CONE BEAM COMPUTED TOMOGRAPHY IN PRE-OPERATIVE ANALYSIS OF ODONTOGENIC CYSTS AND TUMOURS OF THE MAXILLOFACIAL REGION

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CERTIFICATE

This is to certify that **Dr. AATMAN SHARMA**, Post graduate student (2012 – 2015) in the Department of Oral Medicine and Radiology branch IX, Tamil Nadu Government Dental College and Hospital, Chennai – 600 003 has done this dissertation titled **"CONE BEAM COMPUTED TOMOGRAPHY IN PRE- OPERATIVE ANALYSIS OF ODONTOGENIC CYSTS AND TUMOURS OF THE MAXILLOFACIAL REGION"** under my direct guidance and supervision for partial fulfillment of the M.D.S degree examination in April 2015 as per the regulations laid down by Tamil Nadu Dr. M.G.R. Medical University, Chennai -600 032 for **M.D.S., Oral Medicine and Radiology (Branch – IX)** degree examination.

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CONTENTS

ABBREVIATIONS

AOT	Adenomatoid Odontogenic Tumour
CT	Computed Tomography
CBCT	Cone Beam Computed Tomography
CBVI	Cone Beam Volumetric Imaging
CCOT	Calcifying Cystic Odontogenic Tumour
CEOT	Calcifying Epithelial Odontogenic Tumour
CMOS	Complementary Metal Oxide Semiconductor
et al	And Others
FPD	Flat Panel Detector
FOV	Field of View
KCOT/ KOT	Keratocystic Odontogenic Tumour
KV	Kilo Voltage
MSv	Millisieverts
MA	Milliampere
Max sinus	Maxillary sinus
MNBR	Multiprojection Narrow-Beam Radiography

µSv	Microsieverts
N	Number
NRCP	National Council on Radiation Protection and Measurements
OKC	Odontogenic Keratocyst
OPG	Orthopantomogram
PAN	Panoramic Radiograph
ROI	Region of Interest
SPSS	Statistical Package for Social Sciences
WHO	World Health Organisation
2-D	2-Dimensional
3-D	3- Dimensional

INTRODUCTION

Various conditions/ lesions afflict the maxilla and mandible. Some are developmental in origin, whereas the rest maybe acquired or may develop later in one's lifetime. These lesions could either be odontogenic or non odontogenic in origin. Odontogenic lesions are the ones which arise from odontogenic tissues, such as the dental organ or dental follicle and dental lamina. Any part or a combination of any of the smaller component structures of the dental organ may lead to the formation of these odontogenic lesions like the odontogenic cysts and odontogenic tumours. Most odontogenic lesions are benign, but some may exhibit aggressive and destructive behaviour locally [1]. Odontogenic cysts and tumours form two groups of lesions and as the name suggests, one group contains lesions which are cyst like in nature and the other group with lesions which are basically tumour like or neoplastic. Usually these two groups are studied together because of the similarity in origin, clinical presentation and sometimes due to the mode of treatment used. The clinical work up of an odontogenic cyst or tumour may include a lesion from the other group in its differential diagnosis. These lesions maybe encountered frequently in a dental institution or hospital catering to a large population but are a relatively rare sighting in private practices hence making it a diagnostic challenge. Even in an institution when a patient walks in with a swelling of the jaws it may be easy to superficially guess the provisional diagnosis, but a thorough examination- clinical and radiological will be necessary to come to a proper working diagnosis. Radiological assessment can vary from the simple Intra Oral Periapical Radiograph (IOPA) through the Orthopantomogram (OPG) or various craniofacial views and may go up to higher imaging modalities like the Multi Detector Computed Tomography (MDCT) or Magnetic Resonance Imaging (MRI).

An interesting development in the field of dentistry or dental radiology per say has been the advent of the Cone Beam Computed Tomography (CBCT). It has allowed clinicians to view the hard tissues of the head and neck with greater ease as the equipment in question is smaller to fit in a dental office or institution, requires a smaller support staff, is easy to operate and acquire images from and all this at a fraction of the radiation dose of MDCT. This great new technology made everyone sit up and take notice, but as is usually seen whenever a new technology comes up is that, the technology precedes the knowledge. Very little information is available as to how this great technology can be put to best use to help in diagnosis and treatment planning of conditions of the head and neck. Of the various types of these conditions, odontogenic cysts and tumours present with peculiar and interesting clinical and radiological features. Radiologically the lesion may present with a multitude of features which can help us in arriving at a better working diagnosis.

Many lesions that occur in the mandible have a cyst like radiographic appearance. These lesions are often difficult to differentiate on the basis of their radiographic features alone. Mandibular lesions may be odontogenic or non-odontogenic. Among odontogenic lesions without mineralization, ameloblastomas, odontogenic keratocysts, and dentigerous cysts can all appear as well-defined, unilocular, well-corticated, lucent lesions that are often associated with the crowns of impacted or unerupted teeth. Most radicular cysts appear as round or pear-shaped, unilocular, lucent lesions in the periapical region. Among odontogenic lesions with mineralization, complex odontomas contain multiple masses of dental tissue and compound odontomas contain multiple teeth or tooth like structures. Odontogenic myxomas are characterized by lytic osseous changes of varying size, which may be demarcated and expansile or exhibit ill- defined borders. Non- odontogenic lesions

that mimic odontogenic lesions include benign fibro-osseous lesions (conventional or juvenile ossifying fibroma, focal or periapical cemento- osseous dysplasia, florid osseous dysplasia), traumatic bone cyst, lingual salivary gland inclusion defect, central giant cell granuloma, brown tumour of hyperparathyroidism, arteriovenous malformation, and mucoepidermoid carcinoma. The clinical and radiographic features of these mandibular lesions help establish a differential diagnosis, although microscopic tissue evaluation is generally necessary to accurately identify the lesion [1].

Odontogenic tumors, neoplasms, and other lesions related to the jawbones have for years been recognized as presenting clinical, radiologic, and histopathological challenges. Odontogenic cysts and tumours have stood as a diagnostic challenge in the past due to lack of information about the lesion in the third dimension. This changed with the advent of Multi Detector Computed Tomography (MDCT).

The site of the lesion, its size, the expansion of the cortical plates, perforation of said plates, the lesion could be unilocular or multilocular with bony septations, with or without any associated impacted teeth or other structures, how these lesions are located in relation to the adjacent proximal structures also form important radiological aspect of these lesions. Most of these features could be evaluated with a MDCT machine but a CBCT comes up as an interesting alternative with lower radiation dose and easy setup being one of the major advantages.

Reviewing the dental and maxillofacial structures in all perspectives may reveal hidden aspects of relevant disease and may enhance diagnosis. Multiplanar imaging has offered an unparalleled diagnostic approach when dealing with an unknown entity (pathological or not) that has stood as a diagnostic challenge [2].

Once a volume of data has been acquired and stored by CBCT, this data can be reformatted or realigned in any way the diagnostician requires [3]. This allows the area of interest to be viewed clearly without any superimposition with other neighbouring structures and hence helps in its assessment from all perspectives.

AIMS AND OBJECTIVES

The aim of the study is to evaluate Cone Beam Computed Tomography in pre-operative analysis of odontogenic cysts and tumours of the maxillofacial region.

1. To interpret the pre- operative CBCT axial, coronal, sagittal and 3 dimensional images of various odontogenic cysts and tumors of the maxillofacial region (histopathologically proven) in relation to the morphological characteristics like

    a. Site of lesion

    b. Size of lesion (mm)

    c. Proximity to adjacent anatomical structures

    d. Unilocular/ multilocular

    e. Tooth resorption

    f. Presence of Impacted tooth/ teeth

    g. Presence/ absence of bone expansion

    h. Presence/ absence of bone resorption

    i. Measure the short axis to long axis (S/L) ratio

2. To correlate the CBCT imaging features with histopathological findings

3. Formulate the diagnostic algorithm based on the imaging features

REVIEW OF LITERATURE

ODONTOGENIC CYSTS

Kramer[4] has defined a cyst as 'a pathological cavity having fluid, semifluid or gaseous contents and which is not created by the accumulation of pus.

Cysts of the oral and maxillofacial region may either be lined by an epithelium or may lack one. The cysts which are lined by an epithelium are known as true cysts and the ones lacking it may be referred to as pseudo cysts.

Reichart and Philipsen[5] prefer to describe these as 'cavities' rather than cysts; hence, for example, 'aneurysmal bone cavity'.

Shear[4] has classified these Odontogenic cysts as under

I Cysts of the jaws

II Cysts associated with the maxillary antrum

III Cysts of the soft tissues of the mouth, face, neck and salivary glands

The cysts of the jaws are divided into those that are:

A. Epithelial lined

B. Not epithelial lined

The epithelial-lined cysts may be either of:

1 Developmental origin

2 Inflammatory origin

Cysts of developmental origin may be either:

(a) Odontogenic, meaning arising from odontogenic tissues

(b) Non- odontogenic, meaning cysts arising from ectoderm involved in the development of the facial tissues

Classification

I Cysts of the jaws

A. Epithelial-lined cysts

1 Developmental origin

(a) Odontogenic

i Gingival cyst of infants

ii Odontogenic keratocyst

iii Dentigerous cyst

iv Eruption cyst

v Gingival cyst of adults

vi Developmental lateral periodontal cyst

vii Botryoid odontogenic cyst

viii Glandular odontogenic cyst

ix Calcifying odontogenic cyst

(b) Non-odontogenic

i Midpalatal raphé cyst of infants

ii Nasopalatine duct cyst

iii Nasolabial cyst

2 Inflammatory origin

i Radicular cyst, apical and lateral

ii Residual cyst

iii Paradental cyst and juvenile paradental cyst

iv Inflammatory collateral cyst

B. Non-epithelial-lined cysts

1 Solitary bone cyst

2 Aneurysmal bone cyst

II Cysts associated with the maxillary antrum

1 Mucocele

2 Retention cyst

3 Pseudocyst

4 Postoperative maxillary cyst

III Cysts of the soft tissues of the mouth, face and neck

1 Dermoid and epidermoid cysts

2 Lymphoepithelial (branchial) cyst

3 Thyroglossal duct cyst

4 Anterior median lingual cyst (intralingual cyst of foregut origin)

5 Oral cysts with gastric or intestinal epithelium (oral alimentary tract cyst)

6 Cystic hygroma

7 Nasopharyngeal cyst

8 Thymic cyst

9 Cysts of the salivary glands: mucous extravasation cyst; mucous retention cyst; ranula; polycystic (dysgenetic)

disease of the parotid

10 Parasitic cysts: hydatid cyst; *Cysticercus cellulosae*; trichinosis

Dentigerous Cyst

A dentigerous cyst is one that encloses the crown of an unerupted tooth by expansion of its follicle, and is attached to its neck [6].

Browne and Smith stressed that the term 'dentigerous cyst' is preferable to that of 'follicular cyst', as the latter implies a derivation from the tooth follicle which is a mesodermal structure [7]. **Browne** also pointed out, the literal meaning of dentigerous is 'tooth bearing', and this term is most appropriate for the lesion [6].

Three radiological variations of the dentigerous cyst may be observed. In the central variety the crown is enveloped symmetrically. In these instances, pressure is applied to the crown of the tooth and may push it away from its direction of eruption. In this way, mandibular third molars may be found at the lower border of the mandible. The lateral type of dentigerous cyst is a radiographic appearance that results from dilatation of the follicle on one aspect of the crown. This type is commonly seen when an impacted mandibular third molar is partially erupted so that its superior aspect is exposed. The so-called circumferential dentigerous cyst in which the entire tooth appears to be enveloped by cyst, results when the follicle expands. It is important that this variety be differentiated from the envelopmental type of OKC [6].

Frequency

In a study by **Shear and Singh**[8] of the incidence of dentigerous cysts on the Witwatersrand, it was shown that the age-standardised incidence rates for dentigerous cysts, standardised against a world standard population, per million per year, were 1.18, 1.22, 9.92 and 7.26 for black men, black women, white men and white women, respectively.

In an analysis by **Daley et al**[9] of an extensive Canadian sample of 6847 odontogenic cysts dentigerous cysts accounted for 1662 (24%).

An Israeli study by **Bodner**[10] of a series of 69 paediatric patients with cystic lesions of the jaws found that 31 (45%) were dentigerous cysts.

In the series of 7121 odontogenic cysts documented by **Jones et al.**[11], 1292 were dentigerous cysts (18.1%).

Age

Roggan and Donath[12] from Germany did a follow up of 239 follicular cysts and found the cysts to be present predominantly in the second and third decades.

Daley and Wysocki[9] did a study in a Canadian sample of 1545 dentigerous cysts, where they found the peak frequency also occurred in the third decade with a similar gradual decline. Epidemiologic data derived from a comparative study of 1662 dentigerous cysts and 824 dental follicles showed considerable overlap in age distribution and site predilection and were therefore of minimal use in reaching a final diagnosis.

Ledesma- Montes et al.[13] in a Mexican study of 108 dentigerous cysts stated that most cases occurred in the second and third decades, with a rather higher frequency in the first decade (16%).

A Japanese study by **Nakamura et al.**[14] of clinical cases of cysts of the jaw revealed, among patients with dentigerous cyst, those aged less than 20 years accounted for about 60%. Radicular cyst occurred most frequently in the maxillary lateral incisors, dentigerous cyst in the mandibular wisdom teeth, and odontogenic keratocyst in the region between the mandibular molar and the ramus of the mandible.

Gender

In the study by **Shear and Singh**[8] the frequency of dentigerous cysts in the South African sample was significantly greater in men than women (P = 0.001). In a sample of 356 patients with this cyst, 227 (64%) were men and 129 (36%) women, a ratio of 1.8: 1.

In the study by **Daley and Wysocki**[15], in a Canadian sample of 1661 dentigerous cysts, 60% occurred in men and 40% in women.

In the study by **Jones et al.**[11], 722 of 1114 patients were males and 392 were females, a male: female ratio of 1.86:1.

Race

In the South African sample of **Shear and Singh**[8], there was a higher frequency of dentigerous cysts in white than in black patients. Of 356 patients, 219 were white and 137 were black, a ratio of 1.6:1.

In **Mourshed's** series[16], there was also a considerable preponderance of white patients compared with black, but Mourshed discounted this on the grounds that the biopsy service at his school dealt predominantly with material from white patients.

Site

The anatomical distribution of 184 dentigerous cysts by **Shear**[6], in relation to tooth involved, showed a substantial majority involved the mandibular third molar. The maxillary permanent canine was next in order of frequency of involvement, followed by the mandibular premolars and the maxillary third molar.

Jones et al., (2006) [11] The site of presentation was known in 1001 cases and the mandible was the most commonly affected site with 817 (81.6%) cases. The lower molar region accounted for 73.2% of cases (n ¼ 733) followed by the anterior maxilla with 106 (10.6%) cases. Dentigerous cysts accounted for a higher proportion of odontogenic cysts in children (28.9%, n ¼ 160) than in their adult population (17.4%, n ¼ 1114)

Lustmann and Bodner (1988) [17] reported on dentigerous cysts associated with supernumerary teeth. In a review of 42 such cases from their own material and those reported in the literature, they found that about 90% were associated with a maxillary mesiodens.

Kaugars et al. (1989) [18] documented the occurrence of dentigerous cysts associated with a substantial number (27.6%) of a series of 351 odontomas.

Radicular Cyst and Residual Cyst

Inflammatory jaw cysts comprise a group of lesions that arise as a result of epithelial proliferation within an inflammatory focus due to a number of causes. Of the Inflammatory cysts, **Radicular cysts** are the most common and arise from the epithelial residues in the periodontal ligament as a result of periapical periodontitis following death and necrosis of the pulp [19]. These cysts most often arise at the apices of involved teeth, but may sometimes be present adjacent to lateral or accessory canals.

Sometimes a radicular cyst remains behind in the jaws after removal of the offending tooth and this is referred to as a **Residual cyst.**

Frequency

According to **Shear et al.** [4] Radicular and residual cysts are by far the most common cystic lesions in the jaws, comprising 1825 of 3498 (52.2%) jaw cysts and 62% of odontogenic cysts.

Killey et al. (1977) [20] in their series found radicular cysts to comprise 68% of the total cysts evaluated

In Sheffield, **Jones et al. (2006)** [11] found 4297 radicular and residual cysts over a 30-year period, representing 60.3% of all odontogenic cysts.

Age

The age distribution of 948 patients in the series by **Shear et al.** [19] of South African patients reveals that very few cases are seen in the first decade, after which there is a fairly steep rise, with a peak frequency in the third decade. There are large numbers of cases in the fourth and fifth decades, after which there is a gradual decline.

Jones et al., (2006) [11] in an age distribution analysis of 1970 cases from Sheffield suggest that these cysts are found at a somewhat older age in the English. The mean age of all radicular cysts in Sheffield was 37.3years.

Gender

Of 948 cases in the South African series by **Shear et al.,** [19] 555 (58.5%) were in men and 393 (41.5%) in women, a statistically significant difference ($P < 0.002$).

In the Sheffield series by **Jones et al., (2006)** [11] 1914 (51.5%) were in men and 1801 (48.5%) in women, but this gender difference was not significant. The lower frequency in women, which has also been reported by other workers, may be because

they are less likely to neglect their teeth, particularly the maxillary anterior incisors, where most radicular cysts occur. Men, moreover, may be more likely to sustain trauma to their maxillary anterior teeth.

Site

Shear et al., [19] found the anatomical distribution of 1111 cysts from their South African (Johannesburg) population to occur in all tooth-bearing areas of the jaws, although about 60% were found in the maxilla and 40% in the mandible.

