by way of hard copies, online website articles and oral presentations as might be required. Research findings will also be presented in educational conferences and published in a peer reviewed journal.

2.13 Study limitations

Study limitations included data unavailability due to missing radiography images and clinical records. Where images were available, soft tissue dental impactions could not be detected in some images and the distortion of the original tooth impaction pattern by the presence of a cyst or tumour could not be ruled out. Additionally, it was not routine to send specimens for histopathological evaluation after extraction of impacted teeth at the study centre and as such, an assumption that a notable number of qualifying cases were lost was made.

CHAPTER THREE: RESULTS

3.1 Socio-demographic variables

A total of 354 patients were included in this study. Of these 171 (48.3%) were males and 183 (51.7%) were females. The age range was 5 – 85 years with a mean of 28.8 ± 14.9 SD years. Males were slightly younger (mean of 26.9 ±14.7 SD years) than females (mean of 28.6 ± 15.0 SD years) however the difference was not statistically significant (t(352)= 1.12, p=0.26). The modal age for all jaw cysts and tumours was the third decade (107; 30.2%).

3.2 Pattern of tooth impaction

Of the 354 patients, 163 (46.0%) had impacted teeth, 17 (4.8%) had unerupted teeth and 174 (49.2%) cases had fully erupted teeth associated with the lesion. Figure 3 shows the distribution of tooth eruption status by gender. More females (85; 52.2%) were likely to have impacted teeth within lesions than males 78 (47.8%). The difference was however not statistically significant (χ^2=0.02; p=0.87).

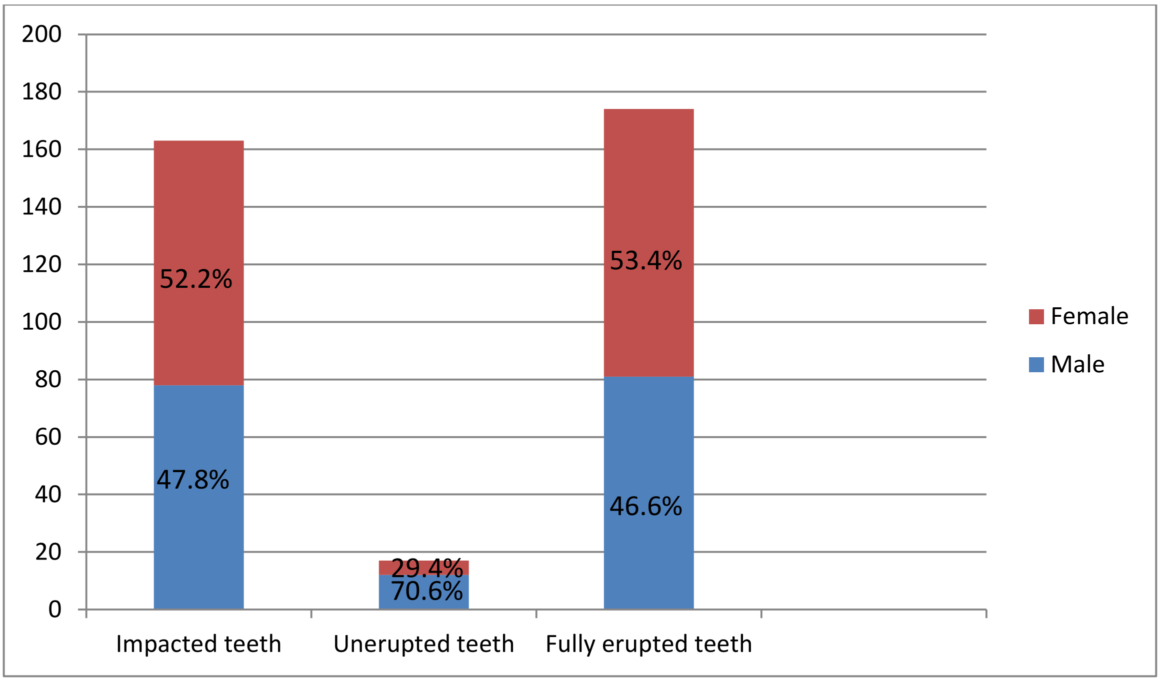

Figure 3: Distribution of tooth eruption status by gender

For lesions with impacted teeth, the modal age bracket was the second decade (65; 39.9%) which was lower than for all lesions combined. Unerupted teeth by operational definition are only found in people younger than 23 years, hence cases were observed almost exclusively in the first and second decades of life. The age distribution and mean ages are given in Table 2. The presentation age difference between impacted and fully erupted teeth jaw lesion cases was statistically significant ($t(335)=6.57$; $p<0.01$).

Table 2: Age distribution by tooth eruption status n (%), (n=354)

Age (years)	Impacted	Unerupted	Fully erupted	**Total**
≤10	11 (6.7)	7 (41.2)	3 (1.7)	**21 (5.9)**
11-20	65 (39.9)	10 (58.8)	24 (13.8)	**99 (28.0)**
21-30	49 (30.1)	0 (0.0)	58 (33.3)	**107 (30.2)**
31-40	23 (14.1)	0 (0.0)	48 (27.6)	**71 (20.1)**
41-50	10 (6.1)	0 (0.0)	18 (10.3)	**28 (7.9)**
Above 50	5 (3.1)	0 (0.0)	23 (13.2)	**28 (7.9)**
Total	163 (100.0)	17 (100.0)	174 (100.0)	**354 (100.0)**
Mean age (years)	23.6 ± 11.8 SD	11.1 ± 2.6 SD	33.4 ± 15.5 SD	**27.8 ± 14.9 SD**

A total of 184 impacted teeth was encountered, 148 (80.4%) occurring as single impactions and 36 (19.6%) occurring as multiple adjacent impactions in 16 lesions. Out of the 184 teeth, 117 (63.6%) were mandibular and 67 (36.4%) were maxillary teeth. The commonly involved in descending order were the mandibular third molars (39; 21.2%), followed by the mandibular (32; 17.4%) and maxillary canines (31; 16.8%). In 3 cases, supernumerary mandibular premolars were involved in the lesions. Multiple adjacent impactions were more common in the mandible than the maxilla (11 vs 5 cases), mostly involving the canines and premolars.

Maxillary canines were the impacted teeth noted in most dentigerous cysts (17; 33.3%) and the mandibular third molars were the next commonest (7; 13.7%). For ameloblastomas, mandibular third molars were observed in 20/44 cases (45.5%) followed by mandibular canines in 13/44 cases (29.5%). The most frequently impacted teeth secondary to odontome presence were the maxillary incisors (11; 42.3%) and the mandibular third molars (5; 19.2%).

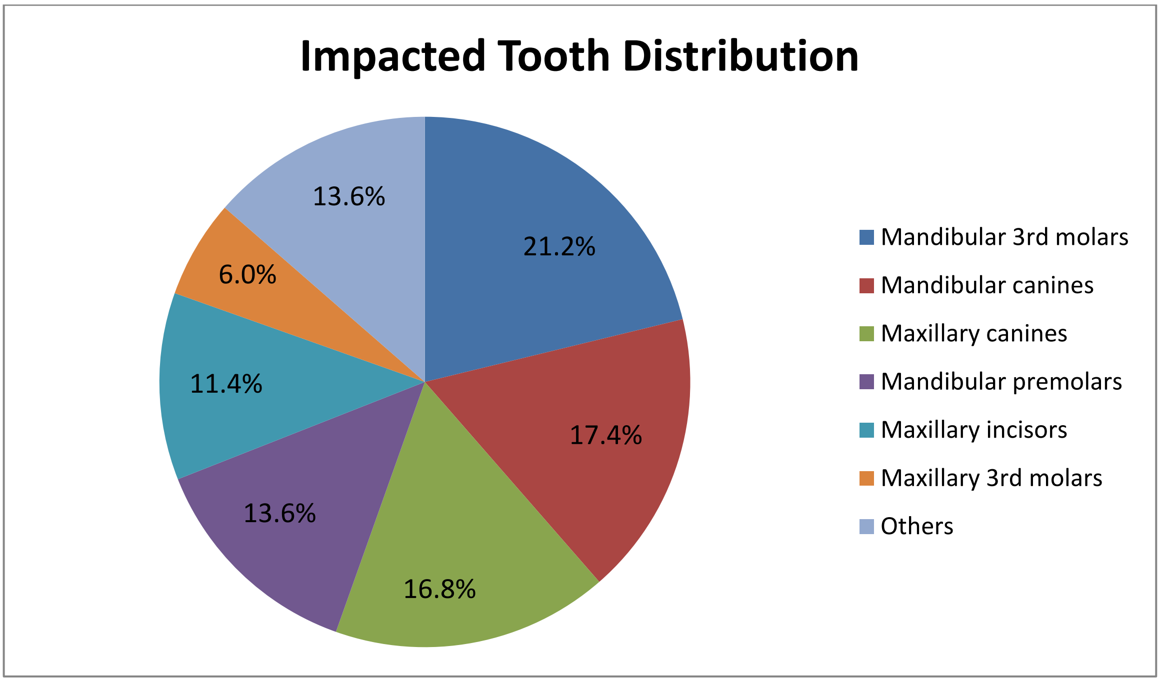

Figure 4: Distribution of impacted teeth (n=184)

Of the 184 impacted teeth, 172 (93.5%) had impaction depth apical to the cemento-enamel junction of the adjacent erupted teeth (SPAND level 3 depth), the majority of which had bony impaction (χ^2=184.3; p<0.01). All multiple adjacent impacted teeth were at the same impaction depth. Mesioangular inclination of impacted teeth was the most frequent (91; 49.5%) compared to other dental angulations (χ^2=26.9; p<0.01). This observation was statistically significant. This was followed by the vertical (61; 33.2%) and horizontal angulations (19; 10.3%). Other variant angulations were observed in 13 (7.1%) of the cases. According to Winter's classification of impacted mandibular third molars, 30/39 (76.9%) had mesioangular orientation, 4/39 (10.3%) had horizontal, 2 (5.1%) vertical and the rest of other angulations had collective 3 cases (7.7%). For the impaction depth and tooth angulation statistical analysis, a split mouth analysis was executed.

Adequacy of eruption space was evaluated by comparison of the mesiodistal width of the impacted teeth and the width of the available space in the dental arch. For 37/184 (20.1%) impacted teeth there was absolutely no eruption space in the dental arch, while there was inadequate space in 105 (57.1%) cases. The remaining 42 (22.8%) teeth had adequate eruption space. SPAND level 3 depth (synonymous to Pell and Gregory level C for mandibular 3rd molars) was more common with limited or no dental eruption space but no statistically significant correlation between eruption space availability and level 3 impaction was found (Fisher exact test statistic value= 0.27). Table 3 shows the tooth distribution by impaction classification.

Table 3: Tooth distribution by SPAND impaction classification n (%), (n=184)

Level of impaction	Frequency	%
1 (at occlusal plane level)	0	0.0
2 (occlusal plane to CEJ of adjacent tooth)	12	6.5
3 (below CEJ of adjacent tooth)	172	93.5
Total	184	100.0
Eruption space		
1 (adequate)	42	22.8
2 (inadequate)	105	57.1
3 (no space)	37	20.1
Total	184	100.0
Angulation		
Mesioangular	91	49.5
Vertical	61	33.2
Horizontal	19	10.3
Distoangular	6	3.3
Buccolingual	6	3.3
Inverted	1	0.5
Total	184	100.0

3.3 Histological characteristics of jaw cysts and tumours

3.3.1 All cases

Of the 358 identified lesions 304 (84.9%) were developmental odontogenic lesions, 24 (6.7%) were inflammatory odontogenic and 30 (8.4%) were non-odontogenic in origin. Thus odontogenic lesions made up 91.6% of all jaw cysts and tumours. Developmental odontogenic lesions had impacted teeth in 52.3% of all cases while all inflammatory odontogenic lesions were cysts and were associated with fully erupted teeth. While fibrous dysplasia is considered a tumour-like lesion in the 2017 WHO classification of jaw pathologies, it was considered as a tumour in this study and 4 cases were encountered overall. Table 4 shows the lesion origin and tooth eruption status.

Table 4: Pathology distribution by origin and tooth eruption status n (%), (n=358)

Odontogenic origin	Impacted tooth	Unerupted tooth	Fully erupted tooth	**Total**
Developmental	159 (97.0)	17 (94.4)	128 (72.7)	**304 (84.9)**
Inflammatory	0 (0.0)	0 (0.0)	24 (13.6)	**24 (6.7)**
None	5 (3.0)	1 (5.6)	24 (13.6)	**30 (8.4)**
Total	164 (100.0)	18 (100.0)	176 (100.0)	**358 (100)**

Twenty-three (23) pathological entities were noted to affect the jaws. Of the 358 observed lesions, 146 (40.8%) were cysts and 212 (59.2%) were tumours. Of the 146 cysts, 111 (76%) were developmental odontogenic, 24 (16.4%) were inflammatory odontogenic and 11 (7.5%) were non-odontogenic. For tumours, 193 (91.0%) were developmental odontogenic and the rest (19; 9.0%) were non-odontogenic. The commonest lesions were the ameloblastoma (123; 34.4%), dentigerous cyst (61; 17.0%), odontogenic keratocyst (44; 12.3%) and the odontome (26; 7.3%). Table 5 shows the distribution of lesions by histopathological diagnosis.