According to **Jones et al., (2006)** [11] of the 2801 cases, where the site of occurrence was indicated, the maxilla was the most commonly affected site with 1996 cases (71.3%), of which 1478 cases (52.8% of all radicular cysts) occurred in the anterior maxillary region.

Residual Radicular Cysts

According to **Shear** [19] Residual radicular cysts are those that are retained after removal of the offending non-vital tooth.

Main, (1970) [21] and **Killey et al., (1977)**[20] estimated that they represent approximately 10% of all odontogenic cysts.

High and Hirschmann (1986) [22] stated that there was an unexpectedly large number in the mandibular premolar region and there was a direct relationship between the age of the cyst and the radiological and histological evidence of mineralisation ($P < 0.001$).

In their second paper on their series of symptomatic cysts that produced pain or swelling or both **High and Hirschmann (1988)** [23] studied the clinical, radiological

and histological characteristics of 31 symptomatic residual radicular cysts and compared and contrasted them with 39 asymptomatic residual cysts. Cyst ages varied from 1 month to 20 years and there was again a perplexingly high frequency in the mandibular premolar region.

Nair (1998)v[24]**, (2003)** [25] considered that the type of cyst was important with regards to persistence after treatment. He confirmed the work of **Simon 1980** [26] who showed that there were two types of radicular cyst, there is the true radicular cyst which contains a closed cavity entirely lined by epithelium, and the periapical pocket cyst (originally called the 'bay cyst' by Simon) in which the epithelium is attached to the margins of the apical foramen in such a way that the cyst lumen is open to the affected root canal. **Nair et al. 1996** [27] showed that only 15% of periapical lesions were radicular cysts and of these 61% were true cysts and 39% were pocket cysts. If only true cysts persisted after removal of the offending tooth, this may account for the relatively low frequency of residual cysts.

ODONTOGENIC TUMORS

According to the **WHO (2005)**, Odontogenic tumours and tumour-like lesions constitute a group of heterogeneous diseases that range from hamartomatous or non-neoplastic tissue proliferations to benign neoplasms to malignant tumours with metastatic potential. They are derived from epithelial, ectomesenchymal and/or mesenchymal elements of the tooth-forming apparatus. Odontogenic tumours are rare, some even extremely rare, but can pose a significant diagnostic and therapeutic challenge[5].

Odontogenic tumors constitute a group of heterogeneous lesions that range from hamartomatous or non-neoplastic tissue proliferations to malignant neoplasms

with metastatic capabilities. These lesions are of varying rarity within odontogenic tissues, but very rare (and in some cases, extremely rare) when viewed in the context of the entire human tumor pathology[28].

Broca [29], a French physician was the first who proposed a classification of tumors originating from dental tissues in 1867.

Bland and Sutton [30] in 1887 had proposed subdividing the 'odontomes' into those arising from aberrations of the enamel organ, aberrations of the follicle, of the papilla, and aberrations of the whole tooth germ.

The report of the British Dental Association, published in 1914 and authored by **Gabell, James and Payne** [29], included both radicular and dentigerous cysts as odontomes, and also grouped the lesions into three categories, those of epithelial, composite and connective tissue origin.

Thoma and Goldman [31] in1946 classified the odontogenic tumors into those of ectodermal, mesodermal and mixed origin.

In 1958, **Pindborg and Clausen** [32] proposed a classification of odontogenic tumors based on the developmental interdependence of dental tissues. The tumors were divided into two main groups, viz., epithelial and mesodermal tumors. The epithelial tumors were subdivided into purely epithelial tumors and epithelial tumors with inductive changes in the connective tissue.

A World Health Organization committee chaired by Jens Pindborg [33] published their recommendations in 1971 in the work Histological Typing of Odontogenic Tumours, Jaw Cysts, and Allied Lesions.

In 1992 **WHO** [34] came out with the second edition of the classification series under the simpler heading Histological Typing of Odontogenic Tumours.

In 2005 the latest and most updated classification for Odontogenic Tumours was published in chapter six of the **WHO Classification of Head and Neck Tumours (2005)** [5].

I. MALIGNANT TUMOURS

1. *Odontogenic carcinomas*
    - Metastasizing (malignant) ameloblastoma1
    - Ameloblastic carcinoma – primary type
    - Ameloblastic carcinoma – secondary type (dedifferentiated), intraosseous
    - Ameloblastic carcinoma – secondary type (dedifferentiated), peripheral
    - Primary intraosseous squamous cell carcinoma – solid type
    - Primary intraosseous squamous cell carcinoma derived from keratocystic odontogenic tumour
    - Primary intraosseous squamous cell carcinoma derived from odontogenic cysts
    - Clear cell odontogenic carcinoma
    - Ghost cell odontogenic carcinoma
2. *Odontogenic sarcomas*
    - Ameloblastic fibrosarcoma
    - Ameloblastic fibrodentino–and fibro-odontosarcoma

II. BENIGN TUMOURS

1. *Odontogenic epithelium with mature, fibrous stroma without odontogenic ectomesenchyme*
    - Ameloblastoma, solid / multicystic type
    - Ameloblastoma, extraosseous / peripheral type
    - Ameloblastoma, desmoplastic type
    - Ameloblastoma, unicystic type
    - Squamous odontogenic tumour
    - Calcifying epithelial odontogenic tumour (CEOT)
    - Adenomatoid odontogenic tumour (AOT)
    - Keratocystic odontogenic tumour (KOT)
2. *Odontogenic epithelium with odontogenic ectomesenchyme, with or without hard tissue formation*
    - Ameloblastic fibroma
    - Ameloblastic fibrodentinoma
    - Ameloblastic fibro- odontoma
    - Odontoma
        - Odontoma, complex type
        - Odontoma, compound type
    - Odontoameloblastoma
    - Calcifying cystic odontogenic tumour (CCOT)
    - Dentinogenic ghost cell tumour
3. *Mesenchyme and/or odontogenic ectomesenchyme with or without odontogenic epithelium*
    - Odontogenic fibroma
    - Odontogenic myxoma / myxofibroma

- Cementoblastoma

4. Bone-related lesions
    - Ossifying fibroma
    - Fibrous dysplasia
    - Osseous dysplasias
    - Central giant cell lesion (granuloma)
    - Cherubism
    - Aneurysmal bone cyst
    - Simple bone cyst

III. OTHER TUMOURS

- Melanotic neuroectodermal tumour of infancy

Frequency of Odontogenic Tumors

Daley et al. (1994) [9] did a study on Relative incidence of odontogenic tumors and oral and jaw cysts in a Canadian population. From the local population, odontomas were by far the most common tumor (51.53%) followed by ameloblastomas (13.52%) and peripheral odontogenic fibromas (8.93%). Locally, radicular (periapical) cysts were the most common odontogenic cyst (65.15%) followed by the dentigerous cyst (24.08%) and the odontogenic keratocyst (4.88%).

Servato et al. (2013) [35] carried out a study by retrospectively analysing 240 cases of odontogenic tumors. The patients' mean age was found to be 29 years, with a male to female ratio of 1:1.1. Benign lesions comprised 97.9% of the cases (mostly keratocystic odontogenic tumours (KCOT), odontomas and ameloblastomas) with the remaining tumours depicting a prevalence of less than 5%. AOT was less frequent than in most previous studies, while malignant Odontogenic Tumors was strikingly

numerous. Most Odontogenic Tumours in children and in the anterior maxilla were odontomas, while maxillary ameloblastomas were rare. Lack of swelling was more frequent in KCOT than in ameloblastomas.

Keratocystic Odontogenic Tumor (KOT)

Recently a lot of clinical and genetic evidence by **Mervyn Shear (2002)** [363738] has indicated that the odontogenic keratocyst (OKC) now has to be regarded as a benign cystic neoplasm. At the Editorial and Consensus Conference held in Lyon in July 2003, there was consensus that the OKC should be included under Odontogenic Tumours under the term Keratocystic odontogenic tumour (KOT).

Sansare et al. (2013) [39], conducted a systematic review of Keratocystic odontogenic tumor from Mumbai, India. The aim of their systematic review was to assess the clinical and imaging findings of keratocystic odontogenic tumor (KOT). The prevalence of KOT was found to be 0.0173% and that of OOC 0.0012%. Male sex, mandible, and the unilocular variation were predominant for the additional cases.

Ameloblastoma

Reichart PA et al. (1995) [40] did a literature review on 3677 cases of Ameloblastoma. They found the average age of patients with ameloblastoma to be 36 years and in developing countries ameloblastomas occurred in younger patients. Men and women were equally affected. The tumours appeared to be larger in females. Dominant clinical symptoms such as painless swelling and slow growth were non-characteristic. The ratio of ameloblastoma of the mandible to maxilla was 5 to 1. Ameloblastomas of the mandible occurred 12 years earlier than those of the maxilla. Ameloblastomas occurred most frequently in the molar region of the mandible.

Radiologically, 50% of ameloblastomas appeared as multilocular radiolucent lesions with sharp delineation. Unicystic ameloblastomas occurring in younger patients were found in 6%.

According to Reichart and Philipsen [28], based on clinical and radiographic characteristics, histopathology, and behavioural and prognostic aspects, three or four subtypes or variants of ameloblastomas can presently be distinguished: - The classic solid/ multicystic ameloblastoma

- The unicystic ameloblastoma

- The peripheral ameloblastoma

- The desmoplastic ameloblastoma, including so-called hybrid lesions

Unicystic Ameloblastoma

Some of the terms used for this lesion prior to 1977,when Robinson and Martinez introduced the concept of unicystic ameloblastoma, were cystic (intracystic) ameloblastoma, ameloblastoma associated with dentigerous cyst, cystogenic ameloblastoma, extensive dentigerous cyst with intracystic ameloblastic papilloma, mural ameloblastoma, dentigerous cyst with ameloblastomatous proliferation, and ameloblastoma developing in a radicular (or "globulomaxillary") cyst [28].

In a review of cases from literature of 193 cases of Unicystic Ameloblastoma by **Philipsen and Reichart (1998)** [41], they stated that UA is a variant of the solid or multicystic ameloblastoma. The mean age at the time of diagnosis of UA was closely related to an association with an impacted tooth. The male: female ratio for the 'dentigerous' type is 1.5:1, but for the 'non-dentigerous' type it is reversed (1:1.8). Location wise the lesion seemed to favour the mandible more than the maxilla

(mandible to maxilla = 3 to 13:1). Between 50 and 80% of cases were associated with tooth impaction, the mandibular third molar being most often involved. The 'dentigerous' type occurred on average 8 years earlier than the 'non- dentigerous' variant. The mean age for unilocular, impaction-associated UAs was 22 years, whereas the mean age for the multilocular lesion unrelated to an impacted tooth was 33 years. Histologically, the minimum criterion for diagnosing a lesion as UA is the demonstration of a single cystic sac lined by odontogenic (ameloblastomatous) epithelium often seen only in focal areas.

RADIOGRAPHY

Dental radiology has played an exciting, vital and critical diagnostic role in dentistry, and has brought revolution in medical field with the invention of newer rapidly expanding wide array of imaging modalities.

Intraoral radiography was first used within weeks of the discovery of X-rays by Roentgen in 1895. Extraoral imaging, including cephalometric radiography, followed soon thereafter. Panoramic radiography has provided broad coverage of the teeth and surrounding structures since the mid-twentieth century. Each of these modalities has adapted to the digital revolution. Recent decades have seen the development of CT, MRI, nuclear medicine, and ultrasonography, imaging modalities that have revolutionized dental and medical diagnosis.

Radiography is often the first step in diagnosing an odontogenic tumor; a screening radiograph is made and evaluated. It can also be the final step before creating a working diagnosis, after a complete history has been taken and physical and laboratory examinations have been done. In both instances, a number of

considerations have to be made relating to the application of imaging procedures that are presently available [28].

Odontogenic tumors are composed of a number of different soft and hard structures, including components derived from ectoderm, ectomesenchyme, and mesenchyme proper, Pulpal tissue and enamel represent the extremes in radiographic density and, in a number of lesions, may be closely associated, Therefore, their radiographic appearance may vary from complete radiolucency to mixed radiolucency/ radiopacity to complete radiopacity. For lesions of the jaws, any suitable imaging procedure requires radiation exposure, except for magnetic resonance imaging (MRI) and sonography. While radiation dose values in dental radiography are comparatively low, radiation dose burdens may be considerable with computed tomography (CT), which has been applied extensively in dentomaxillofacial radiology during the last decade. To keep exposure to diagnostic radiation to a minimum, the background for all radiographic examinations should be based on the principle "as low (exposure) as reasonably achievable (ALARA) [28].

Panoramic radiography

It is the basic and routine fundamental radiograph which is simple and easy to perform and provides useful information regarding mandibular symmetry, the number of teeth present, parallelism of the roots, sequence of dental eruption, dental age, resorption of teeth, presence of pathology, variation in relation to normal teeth as well as provides information of other structures also such as paranasal sinuses and temporomandibular joint articulation [42].

Valle et al. (1976) [43] first used the OPG in the first descriptions of odontogenic tumors (CEOT) in dental panoramic radiographs. An orthopantomogram

showed a multiloculated radiolucent lesion, with an unerupted tooth in the centre surrounded by a radiopaque area.

At present, dental panoramic radiographs provide the state of the art view of the jaws and are mandatory for any screening protocol in oral radiology [44].

Computerized tomography (CT)

In some past recent years, CT has become the imaging modality of choice as they provide more realistic information than conventional radiographic imaging techniques. Computerized tomography was developed by Sir Godfrey Hounsfield in 1967 and since the first prototype; there has been a gradual evolution to five generations of such systems. The method of classification for each system is based on the organization of the individual parts of the device and the physical motion of the beam in capturing the data. CT provides excellent tissue contrast and eliminates blurring of image and overlapping of adjacent anatomical structures. Nonetheless, there are several limitations also with this modality. It requires the large amount of considerable physical space and is much more expensive than other conventional radiographic methods. The images which are captured on the detector screens are made up of multiple axial slices, which are 'stacked' to obtain a final complete image making it time consuming.

James J. Abrahams (2001), stated that differentiation of a benign lesion from a malignant one may be difficult with only plain radiographs. Therefore it is easy to understand that CT was a crucial advancement in imaging the highly differentiated anatomy of the odontogenic cysts and tumors [45].

James J. Abrahams (2001) stated precise size and location are needed in the evaluation of lesions in the maxilla and mandible. Therefore, multi-detector CT (MDCT) scanning is commonly applied for various kinds of lesions in the maxilla and mandible because of its precision and diagnostic accuracy. Multi- detector CT scanning provides rapid acquisition of numerous thin axial images and more accurate reconstruction images. Multi-detector CT scanning provides accurate information about the height, width, and three-dimensional (3D) evaluation of the maxilla and mandible, as well as detailed information about the location of normal anatomical structures, such as the mandibular canal, mental foramen, mandibular foramen, incisive foramen, and maxillary sinus. In addition, the relationship between lesions and anatomical landmarks, including cortical margins and roots of teeth, can be established. These images are also excellent because MDCT eliminates streak artifacts from dental restorations that degrade direct coronal CT scans. With MDCT, axial images are used to reformat the cross-sectional images, projecting the artifact along the crowns of the teeth rather than over the bone that is the region of interest [45].

Radiographically, the radicular cyst is a well-circumscribed radiolucency arising from the apex of the tooth and bounded by a thin rim of cortical bone. On CT imaging, the cyst is shown as a water-dense mass with a well-defined margin. In addition, the cyst is located around the apex of a causative tooth, including it. If the cyst occurs in the maxilla, extension into the maxillary sinus from the maxillary sinus floor may be observed. A periapical granuloma and radicular cyst may have identical radiographic appearances, but a radicular cyst sometimes may be differentiated from the granuloma by its size. An apical granuloma is usually smaller than 1 cm in diameter, whereas a radicular cyst may become as large as 10 cm [46].

Tanaka et al. [47]**,** state that radiologically, the dentigerous cyst consists of a well corticated pericoronal radiolucency exceeding about 2.5 mm on CT images, which is a criterion between cystic change and a normal dental follicular sac. The dentigerous cyst is a well circumscribed radiolucency bounded by a thin rim of cortical bone including the crown of an unerupted tooth. On CT images, this cyst is shown as a water dense mass with a well-defined margin including the crown of an unerupted tooth. Dentigerous cysts cannot strongly absorb the contiguous teeth roots by knife-edge resorption. In addition, dentigerous cysts do not tend to expand the buccolingual cortical bone, but odontogenic tumors do.

Tanaka et al. [47]**,** state that in the case of KCOT, radiologically, the cystic mass is a well-circumscribed multi-loculated radiolucency bounded by a thin rim of cortical bone with smooth or scalloped margins. On CT images, the cystic mass is indicated as a water-dense mass with well-defined smooth or scalloped margins. The contents of KCOT are thick due to desquamated keratinizing squamous cells. These contents can occasionally increase the radiographic attenuation of the lesion on CT scans, but this is not appreciable on panoramic radiographs.

According to **Tanaka et al.** [47], in the case of Ameloblastomas, radiologically, the tumor is a well-circumscribed multi-loculated radiolucency bounded by a thin rim of cortical bone with smooth or scalloped margins. On CT images, the tumor is indicated as a soft tissue or water-dense mass with well-defined smooth or scalloped margins. Therefore, it is sometimes very difficult to differentiate between ameloblastomas and KCOT by characteristic radiographic findings. However, ameloblastomas tend to resorb the roots of teeth with knife-edge resorption, but KCOT have relatively less resorption if the lesions are contiguous with teeth. In

addition, ameloblastomas tend to expand the buccolingual cortical bone markedly as compared to KCOT.