Table 5: Pathology distribution by histological diagnosis (n=358)

Histological diagnosis	Impacted tooth	Unerupted tooth	Fully erupted tooth	**Total (%)**
Ameloblastoma	44	3	76	**123(34.4)**
Dentigerous cyst	51	10	0	**61(17.0)**
OKC	18	1	25	**44(12.3)**
Odontome	26	0	0	**26(7.3)**
Radicular cyst	0	0	21	**21(5.9)**
Odontogenic myxoma	4	3	7	**14(3.9)**
CEOT	4	0	9	**13(3.6)**
Nasopalatine cyst	2	1	8	**11(3.1)**
COF	5	0	2	**7(2.0)**
Ossifying fibroma	0	0	7	**7(2.0)**
AOT	2	0	4	**6(1.7)**
Fibrous dysplasia	2	0	2	**4(1.1)**
Osteoma	0	0	4	**4(1.1)**
Residual cyst	0	0	3	**3(0.8)**
Paradental cyst	3	0	0	**3(0.8)**
Osteosarcoma	0	0	2	**2(0.6)**
COC	1	0	1	**2(0.6)**
Cementoblastoma	1	0	0	**1(0.3)**
Central GCG	1	0	0	**1(0.3)**
Odontogenic carcinoma	0	0	1	**1(0.3)**
Ameloblastic fibroma	0	0	2	**2(0.6)**
Ameloblastic fibrodentinoma	0	0	1	**1(0.3)**
Burkitt's lymphoma	0	0	1	**1(0.3)**
Total	164	18	176	**358(100.0)**

The modal age for all jaw cysts and tumours was the third decade (107; 30.2%). For ameloblastoma and odontogenic keratocyst, the presentation age peaked in the third decade, while dentigerous cysts presentation peaked in the second decade. The mean presentation ages for ameloblastoma and all developmental jaw cysts/tumours was 23.4 ± 9.4 SD years and 23.5 ±11.9 SD years respectively in lesions with impacted teeth while it was 32.2 ± 12.9

SD years and 35.0 ± 16.1 SD years for lesions associated with fully erupted teeth.

3.3.2 Histopathological characteristics of jaw cysts/tumours with impacted teeth

For lesions with impacted teeth, 75 (45.7%) were cysts and 89 (54.3%) were tumours. Cysts were statistically significantly more common in the adult age group (χ^2=5.24; p=0.02) while tumours were more common in patients less than 18 years of age (χ^2=8.02; p<0.01). No malignant lesions were associated with impacted teeth. The commonest jaw lesions associated with impacted teeth were the dentigerous cyst (51; 31.1%), ameloblastoma (44; 26.8%), odontome (26; 15.9%) and the odontogenic keratocyst (18; 11.0%). These four pathological entities contributed 84.8% of the lesions with associated impacted teeth. Table 6 shows the distribution of the histological diagnoses of observed lesions. Of the 44 ameloblastomas, 16 (36.4%) were cystic, 9 (20.5%) were plexiform, 2 (4.5%) were follicular, 17 (38.6%) had mixed pattern and none were of the desmoplastic histologic variant. There was no gender predilection for dentigerous cyst or ameloblastoma development, (χ^2=0.02; p=0.88) and (χ^2=1.8; p=0.18) respectively.

Table 6: Distribution of lesions associated with impacted teeth (n=164)

Histological diagnosis	Maxilla	Mandible	Frequency	**% of total lesions**
Dentigerous cyst	28	23	51	**31.1**
Ameloblastoma	2	42	44	**26.8**
Odontome	14	12	26	**15.9**
Odontogenic keratocyst	5	13	18	**11.0**
Cemento-ossifying fibroma	3	2	5	**3.1**
Odontogenic myxoma	1	3	4	**2.4**
CEOT	3	1	4	**2.4**
Paradental cyst	1	2	3	**1.8**
AOT	1	1	2	**1.2**
Nasopalatine cyst	2	0	2	**1.2**
Fibrous dysplasia	0	2	2	**1.2**
Cementoblastoma	1	0	1	**0.6**
Calcifying odontogenic cyst	1	0	1	**0.6**
Central GCG	0	1	1	**0.6**
Total	62	102	164	**100.0**

The modal age bracket for all lesions with impacted teeth was the second decade (65; 39.9%). Ameloblastoma presentation peaked in the 2nd (45.5%) and 4th (32.9%) decades of life for lesions with and without impacted teeth respectively, while the modal age for odontogenic keratocyst was the 3rd decade in both cases. Table 7 shows the age distribution for the four commonest pathological entities which were encountered.

Table 7: Age distribution for the 4 most prevalent pathologies associated with impacted teeth (n=139)

Diagnosis	<10yrs	11-20	21-30	31-40	41-50	>50	Total
Dentigerous cyst	3 (5.9)	18 (35.3)	12 (23.5)	12 (23.5)	6 (11.8)	0 (0.0)	51 (100.0)
Ameloblastoma	0 (0.0)	20 (45.5)	15 (34.1)	6 (13.6)	2 (4.5)	1 (2.3)	44 (100.0)
Odontome	5 (19.2)	12 (46.2)	7 (26.9)	1 (3.8)	1 (3.8)	0 (0.0)	26 (100.0)
OKC	0 (0.0)	4 (22.2)	8 (44.4)	3 (16.7)	1 (5.6)	2 (11.1)	18 (100.0)
Total	**8 (5.8)**	**54 (38.8)**	**42 (30.2)**	**22 (15.8)**	**10 (7.2)**	**3 (2.2)**	**139 (100.0)**

3.4 Radiographic characteristics of jaw cysts and tumours

3.4.1 All cases

Of the 358 total lesions observed, 245 (68.4%) were located in the mandible, while 113 (31.6%) were in the maxilla. Thus the mandible was involved more than twice the maxilla. For developmental odontogenic lesions, 224 (73.7%) were located in the mandible (99 with impacted, 12 with unerupted and 113 with fully erupted teeth) and 80 (26.3%) were in the maxilla (60 with impacted, 5 with unerupted and 15 with fully erupted teeth). Of the 193 odontogenic tumours, 159 (82.4%) were in the mandible of which 118 (74.2%) were ameloblastomas. The majority of odontogenic keratocysts were in the mandible (33; 75%).

Table 8: Lesion distribution by jaw and tooth eruption status (n=358)

Jaw	Impacted tooth	Unerupted tooth	Fully erupted tooth	**Total**
Mandible	102 (62.2)	12 (66.7)	131 (74.4)	**245 (68.4)**
Maxilla	62 (37.8)	6 (33.3)	45 (25.6)	**113 (31.6)**
Total	164 (100.0)	18 (100.0)	176 (100.0)	**358 (100.0)**

For the mandible, the posterior mandible beyond the canine was the most frequent lesion site (combined 95.1% cases) and there was no regional predilection in the maxilla with 24.8% lesions located in the posterior region, 31.9% in the anterior region and 43.4% involving both the anterior and posterior regions.

A total of 125 (51.0%) mandibular lesions had destruction of the inferior border of the mandible. Of these, 47 (37.6%) had impacted teeth, 8 (6.4%) had unerupted teeth and 70 (56.0%) were associated with fully erupted teeth. The ameloblastoma (92; 73.6%), odontogenic keratocyst (12; 9.6%) and odontogenic myxoma (6; 4.8%) were the pathological entities most frequently associated with destruction of the inferior border of the mandible.

The dentigerous cyst was involved in IBM destruction in 5 cases. Additionally 34 (13.9%) mandibular lesions exhibited condylar destruction.

The overall mean dental involvement was 5.1±3.4 SD teeth. It was 4.2±3.2 SD teeth for lesions associated with impacted teeth, 5.1±2.1 SD teeth for those with unerupted teeth and 6.9±3.5 SD teeth for lesions associated with fully erupted teeth. The size difference between lesions with impacted teeth and those with fully erupted teeth was statistically significant ($t(338) = -5.83$; $p<0.01$).

On radiographic appearance, 286 (79.9%) lesions were radiolucent while 32 (8.9%) were radiopaque and 40 (11.2%) had mixed radiographic appearance. Ameloblastomas exhibited multilocular radiolucency in 84 lesions (68.3%), unilocular radiolucency in 32 (26.0%) and had mixed radiographic appearance in 7 (5.7%). On the other hand odontogenic keratocysts mainly had a unilocular appearance (25; 56.8%). Two (2; 3.7%) dentigerous cysts and 1 (3.8%) odontome had mixed appearance while the rest of the lesions had unilocular radiolucency or radiopacity respectively. Radiopaque odontomes made up 25 (75.8%) of all radiopaque lesions while osteomas contributed 5 (20.0%) of the same. This information is summarised in Table 9.

Table 9: Specific pathology radiographic appearance by tooth eruption status (n=358)

	Mixed	Unilocular radiolucency	Multilocular radiolucency	Radiopacity	**Total**
Ameloblastoma					
Impacted tooth	0	14	30	0	**44**
Unerupted tooth	0	0	3	0	**3**
Fully erupted	7	18	51	0	**76**
Dentigerous cyst					
Impacted tooth	2	49	0	0	**51**
Unerupted tooth	0	10	0	0	**10**
Odontogenic keratocyst					
Impacted tooth	3	12	3	0	**18**
Unerupted tooth	0	1	0	0	**1**
Fully erupted	3	12	10	0	**25**
Odontomes					
Impacted tooth	1	0	0	25	**26**
Unerupted tooth	0	0	0	0	**0**
Others					
Impacted tooth	6	12	4	3	**25**
Unerupted tooth	1	1	2	0	**4**
Fully erupted	17	46	8	4	**75**
Total	**40 (11.2%)**	**175 (48.9%)**	**111 (31.0%)**	**32 (8.9%)**	**358 (100.0)**

3.4.2 Radiographic characteristics of jaw cysts and tumours with impacted teeth

Site of pathology

The mandible was affected approximately 1.6 times more than the maxilla (102 versus 62 cases). For odontogenic tumours 70.9% were located in the mandible. Ameloblastomas and odontogenic keratocysts had unquestionable mandible predilection while dentigerous cysts and odontomes had a slight predilection for the maxilla with mandible to maxilla ratios of 0.82 and 0.86 respectively. There was even distribution of maxillary bone destructive lesions with no noted regional predilections.

The posterior mandible was the most frequent site, involved in 50% of all impacted tooth cases and 80.4% of exclusive mandibular impacted tooth cases (82/102). Of the 102 mandibular lesions, 90 had localised bone destruction. Analysis of lesion site for bone destructive lesions excluded odontomes and the single cementoblastoma case. The modal lesion site was the posterior mandible beyond the canine being involved in 82 lesions (91.1%).

Of all mandibular cases with impacted teeth, condylar involvement was noted in 16 (15.7%) lesions. Thirty-one cases (31; 30.4%) involved the ramus of which 26 (83.9%) were ameloblastomas. The inferior border of the mandible was compromised in 47 (46.1%) mandibular lesions at presentation. Ameloblastomas were the pathological entity mostly associated with destruction of the inferior border of the mandible (IBM) constituting 34 (72.3%) of the cases. Of the total 42 mandibular ameloblastoma lesions, 34 (81.0%) involved the IBM. In comparison to non-ameloblastoma lesions, this finding was statistically significant (χ^2=26.05; $p<0.01$).

Dental involvement

For 137 jaw destructive lesions (90 mandibular and 47 maxillary), the number of teeth involved ranged from 1-15. The mean tooth span for both jaws at presentation was 4.9±3.2 SD teeth with a mean of 5.3 ± 3.3 SD teeth and 3.9 ± 2.8 SD teeth for mandibular and maxillary teeth respectively. The difference in the mean tooth span involvement for the two jaws was statistically significant ($t(135)=2.41$, $p<0.02$). Dentigerous cyst tooth span was 1-13 teeth and the mean was 3.5±2.6 SD teeth while ameloblastomas involved 2-15 teeth with a mean of 6.4 ±3.2 SD teeth. This difference was statistically significant ($t(93)=-5.0$; $p<0.01$). Odontogenic keratocysts in turn involved 2-14 teeth (mean 6.5±3.0 SD teeth).

Radiographic appearance of jaw cysts/tumours with impacted teeth

Radiolucent lesions were observed in 124 (75.6%) cases. All dentigerous cysts had corticated unilocular radiolucent radiographic appearance. The characteristic cyst attachment to the cemento-enamel junction of the tooth was noted in all cases but one which had additional radicular involvement. Multicystic radiolucent ameloblastomas were observed in 68.2% lesions and the remainder had unicystic radiolucent appearance. The average presentation ages were 16.9 ±5.3 SD years and 26.4±9.4 SD years for unicystic and multicystic ameloblastomas respectively. This finding was statistically significant ($t(42)=-3.54$; $p<0.01$). Because of the limited clarity of two dimensional images, the pattern of cortical expansion of jaw lesions was not assessed in this study.

Other radiographic findings

Only 1 case of impacted tooth and adjacent tooth caries was observed. Adjacent dental root resorption was noted in 61 (37.2%) lesions and associated with tooth mobility in 34 (20.7%) of them. In addition, pressure effects of the lesions on the dentition also resulted in tooth tipping and significant malocclusion in 47 (28.7%) patients. Hypereruption of antagonist teeth was however rarely observed, occurring in only 6 (3.3%) of 184 impacted teeth.

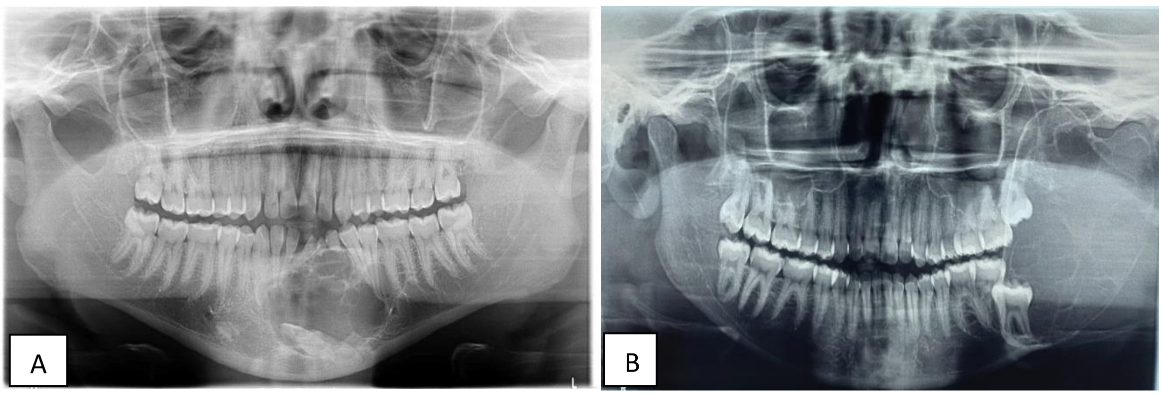

Figure 5: A: Anterior mandible multilocular ameloblastoma in a 19 year old male patient, associated with impacted 32 and 33. B: Multiloculated central giant cell granuloma involving the left mandibular angle, ramus, condyle and coronoid process in a 22 year old female patient, associated with impacted 38. (Pictures courtesy of PO and JN)