Cone Beam Computed Tomography (CBCT)

It is a recent innovation in field of technology that has achieved the rapid acceptance in general, particularly in dentistry despite its current relatively high price when compared with alternative imaging methodologies.

Craniofacial CBCTs were designed to counteract some of the limitations of the conventional CT scanning devices [48]. The object to be evaluated is captured as the radiation source falls onto a two-dimensional detector. This simple difference allows a single rotation of the radiation source to capture an entire region of interest, as compared to conventional CT devices where multiple slices are stacked to obtain a complete image [49]. The cone beam also produces a more focused beam of x-ray and significantly less scatter radiation compared to the conventional fan-shaped CT devices, and this considerably increases the X-ray utilization and reduces the ability of X-ray tube required for volumetric scanning [50].

It has been reported that the total radiation dose is approximately 20% of conventional CTs and equivalent to a full mouth periapical radiographic exposure [51]. These component innovations are significant and allow the CBCT to be less expensive and smaller. Furthermore, the exposure chamber (i.e. head), is custom built and reduces the amount of radiation. The images are comparable to the conventional CTs and also may be displayed as a full head view, as a skull view or regional components depending upon the field of view.

Robb RA reported the use of first CBCT scanner for angiography among at Mayo Clinic in 1982 [52]. Later, several other systems were developed

specifically for angiography. **Fahrig et al**. developed a CBCT system based on an image intensifier and C-arm for use in angiography [53]. **Saint-Felix et al** developed a CTA CBCT system based on the gantry of a conventional CT scanner which reconstructs vasculature from a set of digitally subtracted angiography (DSA) images [54].

CBCT systems are also used for radiation therapy planning, in mammography, and interoperatively for otorhinolaryngological surgery. **Jaffray and Siewerdsen** developed a CBCT system for radiotherapy guidance based on an amorphous silicon (a-Si:H) flat-panel detector [55].

In late 1990s only that it has become possible to create clinical systems that are both inexpensive and small enough to be used in the dental office. The **first commercial CBCT system** for oral and maxillofacial imaging was the NewTom (Quantitative Radiology, Verona, Italy), which was first approved by the Food and Drug Administration (FDA) in **April 2001**, and is currently in its fourth generation as the NewTom VG. Since that time numerous additional systems have been approved or are in development [49].

Presently, the available CBCT equipment differs in size, possible settings, area of image capture (field of view), and clinical usage.

CBCT has application in several diagnostic areas, such as implant treatment, oral surgery, endodontic treatment, and temporomandibular joint imaging. The great advantage of this technology is that offers 3-dimensional (3D) imaging of dental structures and provides clear images of highly contrasted structures, such as bone. In comparison to the conventional computed tomography, CBCT technology in clinical practice has significant

advantages such as minimization of the dose of radiation to the patient, accuracy of image, rapid scanning time, lesser image artifacts, chair-side image display, high spatial resolution and real-time analysis [42] [56].

It uses a divergent or "cone"-shaped [57] source of ionizing radiation and a two dimensional area detector fixed on a rotating gantry to acquire multiple sequential projection images in one complete scan around the area of interest. Four technological factors have contributed to make this possible:

1) The development of compact high quality flat panel detector arrays,

2) Reduction in the cost of computers capable of image reconstruction,

3) Development of inexpensive X-ray tubes capable of continuous exposure and,

4) limited volume scanning (e.g., head and neck), eliminating the requirement of sub second gantry rotation speeds [58].

THIS TECHNOLOGY HAS BEEN GIVEN SEVERAL NAMES INCLUDING

Dental Volumetric Tomography

Digital Volumetric Tomography

Cone Beam Volumetric Tomography

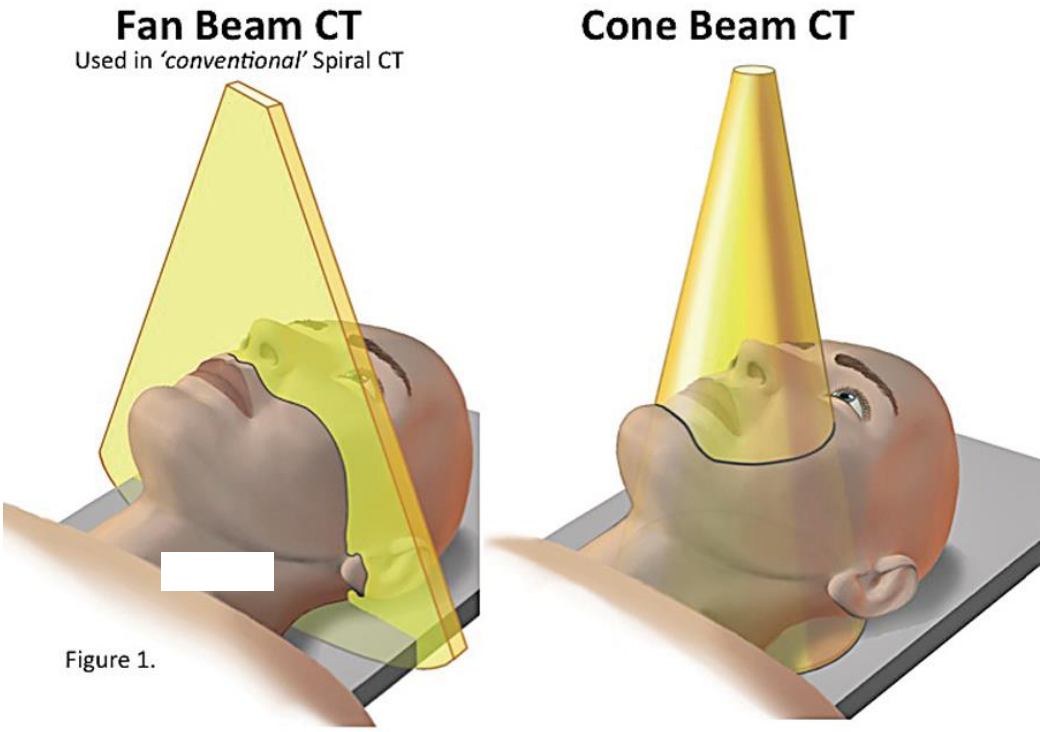
Cone Beam Computed Tomography

Dental Computed Tomography

Cone Beam Imaging

PRINCIPLES OF CONE BEAM COMPUTED TOMOGRAPHY

All CT scanners consist of an x-ray source and detector mounted on a rotating gantry. During rotation of the gantry, the receptor detects x rays attenuated by the patient. These recordings constitute "raw data" that is reconstructed by a computer algorithm to generate cross sectional images whose component picture element (pixel) values correspond to linear attenuation coefficients. CT can be divided into 2 categories on the basis of acquisition x ray beam geometry, namely fan beam and cone beam [58]. Cone beam scanners use a 2 dimensional digital array providing an area detector unlike linear detector as CT does. This is combined with a three dimensional (3D) x-ray beam with circular collimation so that the resultant beam is in the shape of a cone, hence the name "cone beam." Because the exposure incorporates the entire region of interest (ROI), only one rotational scan of the gantry is necessary to acquire enough data for reconstruction. Cone beam geometry has inherent quickness in volumetric data acquisition and therefore the potential for significant cost savings as compared with CT, CBCT produces an entire volumetric dataset from which the voxels are extracted. Voxel dimensions are dependent on the pixel size on the area detector. Therefore CBCT units in general provide voxel resolutions that are isotropic-equal in all three dimensions [59]



Fan shaped x-ray beam in Conventional CT and Cone shaped beam of x-rays in CBCT, Reprinted with permission from MacDonald-Jankowski DS, Orpe E. Computed tomography for oral and maxillofacial surgeons. Part 2: Cone-beam computed tomography. Asian Journal of Oral and Maxillofacial Surgery 2006;18: 85-92.

FIELD OF VIEW

Scanners using flat panel detectors (FPD) describe the dimensions of their cylindrical field of view's (FOV) as height by width (HxW). Width also can be referred to as diameter. Field of view refers to the area of the anatomy that is captured by the scan. Scanners are grouped into three categories based on their field of view.

1. Large field of view-

A scanner with large field of view will show the roof of the orbits and nasion down to the hyoid bone. Scanners with large FOV, usually a FOV

height equal to or greater than 16 cm, are useful for cephalometrics and traditional orthodontic surveys.

Eg- Next Generation (Platinum) i-CAT developed by Imaging Sciences International has a FOV of 17x23 cm.

Kodak 9500 developed by Carestream has a FOV of 18x21cm.

New Tom 3G developed by Imaging Sciences has a FOV of 20x20 cm

2. Medium field of view

Medium FOV scanners will capture the middle of the orbits down to menton vertically, and condyle to condyle horizontally. Scanners with a medium FOV are useful for panoramic radiograph and implant surveys, but not for cephalometric analysis.

Eg- New Tom 9000 by Aperio services has a FOV of 15x15x15cm

I-CAT services by Imaging Sciences International have a FOV of 8x14 cm.

3. Small field of view

Scanners with a small FOV capture a user-defined region, usually symmetrical in shape. Small FOV scanners are used for implant surveys, TMJ surveys, and the localization of impacted teeth.

Eg- Kodak 9000 3D and Kodak 9000 3DC developed by Carestream has a FOV of 4x5cm

ProMax 3D manufactured by Planmeca has a FOV of 8x8cm.

The use of CBCT technology in clinical practice provides the number of potential advantages for maxillofacial imaging compared with conventional CT[58]:

- ***X-ray beam limitation:*** Reducing the size of the irradiated area by collimation of the primary x-ray beam to the area of interest minimizes the radiation dose. Most CBCT units can be adjusted to scan small regions for specific diagnostic tasks. Others are capable of scanning the entire craniofacial complex when necessary.

- ***Image accuracy:*** The volumetric data set comprises a 3D block of smaller cuboid structures, known as voxels, each representing a specific degree of x-ray absorption. The size of these voxels determines the resolution of the image. In conventional CT, the voxels are anisotropic — rectangular cubes where the longest dimension of the voxel is the axial slice thickness and is determined by slice pitch, a function of gantry motion. Although CT voxel surfaces can be as small as 0.625 mm square, their depth is usually in the order of 1–2 mm. All CBCT units provide voxel resolutions that are isotropic — equal in all 3 dimensions. This produces sub-millimeter resolution (often exceeding the highest grade multi-slice CT) ranging from 0.4 mm to as low as 0.125 mm (Accuitomo).

- ***Rapid scan time:*** Because CBCT acquires all basis images in a single rotation, scan time is rapid (10–70 seconds) and

comparable with that of medical spiral CT systems. Although faster scanning time usually means fewer basis images from which to reconstruct the volumetric data set, motion artifacts due to subject movement are reduced.

- ***Dose reduction:*** Published reports indicate that the effective dose of radiation (average range 36.9–50.3 microsievert [μSv] is significantly reduced by up to 98% compared with "conventional" fan-beam CT systems (average range for mandible 1,320–3,324 μSv; average range for maxilla 1,031–1,420 μSv). This reduces the effective patient dose to approximately that of a film-based periapical survey of the dentition (13–100 μSv) or 4–15 times that of a single panoramic radiograph (2.9–11 μSv).

- ***Display modes unique to maxillofacial imaging:*** Access and interaction with medical CT data are not possible as workstations are required. Although such data can be "converted" and imported into proprietary programs for use on personal computers (e.g., Sim/Plant, Materialise, Leuven, Belgium), this process is expensive and requires an intermediary stage that can extend the diagnostic phase. Reconstruction of CBCT data is performed natively by a personal computer. In addition, software can be made available to the user, not just the radiologist, either via direct purchase or innovative "per use" licence from various vendors (e.g., Imaging Sciences

International). This provides the clinician with the opportunity to use chair-side image display, real-time analysis and MPR modes that are task specific. Because the CBCT volumetric data set is isotropic, the entire volume can be reoriented so that the patient's anatomic features are realigned. In addition, cursor-driven measurement algorithms allow the clinician to do real-time dimensional assessment.

- ***Reduced image artifact:*** With manufacturer's artifact suppression algorithms and increasing number of projections, our clinical experience has shown that CBCT images can result in a low level of metal artifact, particularly in secondary reconstructions designed for viewing the teeth and jaws.

Specific applications CBCT in dentistry [58]

CBCT technology has a substantial impact on the maxillofacial imaging. It has been applied to diagnosis in almost all the areas of dentistry and now its role is also expanding into treatment fields.

Implant site assessment

Orthodontics and Three Dimensional Cephalometrics

Temporomandibular joint

Conditions of the maxillofacial complex

Odontogenic Cysts and Tumors

Singer et al. (2009) [60]**,** in their report, "Cone beam computed tomography findings in a case of plexiform ameloblastoma", reported that the CBCT panoramic reconstruction demonstrated expansion and thinning of the mandibular cortex inferiorly. Superiorly, the cortex was unevenly expanded. The teeth in the region of the lesion were displaced, and more notably, the roots had resorbed to a great extent. Anteriorly and posteriorly, the borders were generally smooth, well-defined, and partially corticated. Internally, the lesion was uniformly low attenuating, consistent with soft tissue density. The axial views demonstrated incomplete septae. The axial, sagittal, and lateral cephalometric maximum intensity projection views demonstrated the expansile nature of the lesion, with thin, perforated bony cortices on both the buccal and lingual aspects of the lesion.

M Ahmad et al.(2012) [61] stated that in evaluating cysts or benign tumours all three dimensions are recorded by the multiplanar (axial, coronal and sagittal planes) imaging of CBCT. Such multiplanar views provide important information on the presence and extent of bone resorption, sclerosis of neighbouring bone, cortical expansion and internal or external calcifications, and proximity to other vital anatomy [62]. Multiplanar sections are preferred when examining cysts or tumours deep in the tissues [63].

Newer CBCT units allow slice thickness to be as low as 0.1 mm. These thin slices allow better visualization of the bony margins of a lesion. Oral and maxillofacial surgeons may depend on panoramic radiography if the margins of cystic or benign lesions are well defined [64]. If the margins are ill-defined, CBCT is a better option for diagnosis [65]. Apart from presurgical evaluation of

aggressive benign cysts or tumours, CBCT is also helpful in post-surgical follow-up of the margins of lesions that may have a high recurrence rate.

For surgical planning, a lesion may need to be measured from different angles. For osseous components, when compared to the gold standard dry skull, the measurements on CBCT images are acceptably accurate with less than 1% error [66]. In comparison, panoramic radiographs are not reliable for size measurement due to variable magnification error [67].

Luo et al. (2014) [68]**,** stated that CBCT imaging yields accurate three-dimensional images of lesion shape and structure. Therefore, CBCT can be used for the clinical diagnosis and surgical assessment of ameloblastoma.

Luo et al. (2014) [69]**,** stated that the typical intralesional structure with honeycomb appearance and the dominant buccal/labial cortical expansion with perforation could be proposed as the characteristic features of Desmoplastic Ameloblastoma on CBCT images. CBCT can provide more information for preoperative radiologic assessment of Desmoplastic Ameloblastoma compared with panoramic radiography.

Marques YF et al. (2010) [70] in their report emphasize that the CBCT image allowed a tridimensional visualization that, besides showing the association between lesions, revealed an unusual presentation of the lesion, since the cystic cavity and odontoma could be viewed separately. It was only possible to identify the cystic lesion and to plan the treatment properly after the use of CBCT images. A CBCT was required to clarify detailed structures of a limited area, demonstrating the margins of the connected lesions, as well as their internal architecture.

Patcas et al. (2012) [71] [71]**,** in their study on accuracy of linear intraoral measurements using cone beam CT and multidetector CT found that CBCT was slightly more reliable for linear measurements than MDCT and less affected by metal artefacts. CBCT accuracy of linear intraoral soft-tissue measurements was similar to the accuracy of bone measurements.

M. Shweel et al. (2013) [72]**,** did a comparative study of cone-beam CT and multidetector CT in the preoperative assessment of odontogenic cysts and tumors and found that in the overall assessment of odontogenic cysts and tumors, CBCT was comparable with MDCT with no significant statistical difference ($P<0.05$). However, CBCT was more accurate in linear measurements and identification of tooth displacement and buccal bone defect. It was found to be an optimal radiological modality for preoperative radiological assessment of odontogenic tumors.

MATERIALS AND METHODS

The study was conducted at Department of Oral Medicine and Radiology, Tamil Nadu Government Dental College and Hospital, Chennai – 600 003. The study protocol was approved by the Institutional Ethical Committee.

DURATION OF THE STUDY: From June 2014 to November 2014.

SAMPLE DESIGN:

Totally 24 cases were included under the study out of which 6 were female and 18 were male. 1 patient was excluded from the study as he did not full fill the study criteria after histopathological diagnosis (25-1= 24). The cases were selected from the Department of Oral Medicine and Radiology, Tamil Nadu Government Dental College and Hospital, Chennai – 600 003 between June 2014 and November 2014. All were in the age group of 5 – 60 years.

METHODOLOGY:

Patients reporting to the Department of Oral Medicine and Radiology with complaints of swelling of the jaws with/ without associated pain were subjected to a thorough clinical examination, details of which were entered into the structured proforma specially made for the study. Wherever indicated, conventional radiographs like IOPA, Occlusal radiographs, OPG and other extra oral skull radiographs were taken to arrive at a provisional diagnosis of either an odontogenic cyst or odontogenic tumour.

An informed consent was obtained from all the patients those who have fulfilled the inclusion and exclusion criteria. The study protocol was approved by the Institutional Ethical Committee.