CHAPTER FOUR: DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

4.1 DISCUSSION

4.1.1 Sociodemographic variables

Of the 354 identified patients, there was no gender predilection noted in the occurrence of jaw cysts and tumours (48.3% vs 51.7% respectively). This finding contrasted results from other studies where a slight male predilection was noted and this could possibly be attributed to sampling or population variations[26,37,48]. The age range of 5 to 85 years was however consistent with other studies in literature[58]. Comparable to other studies, the third decade was the overall modal age group for jaw cysts and tumours and cumulative 78.2% of the patients were within the second to fourth decades of life[59,60]. This age distribution pattern was maintained in the analysis of the histological diagnoses for all jaw cysts and tumours and can be partly explained by the fact that excluding the first decade of life, the majority of the population lies between the 2^{nd} and 4^{th} decades of life[61]. Additionally most jaw lesions will possibly be in the early developmental stage and not large enough to be symptomatic in the first decade of life.

4.1.2 Pattern of tooth impaction

Impacted teeth were observed in 163 (46.0%) patients and 164 (45.8%) jaw cysts and tumours. This association was higher than observed in other studies with reported occurrence approximating 15%[56,59]. Racial variations could underlie this noted observation. Additionally it is probable that prophylactic extraction of impacted third molars contributes to the low prevalence of impacted teeth in developmental odontogenic lesions in some studies especially those from developed nations. No statistically significant age differences or predilections were noted between females and males with impacted teeth associated with jaw cysts and tumours unlike reports of older male predilection[11,26]. There was however a 10 year statistically significant age difference at presentation for lesions with impacted teeth and those with fully erupted teeth (p<0.01). The prolonged retention of the pocket-like dental follicle could facilitate early lesion growth and containment as opposed to the fully erupted tooth cases where lesion walls if present could take long to be established circumferentially around the pathology, hence gradual diffuse swelling. This finding and postulation however requires further investigations.

There was a higher predilection for tooth impaction in the mandible compared to the maxilla (1.7:1). In descending order, the commonly involved teeth were the mandibular third molars, the mandibular canines, maxillary canines and mandibular premolars. This finding was coherent with results from other studies though maxillary canines tend to be more frequently impacted than the maxillary ones and most studies do not correlate tooth impaction with jaw cysts/tumours[24,29,62]. It has been noted in literature that the teeth which are last to erupt in the tooth eruption sequence are the ones mostly affected by impaction mainly because of depleted eruption space and this was the case in this study[28]. In 3 cases, supernumerary mandibular premolars were involved in the lesions and this has also been reported in literature[63].

The commonly involved teeth in dentigerous cysts were the maxillary canines, being observed in 33.3% of the dentigerous cysts. This finding of the most prevalent impacted teeth is inferred to be consistent with results from Mitrea et al's study where 88.9% of all dentigerous cysts were located in the maxillary canine-premolar region[64]. Mandibular third molars were the impacted teeth mostly associated with ameloblastomas while maxillary incisors were the commonest in odontome cases as reported in literature[62,65]. No mandibular or maxillary first molars were involved in dentigerous cysts and this could be attributable to the extremely rare occurrence of impacted first molars.

An impaction depth apical to the cemento-enamel junction of the adjacent teeth was observed in 93.5% of the impacted teeth associated with jaw cysts and tumours ($p<0.01$). The majority were bony impactions and displacement by the lesion could not be ruled out. A few other studies have also shown a statistically significant relationship between deeper tooth impaction and the presence of bone pathologies[54,66,67]. Simsek-Kaya in contrast reported no correlation between the depth of tooth impaction and the development of cystic changes in the pericoronal tissues[68]. This finding was however derived from only 5 cases of cystic lesions unlike in this current study where 164 lesions were examined of which 75 were cysts.

As in previous Kenyan studies and other global studies, the mesioangular inclination of impacted teeth was the most frequently encountered (49.4%) compared to other dental angulations[6]. Vertical and horizontal angulations were the next commonest impaction angulations. This distribution of impaction angulation is consistent with results from other studies[6,54]. Differences in eruption space availability were not statistically significant.

Most global and particularly African studies in literature report solely on the angulation of impacted third molars and do not report on impaction depth and tooth eruption space thus there is scarcity of studies which document dental impactions fully. Because jaw cysts and tumours are reportedly found in association with 2- 6.2% of impacted third molars, there will be marked differences in sample sizes between non-selective impacted teeth studies and those focusing on associated jaw cysts and tumours[7]. Table 10 shows a comparison between mandibular 3rd molar impaction pattern in the general population and in patients with jaw cysts and tumours. There is a redistribution of case representation with a decline in proportion of level A impaction and adequate eruption space (I) in the jaw cysts/tumours samples. There was a statistically significant association between deep impactions below the CEJ of adjacent teeth and the presence of a jaw cyst or tumour ($p<0.01$).

Table 10: Mandibular 3rd molar impaction pattern study comparison

	Haddad et al[54]	**Eshghpour et al[69]**	**Current study**
Pell & Gregory, Winter	Frequency (%)	Frequency (%)	Frequency (%)
Depth			
A	684 (42.8)	318 (22.8)	1 (2.6)
B	749 (46.8)	892 (63.9)	4 (10.3)
C	167 (10.4)	187 (13.4)	34 (87.2)
Eruption space			
I	756 (47.3)	510 (36.5)	7 (17.9)
II	820 (51.3)	677 (48.5)	23 (59.0)
III	24 (1.5)	210 (15.0)	9 (23.1)
Angulation			
Mesioangular	576 (36)	680 (48.7)	30 (76.9)
Horizontal	231 (14.4)	393 (28.1)	4 (10.3)
Vertical	535 (33.4)	218 (15.6)	2 (5.1)
Others	258 (16.1)	106 (7.6)	3(7.7)
Total cases	**1600 (100.0)**	**1397 (100.0)**	**39 (100.0)**

4.1.3 Histological characteristics of jaw cysts and tumours

4.1.3.1 All cases (358 lesions)

Of the 358 identified jaw cysts and tumours, 91.6% were of odontogenic origin. This finding was consistent with most studies where odontogenic cysts and tumours occurred more frequently than non-odontogenic entities[70,71]. No inflammatory lesions were associated with impacted teeth possibly due to the bony impaction and the exclusion of a cariogenic environment in the majority of the teeth.

Tumours were in excess of cysts in contrast to other studies where odontogenic cysts are multiple times more prevalent than tumours[71,72]. Racial predilections have been postulated to be contributory to this discrepancy with tumours like the ameloblastoma being more prevalent among people of African origin[73]. Additionally radicular cysts constitute a notable percentage of lesions in other studies whereas in this study setting, patients' financial constraints and individual surgeons' diagnosis and management protocol preference may preclude histopathological evaluation. Alternatively the cariogenic diet in most developed nations could be the reason for the high occurrence of radicular cysts in their setting in which case the noted differences could actually be a true reflection of pathology occurrence pattern.

A total of 23 pathological entity diagnoses was documented, indicating the wide spectrum of pathologies which can affect the jaws. The most frequently encountered pathologies were the ameloblastoma, dentigerous cyst and the odontogenic keratocyst. Ameloblastomas were the commonest tumour observed in this study. This finding was in keeping with reviewed literature where ameloblastoma was the commonest odontogenic tumour with a proportion ranging from 49.0 -71.2%[59,71,72,74,75]. However in a study by Buchner et al in the USA, the commonest odontogenic tumour was the odontome (75.9%) while ameloblastomas contributed only 11.7% of the odontogenic tumours[76]. Explanations for the different distributions of odontogenic tumours are lacking, though possibly the better access to medical imaging and greater concern for aesthetics among the population in developed nations can contribute to increased discovery of odontomes due to their negative effects on occlusion and aesthetics.

The overall ameloblastoma peak was noted in the third decade. This is in agreement with results from a Nigerian study and a meta-analysis study by Hendra et al which showed a peak in the third decade[75,77]. In contrast, the modal age for ameloblastoma presentation is reported to be in the 5th and 6th decades in the European population[77]. Genetic variations in the different populations could account for the noted difference.

It was noted that developmental odontogenic lesions present approximately a decade earlier in patients with associated impacted teeth when compared to lesions with fully erupted teeth (23.5 years vs 35.0 years). This observation was statistically significant. The observed age differences could possibly arise from the intraosseous over-retention of the dental follicle or the mechanical obstruction of tooth eruption by pre-existing intraosseous lesions.

4.1.3.2 Histopathological characteristics of jaw cysts and tumours with impacted teeth

Of the 164 encountered lesions the cyst: tumour ratio was 0.84. Cysts were statistically significantly more common in the adult age group (18 years old and above) while tumours were more common in patients less than 18 years of age. A similar trend has also been noted in other studies[78]. This finding could be attributed to the higher replicative potential of young cells as opposed to senescent cells which exhibit a lower Ki67 index[79].

Consistent with reports that malignant odontogenic lesions are rare, no malignant lesions were associated with impacted teeth in this study[80,81]. The commonest jaw lesions associated with impacted teeth in descending order were dentigerous cysts, ameloblastomas, odontomes and odontogenic keratocysts contributing a combined 84.8% of all cases. This trend was observed in other studies with minor variations[62,81].

Dentigerous cysts made up 68.0% of all cysts which were associated with impacted teeth. There was no gender predilection for dentigerous cyst formation. This finding parallels results from other studies where minor differences were noted between the two genders[64,82]. In agreement with results from this current study, dentigerous cysts are reportedly common in the 2nd to 4th decades and not in the first decade[63,83]. This could be explained by the pre-requisite time lag between cyst initiation and the symptomatic progression phase.

Consistent with several studies, ameloblastoma, odontome, odontogenic myxoma and calcifying epithelial odontogenic tumours were the most frequently encountered odontogenic tumours associated with impacted teeth[62,84,85]. Approximately a third of ameloblastomas associated with impacted teeth had cystic histopathological pattern (34.1%). This occurrence was higher in contrast to results from non-selective studies[84]. This could be because of the noted development of ameloblastoma in pre-existing cysts such as the dentigerous cyst which were common in this study[62,86]. Odontomes contributed 13.5% of all odontogenic tumours in contrast to 75.9% in Buchner's study and they were all associated with impacted teeth[76].

Better access to medical imaging and orthodontics services could be some of the reasons for the higher odontome incidence in Buchner's study.

4.1.4 Radiographic characteristics of jaw cysts and tumours

4.1.4.1 All cases (358 lesions)

There was an apparent lesion predilection for the mandible with a mandible to maxilla ratio of approximately 2.2:1 for all lesions. For developmental odontogenic lesions the ratio escalated to 2.8:1. This observation was consistent with findings from other studies though the reasons for this predilection are currently not clear[80,87]. Of the observed 193 odontogenic tumours, 82.4% were located in the mandible, of which 74.2% of those were ameloblastomas. Similar to ameloblastoma, there was a predilection for the mandible for odontogenic keratocysts however there was no jaw predilection when all developmental odontogenic cysts were considered. This lack of jaw predilection for cysts was also reported in other studies[70,88]. The posterior mandible beyond the canine was the most prevalent lesion site (combined 95.1% cases) and there was no regional predilection in the maxilla. Reasons for this pattern are still unclear.

Ameloblastomas and odontogenic keratocysts were the pathological lesions commonly associated with destruction of the inferior border of the mandible. This is in contrast to findings from Jordan and Goa where none and 36.4% of ameloblastomas affected the inferior mandibular border respectively[89,90]. Additionally condylar destruction rate was higher than noted in studies which reported condylar involvement. Late presentation could be the reason for the extensive bone destruction noted in the current study.

The overall mean dental involvement was translated to an average loss of approximately 5 teeth if all lesions were to be resected. A few studies have measured lesion size in metric units and a noted limitation in this study was that no metric measurements were done. Nevertheless observed lesions could be larger than those described by Akram et al (28mm) and by Fulco et al (43mm) considering that ramus and condylar extensions were not factored in[58,91]. The involved tooth span was larger for fully erupted teeth and this finding is likely attributable to the older presentation age of the patients in this group. Nevertheless symptom duration though not accurate because of delayed perception would be a better measurement for lesion progress rate than absolute patient ages.

The majority of lesions (79.9%) had radiolucent appearance. Ameloblastomas and all cysts predominantly contributed to the radiolucent lesions while odontomes were the main pathology manifesting as radiopacities. These findings have been reported in multiple studies and are due to the pathogenic processes in the identified lesions[62,92]. The variations in bone content and mineralisation result in the differences in radiation attenuation and subsequently differences in radiographic appearance[65]. The finding of 5.7% mixed radiographic appearance for ameloblastomas is less compared to 48.0% reported by Ranchod et al[92]. This finding has been reported to be rare and observed in desmoplastic variants but none such were reported in this study[92]. Reasons for this finding are yet to be elucidated and CT scans could better characterise the calcifications observed.

4.1.4.2 Radiographic characteristics of jaw cysts and tumours with impacted teeth

Site of pathology

The mandible was affected 1.6 times more than the maxilla when impacted teeth were involved. Explanation for this finding is the obvious predilection for tooth impaction in the mandible (1.7:1) the impact of which was inherent in the study design. The discrepancy between the lesion and impaction ratios (1.6:1.7) is due to the variations which were introduced by multiple adjacent impactions, which were more common in the mandible. While impacted teeth were found in 52.3% of all developmental odontogenic lesions (1.6:1 ratio for mandible and maxilla), in the fully erupted tooth cases the mandible to maxilla ratio was 7.5:1 (113 mandible cases and 15 maxillary cases). This difference in jaw lesion proportion in relation to tooth eruption status was statistically significant ($\chi^2 = 24.9$; $p < 0.01$) and alludes to a mandibular predilection for jaw cysts and tumours which is independent of tooth impaction. Anecdotal explanations include the antigravity mandibular tooth eruption and the increased bone density which could possibly favour the entrapment of epithelial cell rests. Longitudinal studies are necessary to investigate this finding and assertions.