CBCT for each patient was taken in Department of Oral Medicine and Radiology, Tamil Nadu Government Dental College and Hospital, Chennai–600 003 after which the patients were referred for an incisional biopsy to get a confirmatory final diagnosis based on the histopathological features.

The patients who were histopathologically confirmed to either have an odontogenic cyst or tumor were then taken up for the pre- operative evaluation with the CBCT scans already taken.

INCLUSION CRITERIA

1. Patients of both the genders
2. Histopathologically diagnosed case of odontogenic cysts and tumours
3. Referral cases of odontogenic cysts and tumours
4. Patients who are willing to participate in the study.

EXCLUSION CRITERIA

1. Postsurgical recurrent cases
2. Pregnancy
3. Patients reporting with maxillofacial trauma
4. Patients suffering from severe physical and/ or mental disability
5. Uncooperative & Unwilling to participate in the study

Armamentarium: (Figure 1)

1. Disposable gloves

2. Face mask
3. Patient's apron
4. Stainless steel tray
5. Mouth mirror
6. Tweezers
7. Probe
8. Gauze
9. Syringe with 18 gauge needle
10. Metal ruler

CS 9300 Select (Carestream Health, Inc.) cone beam 3D extraoral imaging system was used. The CBCT machine had a scanning time of 12-28 seconds (+/- 10%), voxel size 90µm to 180µm, field of view 5x5cm, 8x8cm, 10x5cm, 10x10cm and fitted with a TFT sensor (Figure 2). Exposure parameters for the patients varied from, tube voltage 60 - 90 kV, tube current 2 - 15 mA, with a scan time of 12- 28 seconds. Routine radiation safety procedures were followed. Patients were positioned in standing position while taking the scan. The total image acquisition time was less than 2 minutes. Radiation exposure for a Single CBCT scan was in the range 0.02 to 0.08 mSv. The radiographic exposure for patients was well below the maximum permissible dose of 2.4 mSv as per the NCRP guidelines[73].

The 3 D volumetric image data and the various sections were viewed in the Dental Imaging Software 6, 13, 1, 8 (Copyright Carestream Health, Inc., 2013) on Hewlett- Packard HP Z220 CMT Workstation running on Windows 7 Professional Operating System (Copyright © 2009 Microsoft Corporation).The DICOM data was analyzed on secondary reconstructed orthogonal slices, reformatted OPG and

reconstructed 3 dimensional images. Cross sectional CBCT images were evaluated for maximum dimension of the lesion on the axial section images in the mesio- distal and bucco- lingual direction, ratio of the two measurements, evidence of expansion and perforation of cortical plates, evidence of displacement and resorption of adjacent teeth, presence/ absence of impacted teeth, locularity of the lesion, internal density and involvement/ displacement of adjacent vital structures like inferior alveolar nerve canal, mental foramen, maxillary sinus, floor of nasal cavity and nasopalatine foramen. Manual tracing of the inferior alveolar canal was done in case of mandibular lesions using the company proprietary software.

Imaging features

Measurements were performed and all imaging features were expressed as binary numbers or quantitative values. The CBCT images were evaluated with regard to the following aspects:

(1) **Site**: Jaws divided into 6 portions (Figure 3)

   a. Right posterior maxilla (up to distal surface of canine)

   b. Anterior maxilla (canine to canine)

   c. Left posterior maxilla (up to distal surface of canine)

   d. Left posterior mandible (up to distal surface of canine)

   e. Anterior mandible (canine to canine)

   f. Right posterior mandible (up to distal surface of canine)

(2) **Size**, A- Maximum measurement in M/D direction (Figure 4)

(3) **Size**, B- Maximum measurement in B/L direction (Figure 4)

(4) **Size**, ratio of A: B, where A- Maximum measurement in M/D direction

B- Maximum measurement in B/L direction

The maximum diameter of the lesion on the axial section was measured.

(5) **Bone expansion**: Cortical expansion was seen and if present was given a score "1" and if not present a score of "0" was given. (Figure 5)

(6) **Bone perforation**: When any cortical plate was resorbed, the lesion was given a score ''1''. When the cortical plate was not resorbed or it was thinned, it was defined as ''0''. (Figure 5)

(7) **Displaced tooth**: Presence of displaced tooth was given a score of "1", if not then "0". (Figure 6)

(8) **Impacted tooth**: It was seen whether the crown of the impacted tooth was included in the lesion. Inclusion was defined as ''1'', and no inclusion was defined as ''0''. (Figure 7)

(9) **Locularity**: Based on the number of locules, multilocular lesions were defined as ''1'', and unilocular lesions were defined as ''0''. (Figure 7 & 8)

(10) **Tooth resorption**: Resorption of the roots of adjacent teeth was evaluated. Lesions showing tooth resorption were defined as ''1'', and those showing no resorption were defined as ''0''. (Figure 9)

(11) **Internal Density**: Homogenous lucent lesions were given a score of "0" and when the lesion was found to be heterogeneous with radiopacities a score of "1" was given. (Figure 10)

(12) **Vital structure**: involvement meant pushing/ displacing/ perforating/ involving the structure. If yes then a score "1" was given, if not then "0". (Figure 11a, 11b and 11c)

PHOTOGRAPHS

FIGURE 1

ARMAMENTARIUM

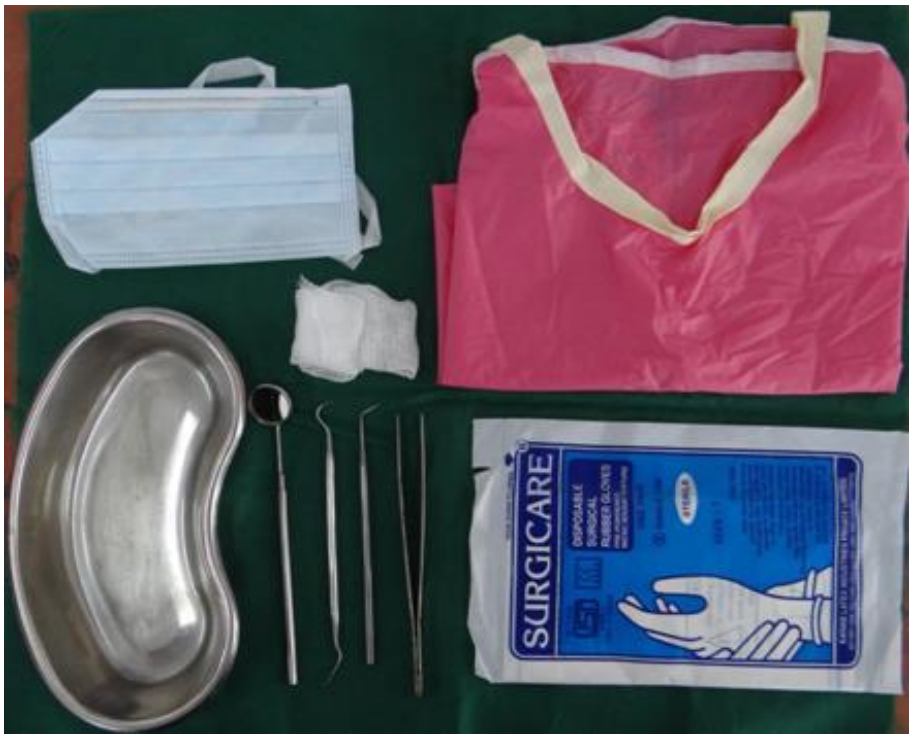


FIGURE 2

CBCT MACHINE

FIGURE 3

CROPPED IMAGE OF CBCT REFORMATTED PANORAMIC IMAGE SHOWING THE 6 SITES

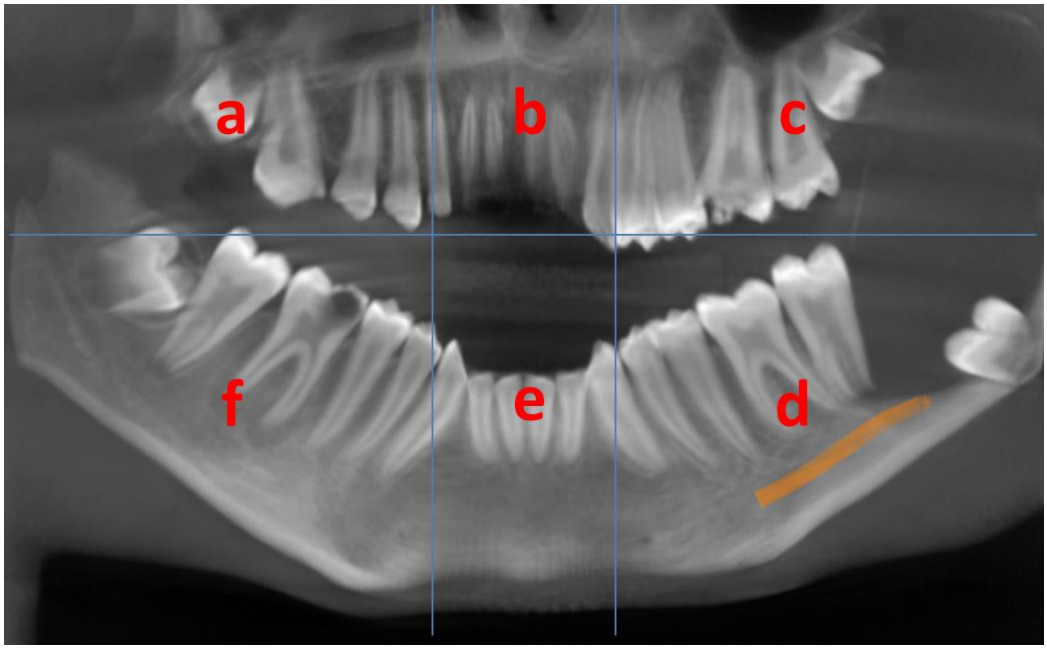


FIGURE 4

AXIAL SECTION OF CBCT, SIZE, A- MAXIMUM MEASUREMENT IN M/D DIRECTION

B- MAXIMUM MEASUREMENT IN B/L DIRECTION

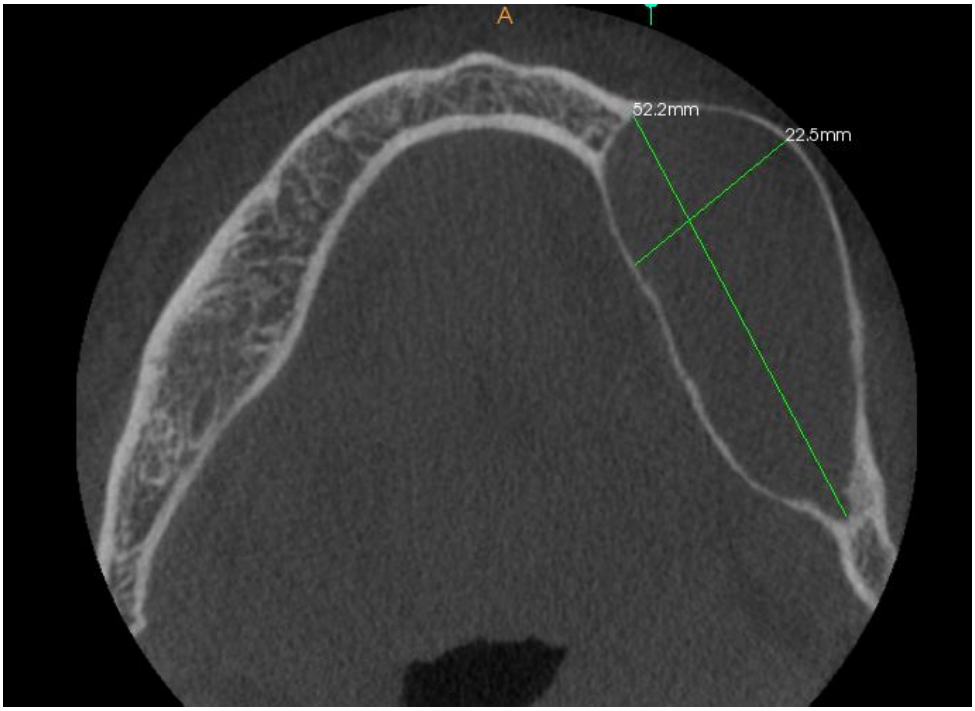


FIGURE 5

AXIAL SECTION OF CBCT SHOWING EXPANSION AND PERFORATION OF CORTICAL PLATES

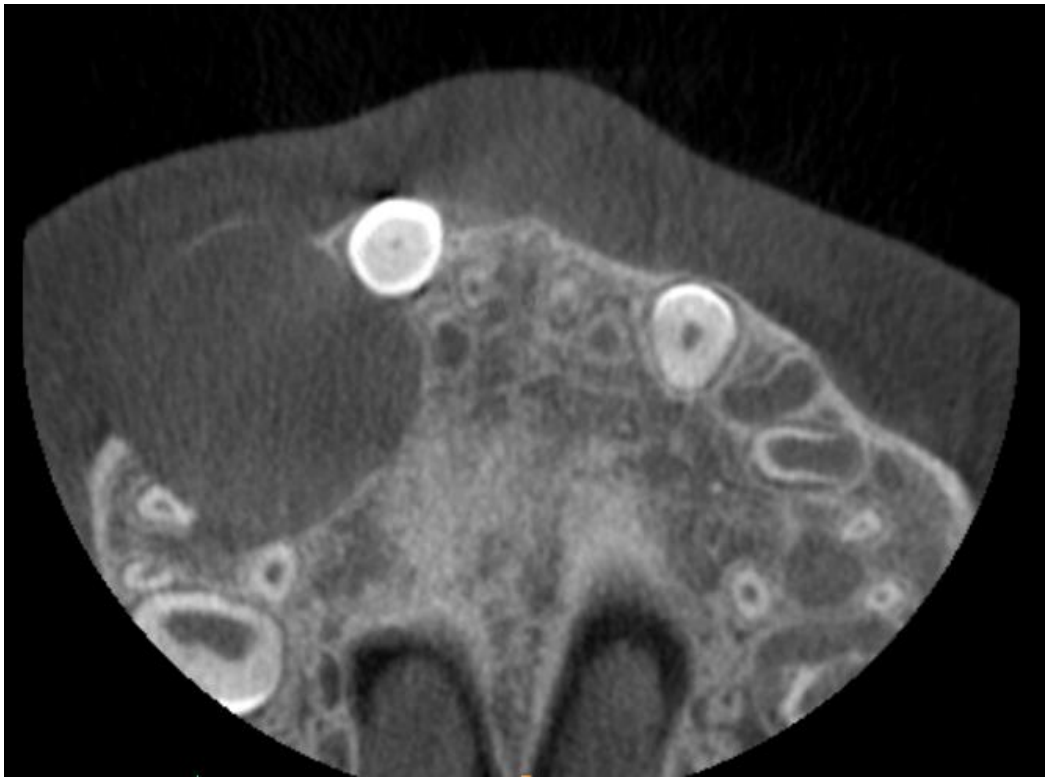


FIGURE 6

CROPPED IMAGE OF REFORMATTED PANORAMIC SECTION OF CBCT SHOWING DISPLACED TOOTH

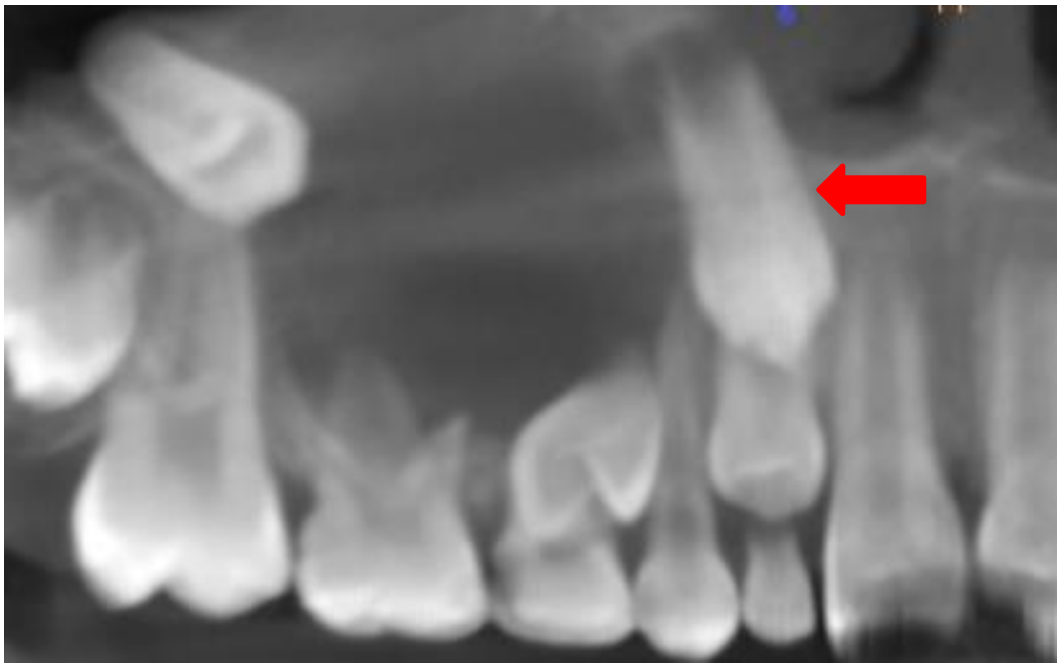


FIGURE 7

AXIAL SECTION OF CBCT SHOWING ASSOCIATED IMPACTED TOOTH (ARROW)
AXIAL SECTION OF CBCT SHOWING UNILOCULAR LESION

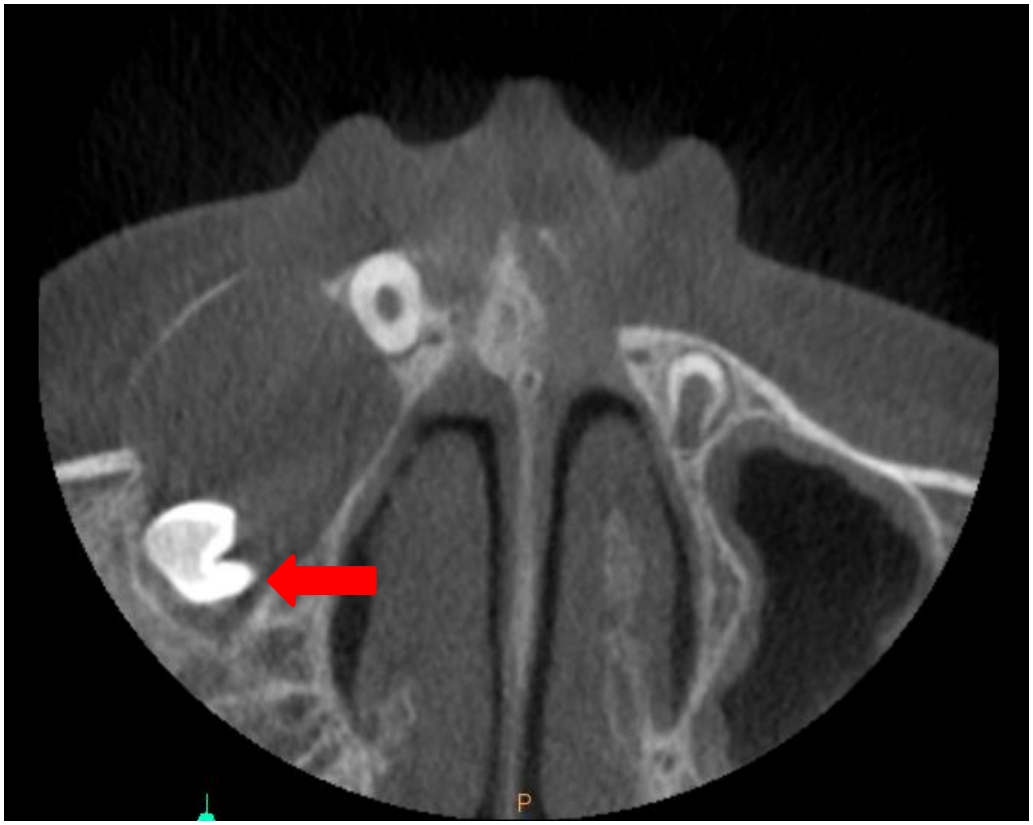


FIGURE 8

AXIAL SECTION CBCT SHOWING MULTILOCULAR LESION

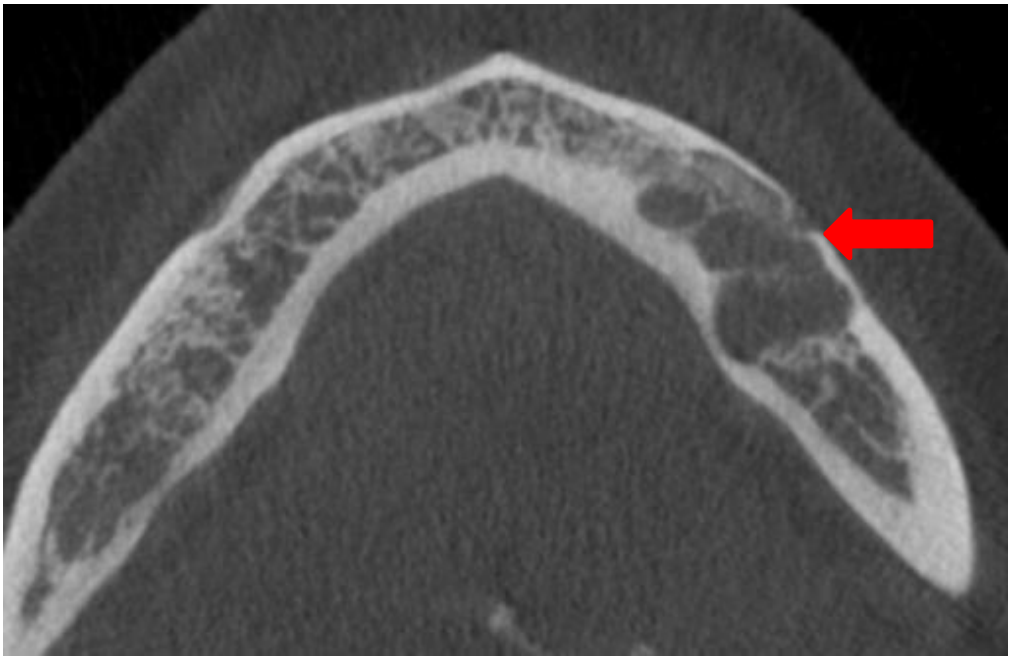


FIGURE 9

CROPPED IMAGE OF SAGITTAL SECTION OF CBCT SHOWING RESORPTION OF MOLAR ROOTS

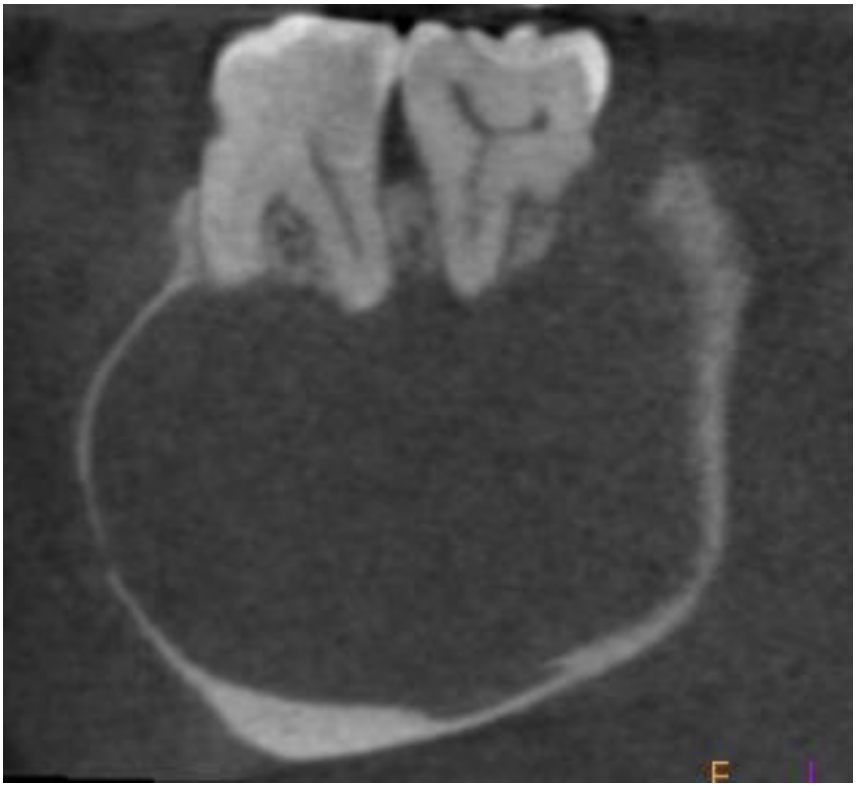


FIGURE 10

CROPPED IMAGE OF AXIAL SECTION OF CBCT SHOWING PRESENCE OF INTERNAL DENSITIES

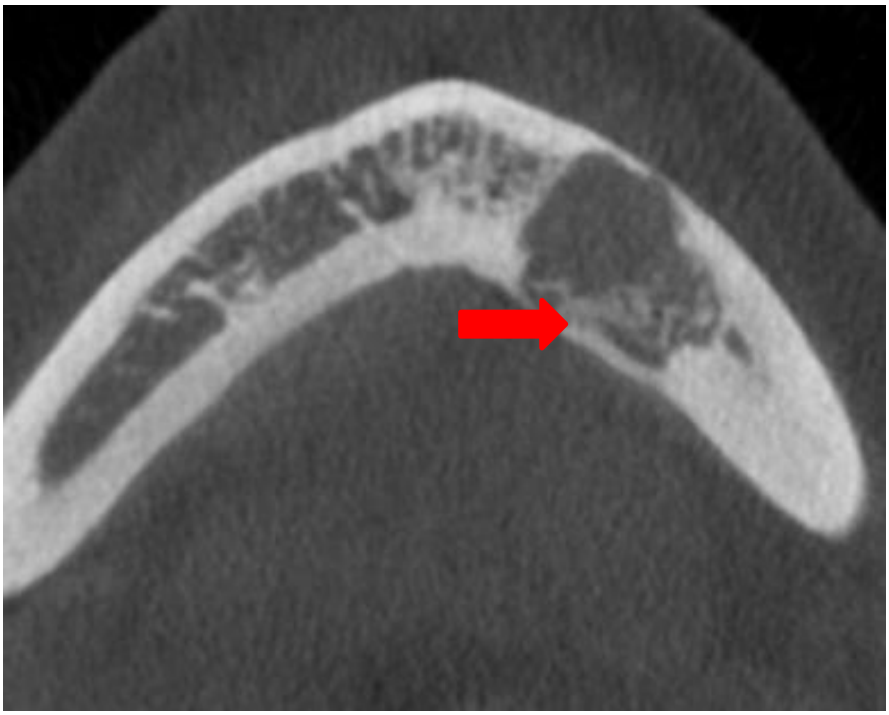


FIGURE 11a

CROPPED IMAGE OF SAGITTAL SECTION OF CBCT SHOWING LESION INVOLVING MAXILLARY SINUS

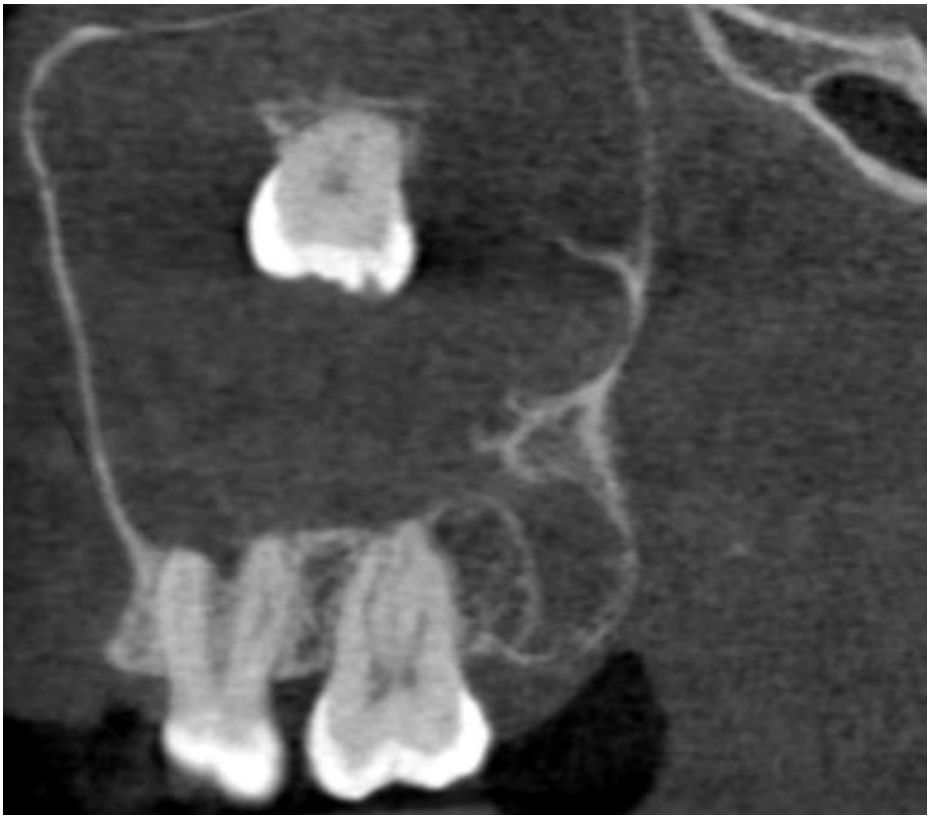


FIGURE 11b

CROPPED IMAGE OF CORONAL SECTION OF CBCT SHOWING LESION PUSHING NASAL FLOOR SUPERIORLY

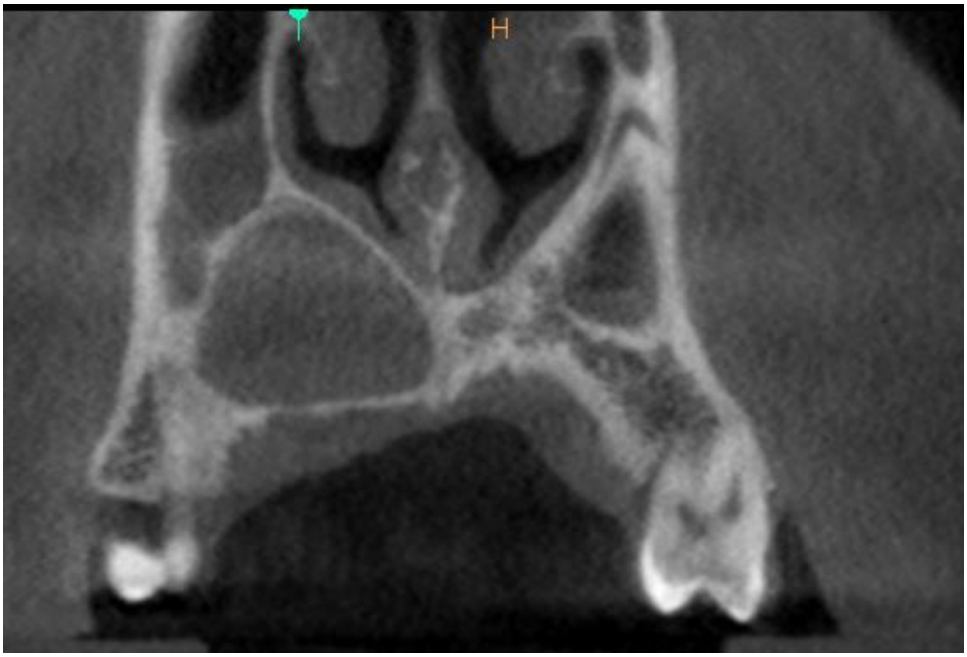
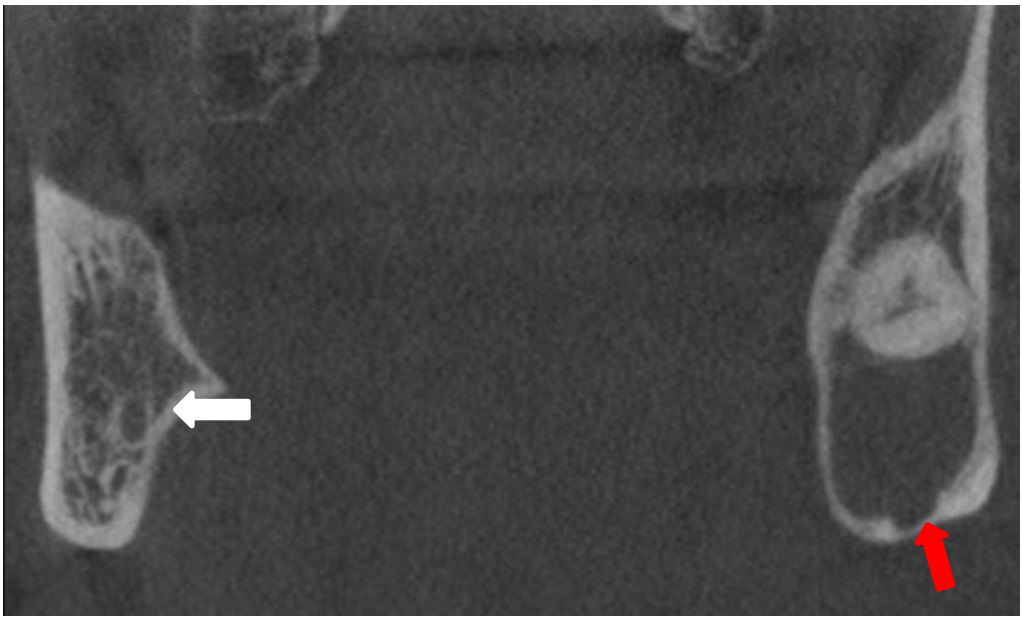
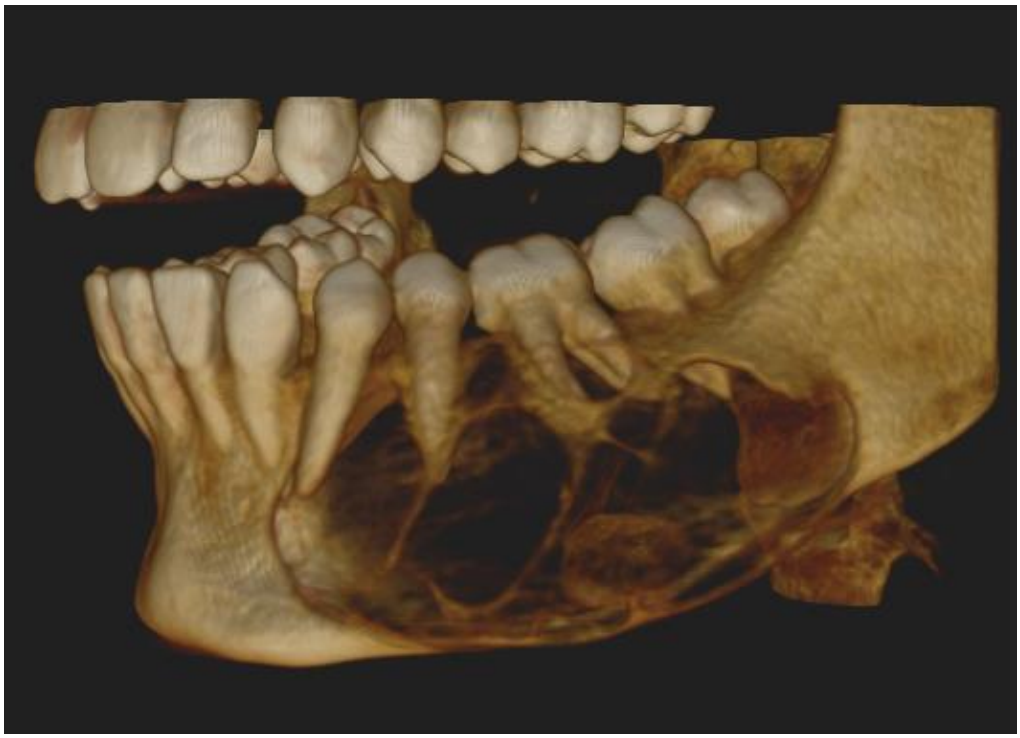