For odontogenic tumours associated with impacted teeth, 70.9% were located in the mandible. Other studies support this finding of mandible predilection with mandible to maxilla odontogenic tumour ratios above 2 which translate to a mandibular neoplasm rates above 67%[58,75,77,87]. Specifically for ameloblastomas, 95.5% were located in the mandible and this finding resonated with uncategorised ameloblastoma results from a previous Kenyan study[93]. Odontome distribution was comparable for the maxilla and the mandible. This is in contrast to some studies which have shown a maxillary preponderance[59]. Dentigerous cysts in isolation however had a slight maxilla predilection compared to the mandible. Literature has mixed results with some studies describing mandible dentigerous cysts proportions ranging from 69.2-100.0% while others report a maxilla predisposition[56,58,64]. These predilections depend on the distribution of the impacted teeth which varies among different populations. The modal lesion site in impacted tooth cases was the posterior mandible and this was in keeping with results from other studies[59,93]. This could be because the majority of all observed impacted teeth were mandibular posterior teeth. The involvement of the condyle was however higher than in most studies and this could also be partly explained by the preponderance of posterior teeth involvement and larger lesion size[55,84].

Ameloblastomas were the pathological entity mostly associated with destruction of the inferior border of the mandible. Of all mandibular ameloblastomas, 81% involved the IBM necessitating segmental mandibulectomy and the creation of a continuity defect. This is in contrast to the low IBM involvement noted in some Jordan and Goa studies[89,90]. However these studies had less than 15 participants each. Hardly any large scale studies report on the involvement of the inferior mandibular border by pathologic lesions.

Dental involvement

In this study, the average dental involvement for all the lesions associated with impacted teeth (excluding odontomes and cementoblastoma) was 4.9 ±3.2 SD teeth and no statistically significant difference was noted between the mandible and the maxilla. This tooth span was indicative of the number of teeth involved in a lesion and excluded the posterior edentulous regions of the jaws. The ameloblastomas statistically significantly involved more teeth than the dentigerous cysts. Considering that the presentation age for dentigerous cysts was slightly higher than for ameloblastomas (25.6 vs 23.4 years), it is probable that ameloblastomas have a more aggressive course than dentigerous cysts. This position is supported by the neoplastic characteristic of tumours. No complete dental set odontometric studies in Kenya could be found for the conversion of the tooth spans to approximate metric dimensions. Considering that 26 ameloblastoma lesions had ramus involvement, the average lesion size for ameloblastomas (in excess of 6.4 ±3.2 SD teeth) was far much larger than the 28mm reported by Akram et al and 43mm by Fulco et al[58,91]. An ameloblastoma mean size of 83mm was reported in a South African study and attests to the large lesion size in African populations[52,92].

The larger lesion size noted could be a result of healthcare disparities and sociocultural beliefs. In most developing nations, financial constraints and low availability of specialist care result in late patient presentation to the appropriate facility hence the larger lesions[92]. Some studies have showed that alcohol and tobacco use propagate cyst/tumour development and growth[7]. This assertion could not be validated in this study since only 5 and 16 patients reportedly used tobacco and drank alcohol respectively.

Radiographic appearance of jaw cysts/tumours with impacted teeth

Overall, radiolucency was the most prevalent radiographic appearance of jaw cysts/tumours. The classical central dentigerous cyst appearance was noted and is dictated by the developmental pattern of the dental follicle which is attached to the CEJ of the tooth[62,86]. Variations in the shape of the cyst have been described in literature and these include the lateral and circumferential forms[62,86]. One lateral variant was noted in this study and the radiolucency extended along the dental root.

The majority of ameloblastomas are reported to be multilocular radiolucent and our finding of 68.2% multilocular radiolucent ameloblastomas was commensurate with results from related studies[91]. It was also observed that the unicystic variant of ameloblastoma occurred at a younger mean age (16.9 years) when compared to the multicystic variant (26.4 years) as reported by other researchers[92,94]. Odontogenic keratocysts had well corticated radiolucent appearance in 86.4% of the cases. Smooth edges were more common than the scalloped variant. These variants have been noted in other studies[62]. In turn, the odontomes observed in this study were radiopaque in 96.2% of the cases. Three odontome developmental stages have been described in literature and these arise from differences in magnitude of lesion calcification, hence the non-identical radiological appearances[62].

Other radiological findings

Because the majority of associated teeth had bony impaction, dental caries was observed in only one case. This finding is expected and substantiates the variation of pathological entities associated with different dental impaction patterns[43]. Ameloblastomas had a higher rate of root resorption (61%) in contrast to a South African study where only 26.7% of ameloblastomas resulted in root resorption[92]. The observed low occurrence of tooth hypereruption could be due to the partial or complete obliteration of dental arch space in the majority of the cases and also the impaction of opposing teeth. Radiologically undetectable hypereruption could not be ruled out.

4. 2 CONCLUSIONS

1. Developmental odontogenic jaw cysts and tumours at the UONDH had associated impacted teeth in 52.3% of the cases. The impaction depth was almost exclusively below the CEJ of the erupted adjacent tooth and this finding was statistically significant. The mesioangular impaction pattern was the most frequently encountered (49.5%). In descending order, the observed impacted teeth were mandibular third molars, mandibular canines and the maxillary canines.

2. Dentigerous cysts, ameloblastomas, odontomes and the odontogenic keratocysts were the pathological entities commonly associated with impacted teeth.

3. Among all jaw cysts/tumour lesions and the impacted teeth subset, radiolucency was the most prevalent radiographic appearance. The unilocular appearance was more frequent than the multilocular and for ameloblastoma, the unicystic variant presented earlier than the multicystic type ($p < 0.01$). There was a general lesion predilection for the posterior mandible and on average 5 teeth were involved in all lesions.

4. Developmental odontogenic lesions presented approximately one decade earlier in patients with associated impacted teeth than those with fully erupted teeth ($p<0.01$).

4. 3 RECOMMENDATIONS

1. The radiologic evaluation of missing teeth post-eruption age is highly recommended followed by long term surveillance for pathologies related to level 3 deep impacted teeth. This will enable early diagnosis and intervention for jaw cysts/tumours associated with impacted teeth.
2. Routine submission of suspicious lesion tissue for histopathology to reduce the rate of underdiagnosis and undertreatment of pathologies.
3. Further research is recommended to investigate the early presentation of developmental odontogenic cysts and tumours in persons with impacted teeth. Longitudinal studies are advocated for, with the aim of supplementing scientific evidence towards the development of management protocols for impacted teeth and jaw cysts/tumours.