FIGURE 11c

CROPPED IMAGE OF CORONAL SECTION OF CBCT SHOWING LESION DISPLACING THE LEFT MANDIBULAR CANAL INFERIORLY (RED ARROW) AS COMPARED TO NORMALLY PLACED CANAL ON THE RIGHT SIDE (WHITE ARROW)

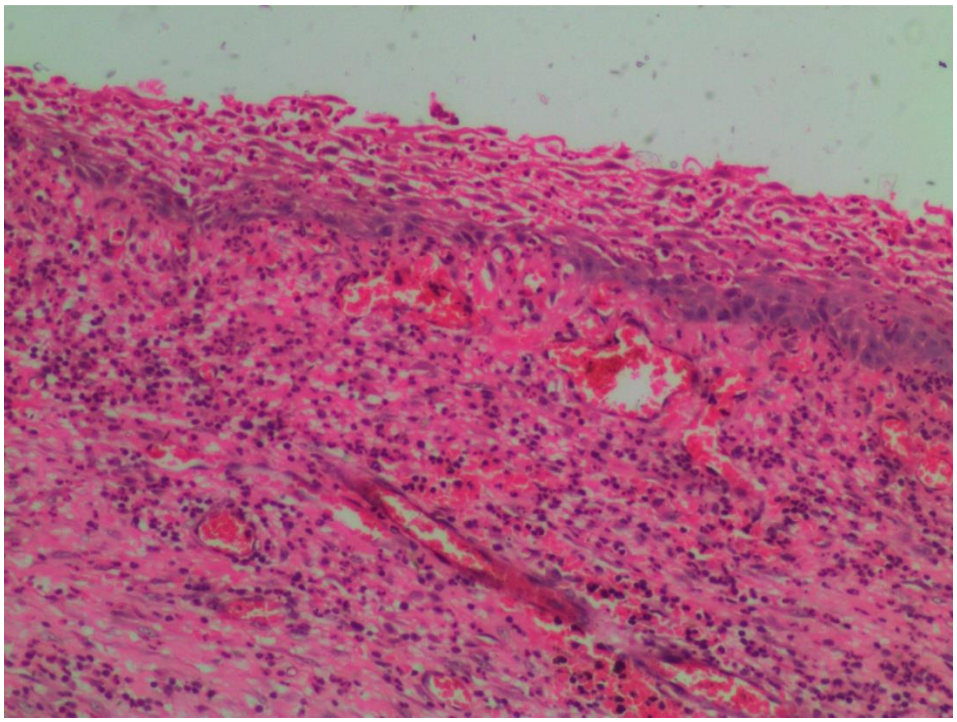


3 DIMENSIONAL VOLUME RENDERED IMAGE DEPICTING MULTILOCULAR LESION IN LEFT BODY OF MANDIBLE



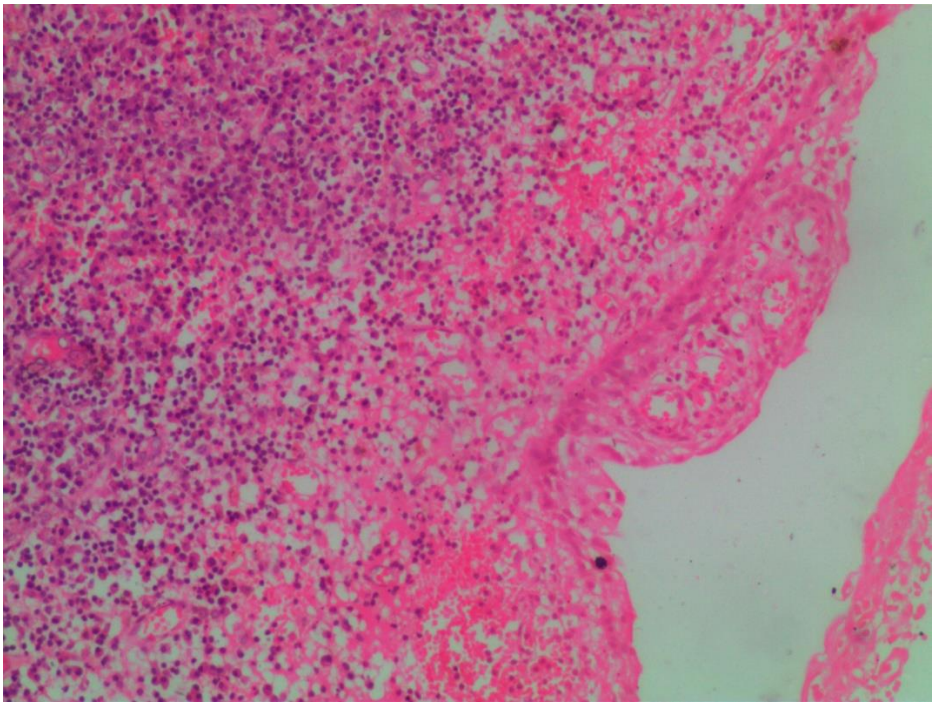
PHOTOMICROGRAPH OF DENTIGEROUS CYST (x100)

CYSTIC LESION WITH A NON-SPECIFIC LINING



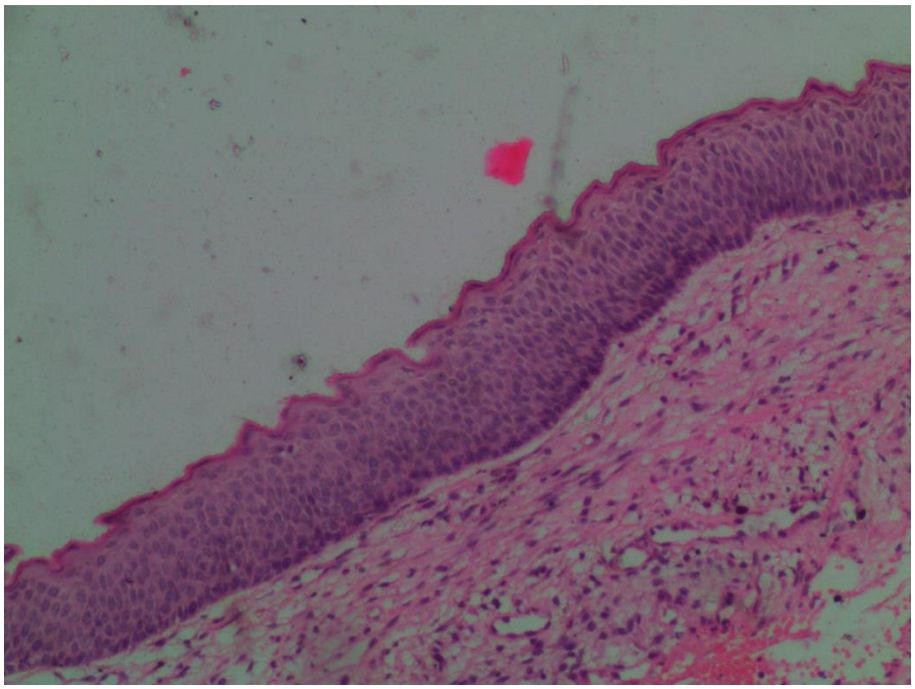
PHOTOMICROGRAPH OF PERIAPICAL CYST (x100)

CYSTIC LESION WITH WALL SHOWING INFLAMMATORY CHANGES,



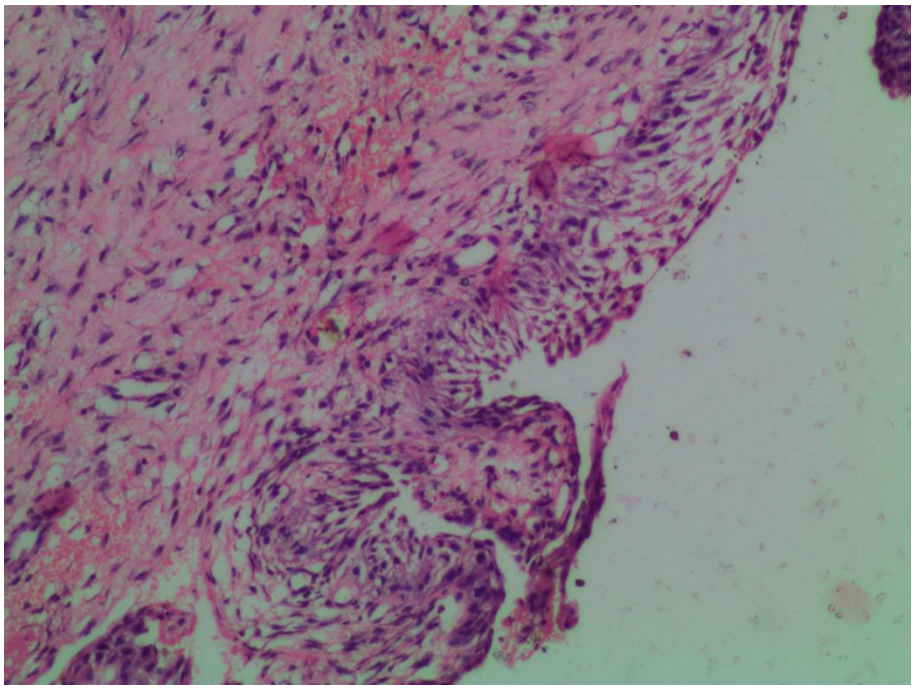
PHOTOMICROGRAPH OF KCOT (x100)

CYSTIC LESION WITH LINING CHARACTERISED BY PALISADING BASAL CELL LAYER AND CORRUGATED SURFACE PARAKERATIN



PHOTOMICROGRAPH OF UNICYSTIC AMELOBLASTOMA (x100)

CYSTIC LESION SHOWING LINING CHARACTERISED BY HYPERCHROMATIC BASAL CELL LAYER AND SUPERFICIAL STELLATE RETICULUM LIKE CELLS



MASTER CHART

Serial No	H/P Diagnosis	Age	Sex	Site	A	B	A:B	Expansion	Perforation	Displaced tooth	Impacted tooth	Locularity	Resorption	Internal Density	Vital structures				
															Maxillary sinus	Nasal Fossa	Nasopalatine foramen	Mandibular canal	Mental Foramen
1	UA	11	M	d	30	25.1	1.195	1	1	0	1	0	0	0	0	0	0	1	0
2	UA	18	M	b	39.2	27.2	1.441	1	1	1	1	0	1	0	1	1	0	0	0
3	KCOT	10	M	a	29.8	23.3	1.278	1	1	1	1	0	1	0	1	0	0	0	0
4	DC	17	M	c	41.2	36.7	1.122	1	1	0	1	0	1	0	1	0	0	0	0
5	DC	27	F	c	40.2	34.3	1.172	1	1	0	1	1	1	1	1	1	0	0	0
6	DC	5	M	d+e	32.4	24.8	1.306	1	0	1	1	0	1	0	0	0	0	0	1
7	RC	43	F	a	37.8	31.4	1.203	1	1	0	0	0	0	0	1	0	0	0	0
8	PC	30	M	b	26.4	22.1	1.194	1	0	0	0	0	1	0	1	1	1	0	0
9	PC	24	M	b	33.4	24.9	1.341	1	1	1	0	1	0	0	1	1	0	0	0
10	PC	22	M	b	19.7	13.8	1.427	0	1	0	0	0	1	0	0	0	1	0	0
11	PC	39	M	b	13.6	14	0.971	1	1	1	0	0	1	0	0	0	1	0	0
12	PC	61	M	b	46.6	47.6	0.978	1	1	1	0	0	1	0	0	1	1	0	0
13	PC	50	M	b	20.2	24.8	0.814	1	0	0	0	0	0	0	0	0	0	0	0
14	PC	27	M	f	26	21.4	1.215	1	0	1	0	0	1	0	0	0	0	0	0
15	DC	47	M	d	54.6	22.5	2.426	1	1	0	1	0	1	0	0	0	0	1	1
16	DC	46	M	a+b	46.4	28.9	1.605	1	1	1	1	1	1	0	1	0	0	0	0
17	KCOT	19	M	e	32.8	16.5	1.987	1	1	1	0	0	1	0	0	0	0	0	1
18	KCOT	23	M	b	42.6	26.8	1.589	1	1	1	0	0	1	0	1	1	0	0	0

19	KCOT	51	F	e+f	40.3	13	3.1	1	1	0	1	1	1	1	0	0	0	1	1
20	KCOT	45	F	d+e	27.3	12.9	2.116	1	1	0	0	1	1	1	0	0	0	0	0
21	UA	30	F	f	42.3	37	1.143	1	1	1	1	0	1	0	0	0	0	1	0
22	UA	22	M	d	63.5	56.4	1.125	1	1	1	1	1	1	1	0	0	0	1	0
23	SMA	19	F	d	51.3	21.8	2.353	1	1	1	0	1	1	1	0	0	0	1	1
24	UA	60	M	d	55.4	51.1	1.084	1	1	1	0	0	1	0	0	0	0	1	0

A- Maximum measurement in M/D direction

B- Maximum measurement in B/L direction

DC- Dentigerous Cyst

KCOT- Keratocystic Odontogenic Tumour

PC- Periapical Cyst

RC- Residual Cyst

SMA- Solid Multicystic Ameloblastoma

UA- Unicystic Ameloblastoma

STATISTICAL ANALYSIS

Statistical analysis was done with SPSS (Statistical Package for Social Sciences) version 16. Continuous Data was tested for Normality using Shapiro Wilks Test and the data was found to be parametric in nature. Comparison of the quantitative and parametric data was done using One Way ANOVA and the comparison of the categorical data was done using CHI square test. P value of < 0.05 was considered as significant in the present study.

Arithmetic Mean and Standard Deviation were estimated for different variables in each study group.

The P value or calculated probability was the estimated probability of rejecting the null hypothesis (H0) of a study question when that hypothesis was true. The smaller the p- value, the more significant the result was said to be. All P- values are two tailed, and confidence intervals were calculated at the 95% level. Differences between the two populations were considered significant when $p \leq 0.05$.

TABLES

TABLE 1: CASE DISTRIBUTION

Lesion type	*Provisional Diagnosis(CBCT)*	*Final Diagnosis (Histopathology)*
Dentigerous Cyst	8	5
Periapical Cyst	8	8
KCOT	4	5
Ameloblastoma Related	4	6
Total	24	24

TABLE 2: AGE DISTRIBUTION

Lesion type	*Minimum age (Years)*	*Maximum age (Years)*	*Mean age (Years)*
Dentigerous Cyst	5	47	28.4
Periapical Cyst	22	61	37
KCOT	10	51	29.6
Ameloblastoma Related	11	60	26.6

TABLE 3: SEX DISTRIBUTION

Sex	Male	Female
Lesion type		
Dentigerous Cyst	4	1
Periapical Cyst	7	1
KCOT	3	2
Ameloblastoma Related	4	2
Total	18	6

TABLE 4: SITE DISTRIBUTION

Lesion type	*Right posterior maxilla* ***(a)***	*Anterior maxilla* ***(b)***	*Left posterior maxilla* ***(c)***	*Left posterior mandible* ***(d)***	*Anterior mandible* ***(e)***	*Right posterior mandible* ***(f)***
Dentigerous Cyst	1	1	2	2	1	
Periapical Cyst	1	6				1
KCOT	1	1		1	3	1
Ameloblastoma Related		1		4		1
Total	3	9	2	7	4	3

Some lesions were present across more than one segment

TABLE 5: MESIO-DISTAL DIMENSION IN mm (A)

Lesion type	*N*	*Mean*	*Std. Deviation*
Dentigerous Cyst	5	42.9600	8.20902
Periapical Cyst	8	27.9625	10.78887
KCOT	5	34.5600	6.63423
Ameloblastoma Related	6	46.9500	12.10962
Total	24	37.2083	12.24279

TABLE 6: BUCCO- LINGUAL DIMENSION IN mm (B)

Lesion type	*N*	*Mean*	*Std. Deviation*
Dentigerous Cyst	5	29.4400	6.04797
Periapical Cyst	8	25.0000	10.82048
KCOT	5	18.5000	6.27575
Ameloblastoma Related	6	36.4333	14.43560
Total	24	27.4292	11.64304

TABLE 7: RATIO OF A: B

Lesion type	*N*	*Mean*	*Std. Deviation*
Dentigerous Cyst	5	1.5262	.53693
Periapical Cyst	8	1.1429	.20574
KCOT	5	2.0140	.69153
Ameloblastoma Related	6	1.3902	.48844
Total	24	1.4660	.54949

TABLE 8: EXPANSION OF CORTICAL PLATES

Lesion type	*Expansion seen*	*Expansion not seen*
Dentigerous Cyst	5	0
Periapical Cyst	7	1
KCOT	5	0
Ameloblastoma Related	6	0
Total	23	1

TABLE 9: PERFORATION OF CORTICAL PLATES

Lesion type	*Perforation seen*	*Perforation not seen*
Dentigerous Cyst	4	1
Periapical Cyst	5	3
KCOT	5	0
Ameloblastoma Related	6	0
Total	20	4

TABLE 10: DISPLACEMENT OF ADJACENT TEETH

Lesion type	*Displacement present*	*Displacement not present*
Dentigerous Cyst	2	3
Periapical Cyst	4	4
KCOT	3	2
Ameloblastoma Related	5	1
Total	14	10

TABLE 11: ASSOCIATED IMAPCTED TOOTH/ TEETH

Lesion type	*Present*	*Not present*
Dentigerous Cyst	5	0
Periapical Cyst	0	8
KCOT	2	3
Ameloblastoma Related	4	2
Total	11	13

TABLE 12: LOCULARITY

Lesion type	*Multilocular*	*Unilocular*
Dentigerous Cyst	2	3
Periapical Cyst	1	7
KCOT	2	3
Ameloblastoma Related	2	4
Total	7	17

TABLE 13: RESORPTION OF ADJACENT TEETH

Lesion type	*Resorption present*	*Resorption not present*
Dentigerous Cyst	5	0
Periapical Cyst	5	3
KCOT	5	0
Ameloblastoma Related	5	1
Total	20	4

TABLE 14: INTERNAL DENSITY

Lesion type	*Radiolucent*	*Radiopaque/ Mixed lucency*
Dentigerous Cyst	4	1
Periapical Cyst	8	0
KCOT	3	2
Ameloblastoma Related	4	2
Total	19	5

TABLE 15: INVOLVEMENT OF MAXILLARY SINUS

Lesion type	*Involved*	*Not involved*
Dentigerous Cyst	3	2
Periapical Cyst	3	5
KCOT	2	3
Ameloblastoma Related	1	5
Total	9	15

TABLE 16: INVOLVEMENT OF NASAL FOSSA

Lesion type	*Involved*	*Not involved*
Dentigerous Cyst	1	4
Periapical Cyst	3	5
KCOT	1	4
Ameloblastoma Related	1	5
Total	6	18

TABLE 17: INVOLVEMENT OF NASOPALATINE FORAMEN

Lesion type	*Involved*	*Not involved*
Dentigerous Cyst	0	5
Periapical Cyst	4	4
KCOT	0	5
Ameloblastoma Related	0	6
Total	4	20

TABLE 18: INVOLVEMENT OF MANDIBULAR CANAL

Lesion type	*Involved*	*Not involved*
Dentigerous Cyst	1	4
Periapical Cyst	0	8
KCOT	1	4
Ameloblastoma Related	5	1
Total	7	17

TABLE 19: INVOLVEMENT OF MENTAL FORAMEN

Lesion type	*Involved*	*Not involved*
Dentigerous Cyst	2	3
Periapical Cyst	0	8
KCOT	2	3
Ameloblastoma Related	1	5
Total	5	19

SENSITIVITY AND SPECIFICITY ANALYSIS

TABLE 20: DENTIGEROUS CYST

Screening Test Results	*DIAGNOSIS*		*Total*
	Present	*Absent*	
Positive	5	3	8
Negative	0	16	16

Sensitivity: 100%

Specificity: 84.2%

PPV: 62.5%

NPV: 100%

TABLE 21: PERIAPICAL CYST

Screening Test Results	*DIAGNOSIS*		*Total*
	Present	*Absent*	
Positive	8	0	8
Negative	0	16	16

Sensitivity: 100%

Specificity: 100%

PPV: 100%

NPV: 100%

TABLE 22: KCOT

Screening Test Results	*DIAGNOSIS*		*Total*
	Present	*Absent*	
Positive	3	0	3
Negative	1	20	21

Sensitivity: 75%

Specificity: 100%

PPV: 100%

NPV: 95.23%

TABLE 23: AMELOBLASTOMA RELATED

Screening Test Results	*DIAGNOSIS*		*Total*
	Present	*Absent*	
Positive	4	0	4
Negative	2	18	20

Sensitivity: 66.7%

Specificity: 100%

PPV: 100%

NPV: 90%

CHARTS

CHART 1: CASE DISTRIBUTION

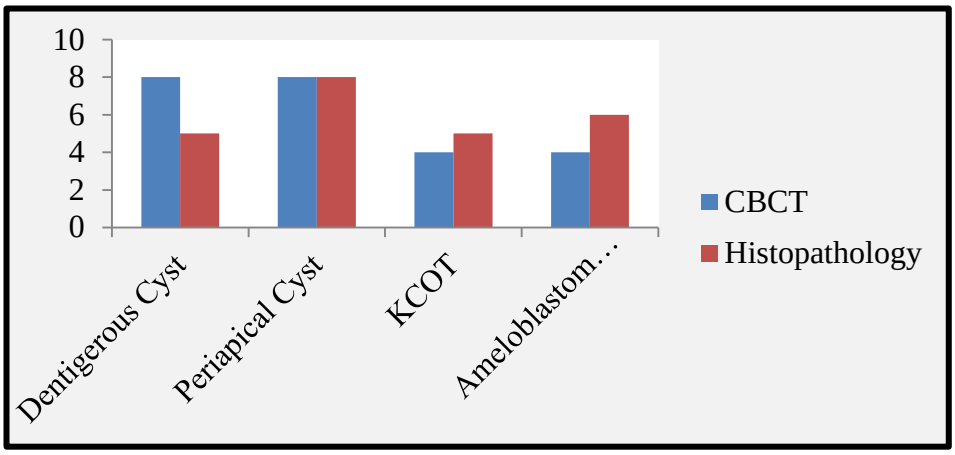


CHART 2: SEX DISTRIBUTION

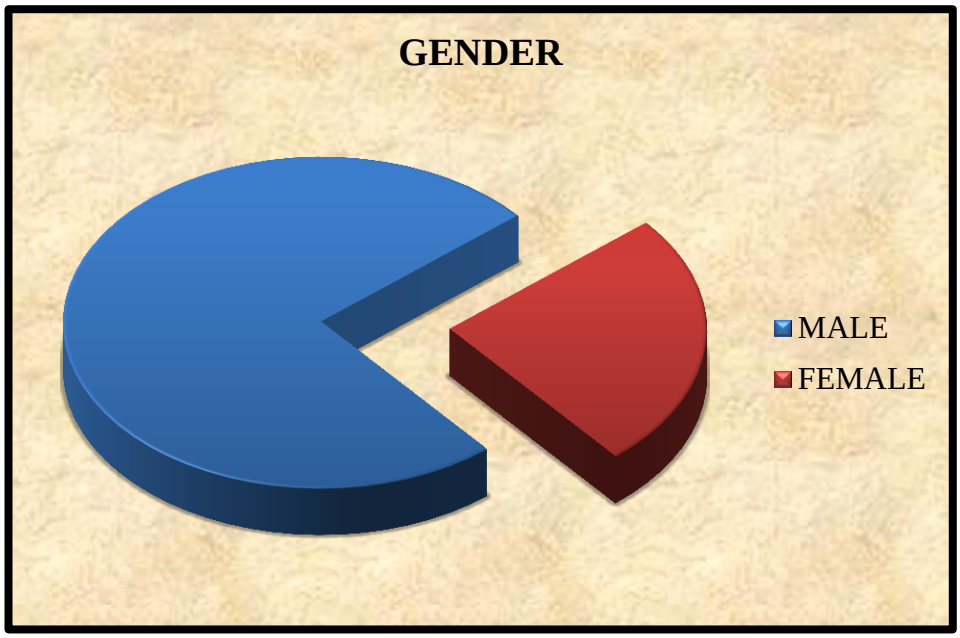


CHART 3: SITE DISTRIBUTION

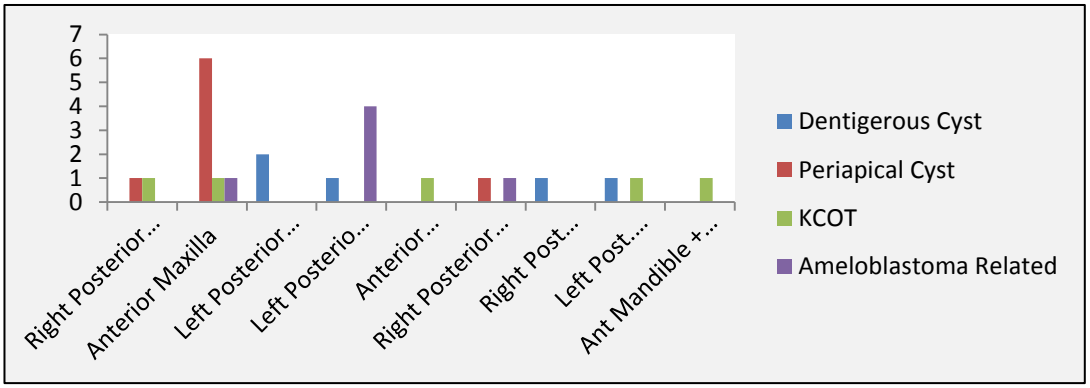


CHART 4: MESIO-DISTAL DIMENSION IN mm (A)

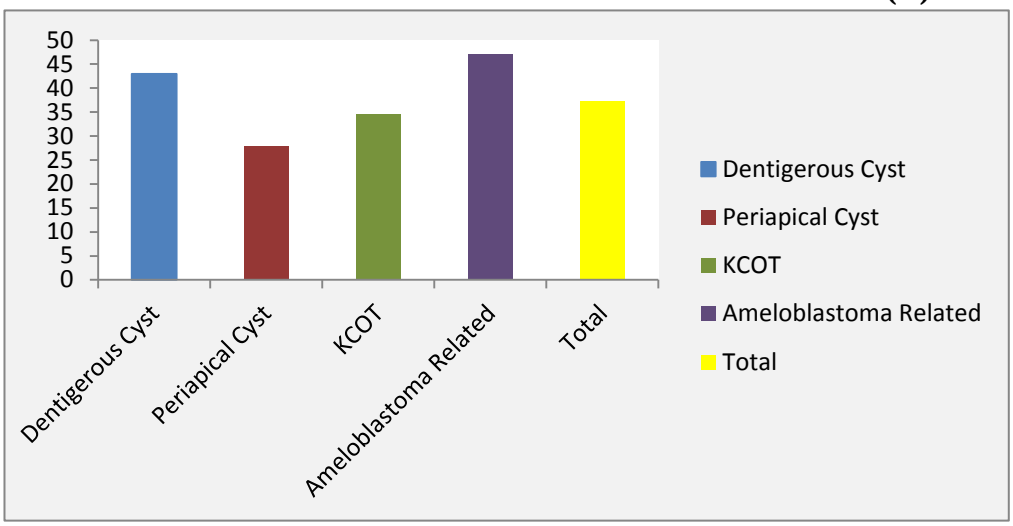


CHART 5: BUCCO- LINGUAL DIMENSION IN mm (B)