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APPENDIX

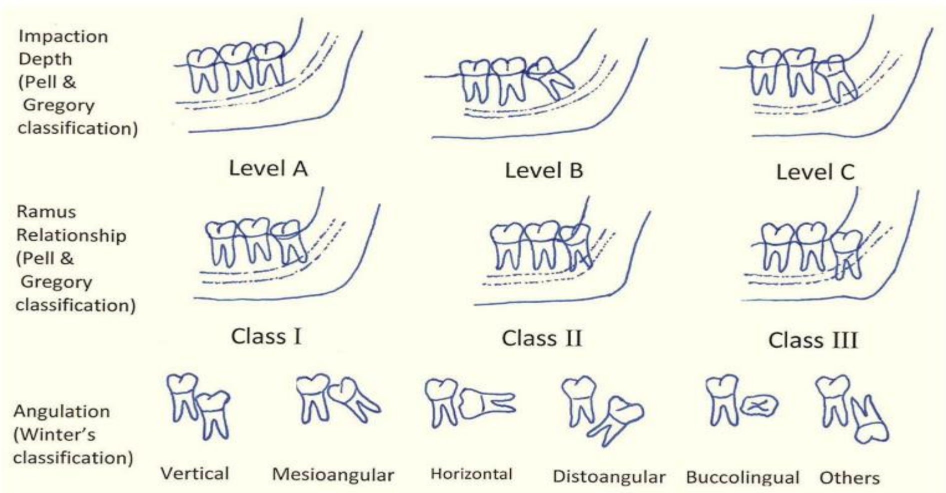
Appendix 1: Classifications of tooth impaction

SPAND classification (32)

Grade	S	P	A	N	D
Description	Mesiodistal space	Tooth height	Angulation	Distance from vital structure	Space from NP canal
1	Adequate	At occlusal plane	Vertical	More than 2mm	Present
2	Inadequate	Occlusal plane – CEJ	MA- lower DA - upper	Less than 2mm	None
3	No space	Apical to CEJ	Buccolingual	At border	
4			Horizontal	Encroachment	
5			DA- lower MA- upper		
6			Inverted		
7			Aberrant		

MA-mesioangular, DA-distoangular, NP-nasopalatine

Pell and Gregory + Winter's classification



https://www.scielo.br/img/revistas/pboci/v20//1519-0501-pboci-20-e5411-gf01.jpg

Appendix 2: Data collection tool

File number…….

Age…………… Sex

M	F

Histopathology diagnosis	Radiographic appearance	Site	Tooth span	IMB involvement	Impacted tooth # & site	SPAND class	PGW class

NB: Impaction is according to Schour and Massler tooth eruption atlas

IMB: Inferior Mandibular Border, PGW: Pell and Gregory + Winter

		Tick		Tick
Signs and symptoms	Pain		Swelling	
	Mobile teeth		Other	
S&S Duration				
Other impacted tooth associated pathology	Impacted tooth caries		Adjacent tooth caries	
	Adjacent root resorption		Hypereruption of opposing tooth	
Comorbidities/Risks	Tobacco use		Alcohol use	

Appendix 3: Access to medical records permission

University of Nairobi

Department of Dental Sciences

P.O Box 19676-00202

Nairobi

Kenya

19 August 2021

Dear Prof M.L. Chindia

Secretary KNH-UON-ERC

RE: Dr. Muungani Welcome V60/8008/2017, Principal Investigator, Unit of Oral and Maxillofacial Surgery, Department of Dental Sciences

Research Topic: THE PATTERN AND CHARACTERISTICS OF IMPACTED TEETH ASSOCIATED WITH JAW CYSTS AND TUMOURS AMONG PATIENTS ATTENDING THE UNIVERSITY OF NAIROBI DENTAL HOSPITAL

You are hereby informed that the University Of Nairobi Department Of Dental Sciences has no objection in availing access to patients' imaging and clinical records at the UoN Dental Hospital to the researcher for her dissertation study which is mentioned above and for which the proposal is being submitted to the ERC.

Regards,

Dr W.A. Odhiambo (Executive Chairman, Department of Dental Sciences)

[signature] 20/08/2021

Signature Date

Appendix 4: Ethics and Research Council study proposal approval

UNIVERSITY OF NAIROBI
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KENYATTA NATIONAL HOSPITAL
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Tel: 726300-9
Fax: 725272
Telegrams: MEDSUP, Nairobi

Ref: KNH-ERC/A/484

20th December 2021

20 DEC 2021

Dr. Welcome Muungani
Reg. No. V60/8008/2017
Unit of Oral and Maxillofacial Surgery, Oral Pathology and Oral Medicine
Dept. of Dental Sciences
University of Nairobi

Dear Dr. Muungani,

RESEARCH PROPOSAL: THE PATTERN AND CHARACTERISTICS OF IMPACTED TEETH ASSOCIATED WITH JAW CYSTS AND TUMOURS AMONG PATIENTS ATTENDING THE UNIVERSITY OF NAIROBI DENTAL HOSPITAL (P696/08/2021)

This is to inform you that KNH-UoN ERC has reviewed and approved your above research proposal. Your application approval number is **P696/08/2021.** The approval period is 20th December 2021 – 19th December 2022.

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 KNH-UoN ERC.
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 KNH-UoN ERC 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 KNH-UoN ERC 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 KNH-UoN ERC.

Protect to discover

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

Yours sincerely,

PROF. M.L. CHINDIA
SECRETARY, KNH-UoN ERC

c.c. The Dean-Faculty of Health Sciences, UoN
The Senior Director, CS, KNH
The Chairperson, KNH- UoN ERC
The Assistant Director, Health Information, KNH
The Chair, Dept. of Dental Sciences, UoN
Supervisors: Dr. Walter A. Odhiambo, Unit of Oral and Maxillofacial Surgery, Oral Pathology and Oral Medicine, UoN
Dr. Eunice N. Kihara, Unit of Oral and Maxillofacial Surgery, Oral Pathology and Oral Medicine, UoN
Prof. Loice W. Gathece, Unit of Periodontology/ Community and Preventive Dentistry, UoN

Appendix 5: NACOSTI Research License

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Ref No: 843166

Date of Issue: 10/March/2022

RESEARCH LICENSE

This is to Certify that Dr.. Welcome Muungani of University of Nairobi, has been licensed to conduct research in Nairobi on the topic: THE PATTERN AND CHARACTERISTICS OF IMPACTED TEETH ASSOCIATED WITH JAW CYSTS AND TUMOURS AMONG PATIENTS ATTENDING THE UNIVERSITY OF NAIROBI DENTAL HOSPITAL for the period ending : 10/March/2023.

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Appendix 6: Anti-plagiarism check certificate

PATTERN AND CHARACTERISTICS OF IMPACTED TEETH ASSOCIATED WITH JAW CYSTS AND TUMOURS AMONG PATIENTS ATTENDING THE UNIVERSITY OF NAIROBI DENTAL HOSPITAL

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DR. WA ODHIAMBO (Executive Chairman Department of Dental Sciences)

Signature ------------------------------------- Date 20/06/2022 -------------------------------