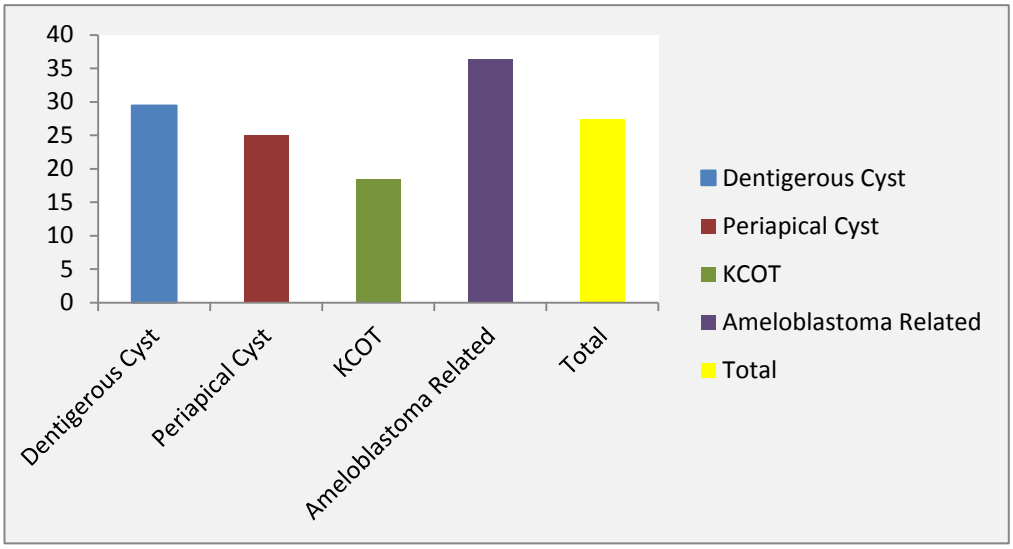


CHART 6: RATIO OF A : B

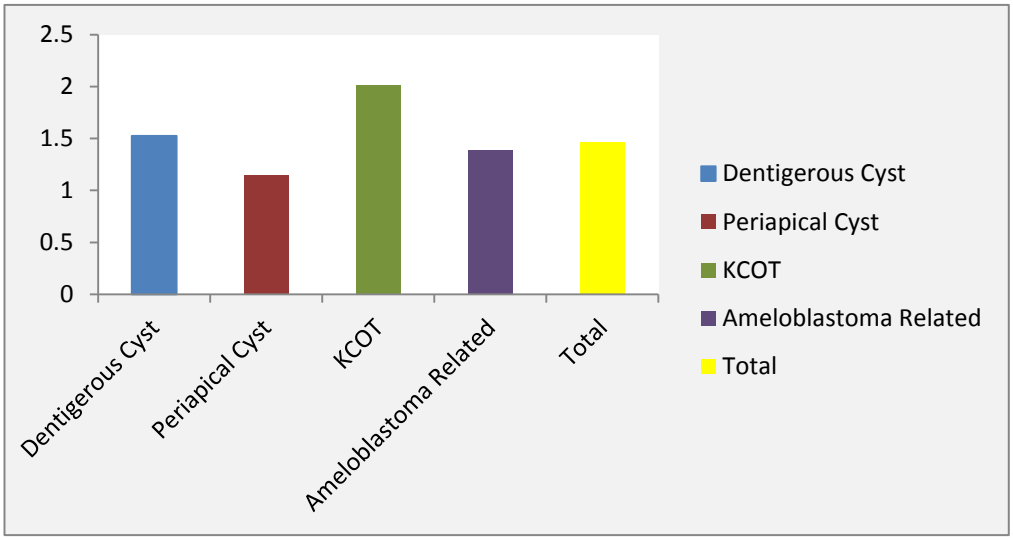


CHART 7: EXPANSION OF CORTICAL PLATES

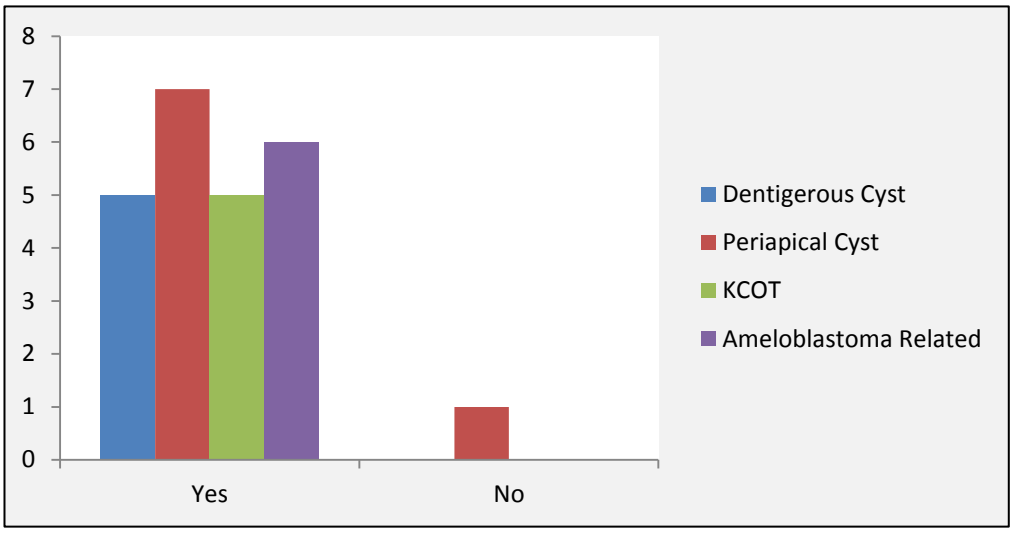


CHART 8: PERFORATION OF CORTICAL PLATES

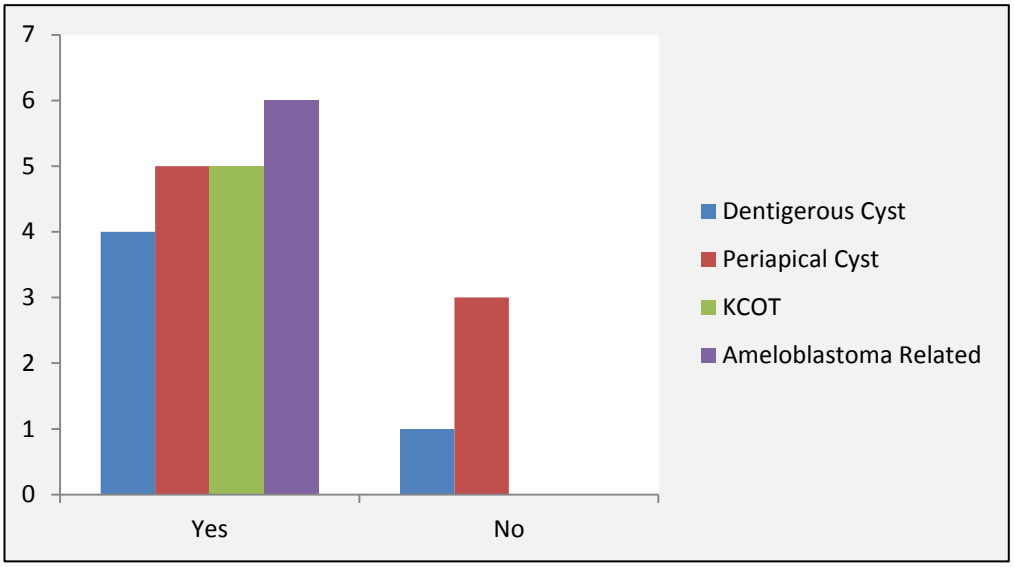


CHART 9: DISPLACEMENT OF ADJACENT TEETH

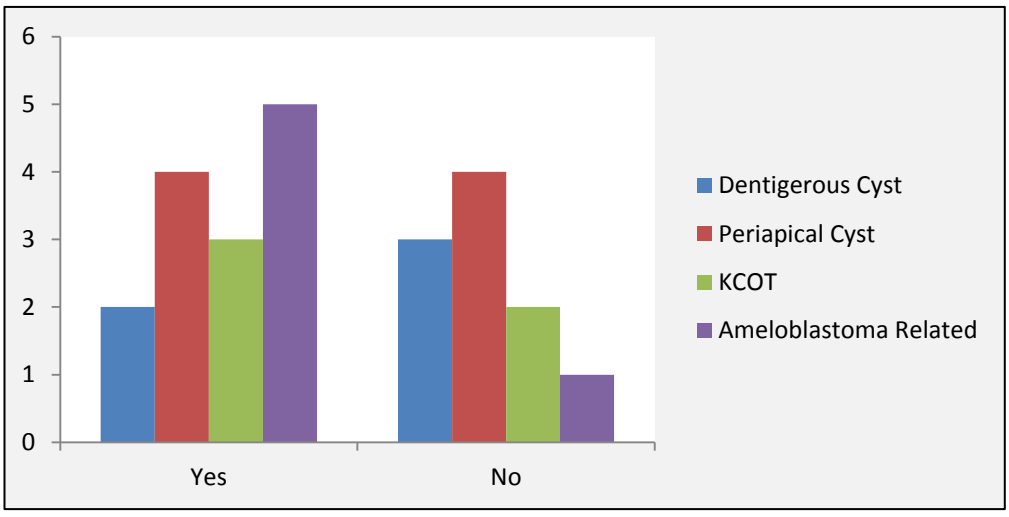


CHART 10: ASSOCIATED IMAPCTED TOOTH/ TEETH

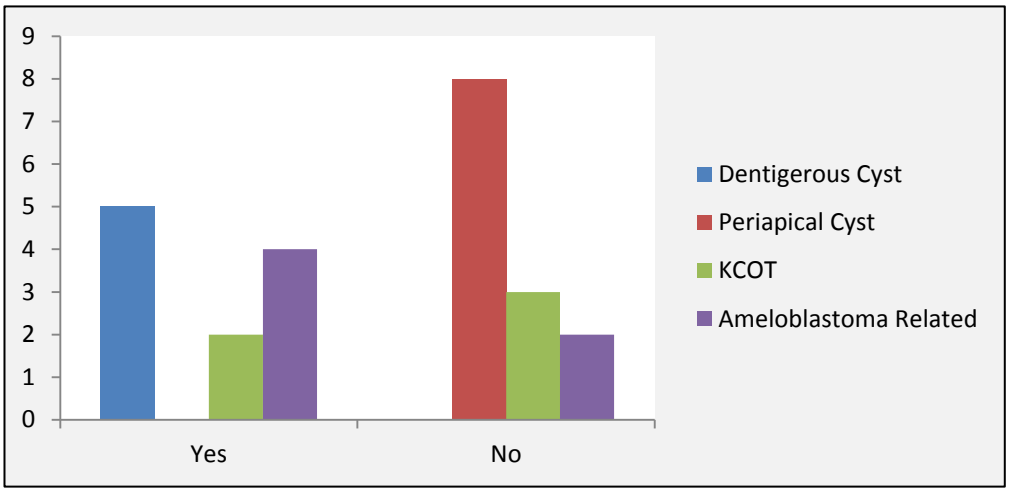


CHART 11: LOCULARITY

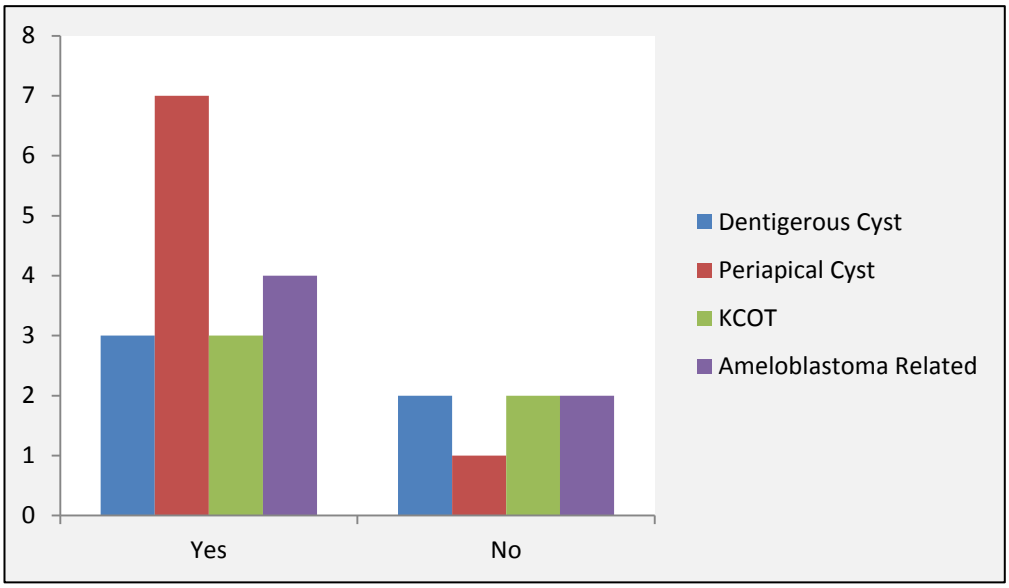


CHART 12: RESORPTION OF ADJACENT TEETH

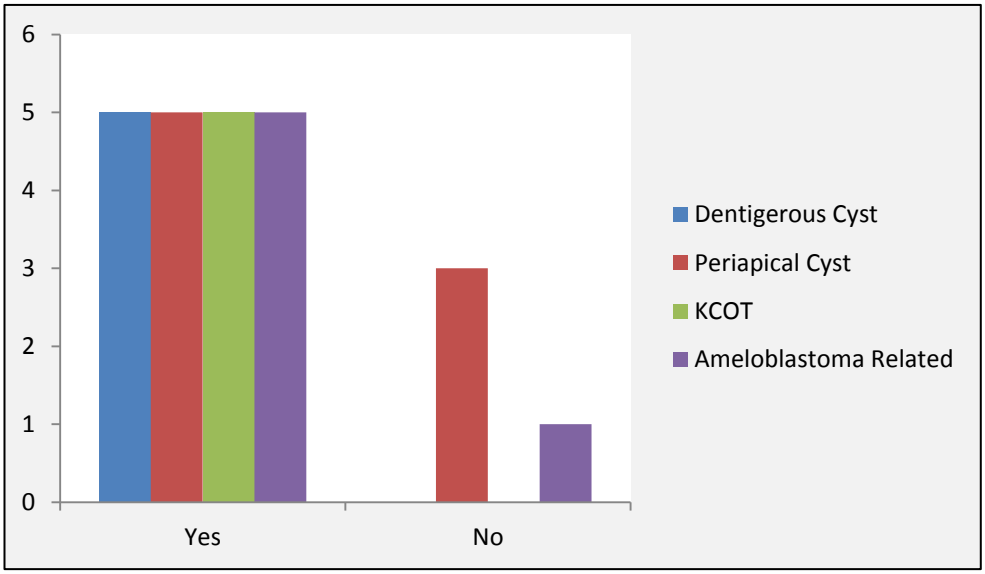


CHART 13: INTERNAL DENSITY

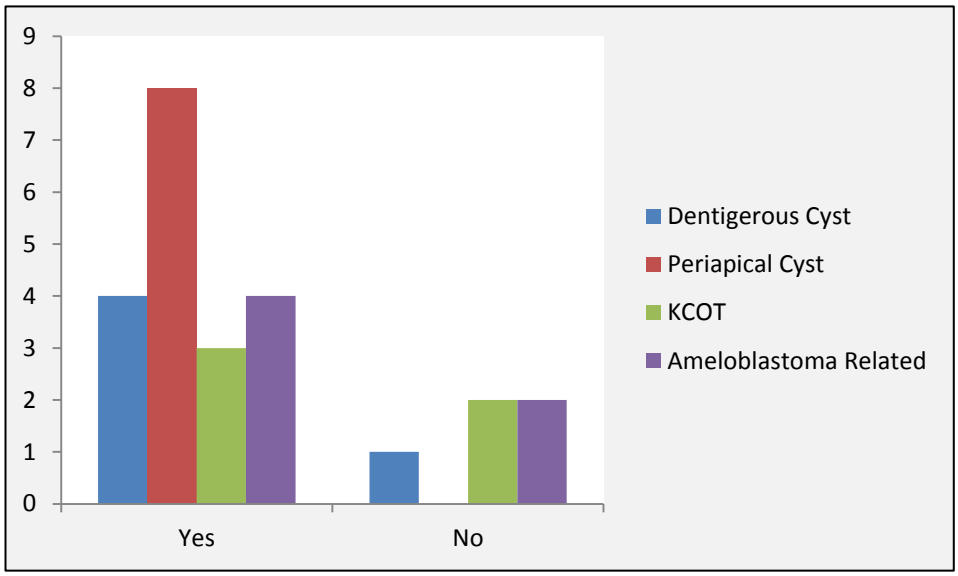


CHART 14: INVOLVEMENT OF MAXILLARY SINUS

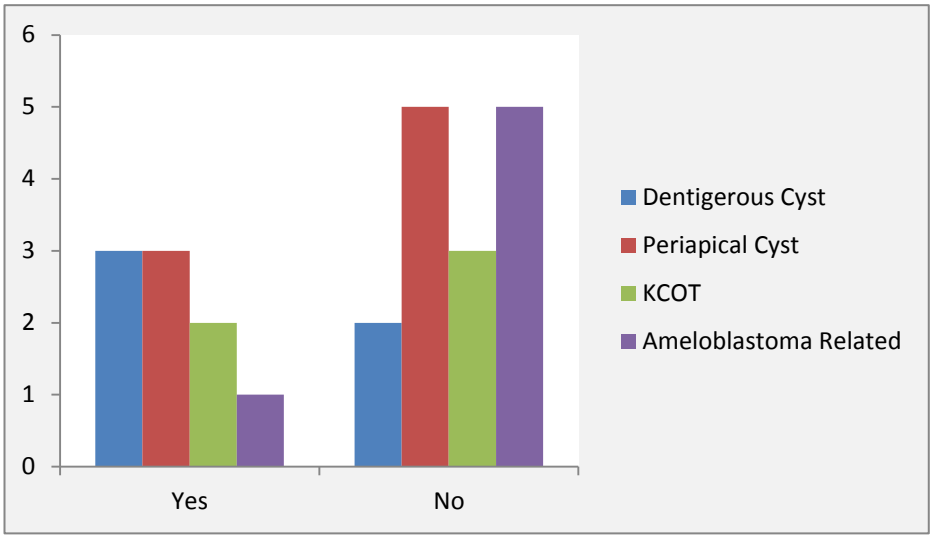


CHART 15: INVOLVEMENT OF NASAL FOSSA

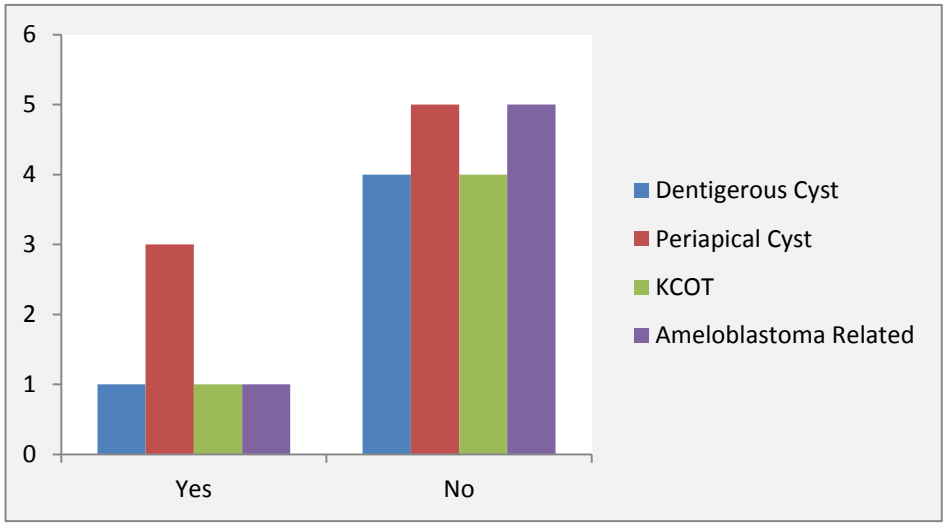


CHART 16: INVOLVEMENT OF NASOPALATINE FORAMEN

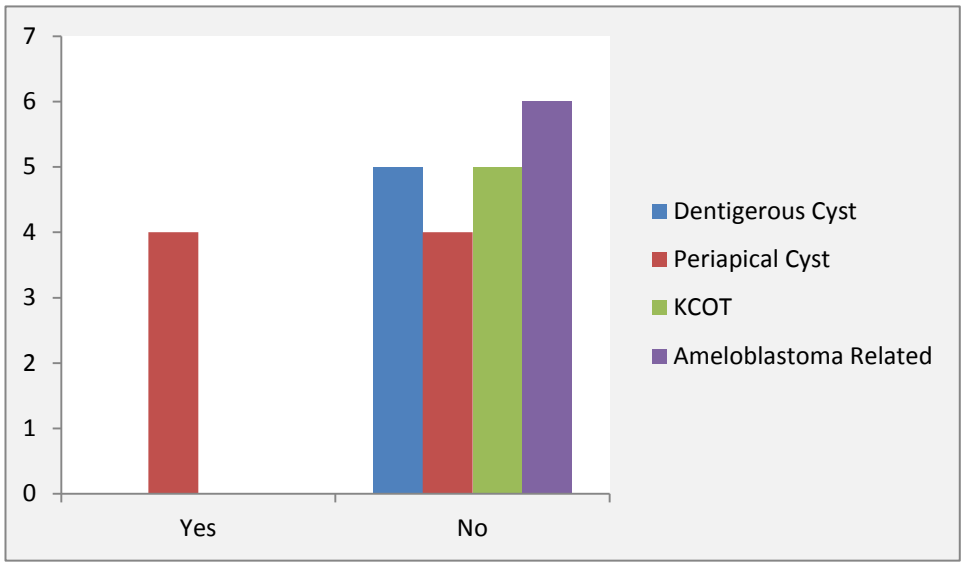


CHART 17: INVOLVEMENT OF MANDIBULAR CANAL

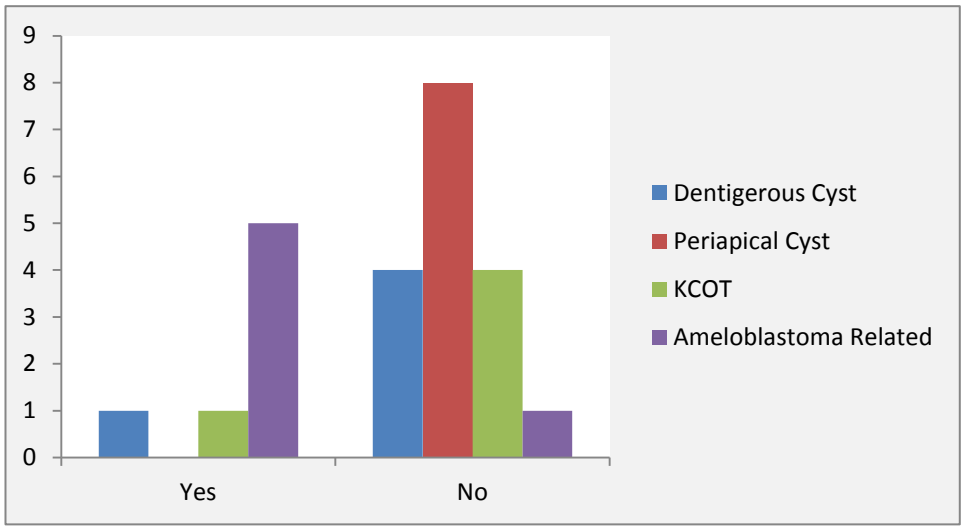
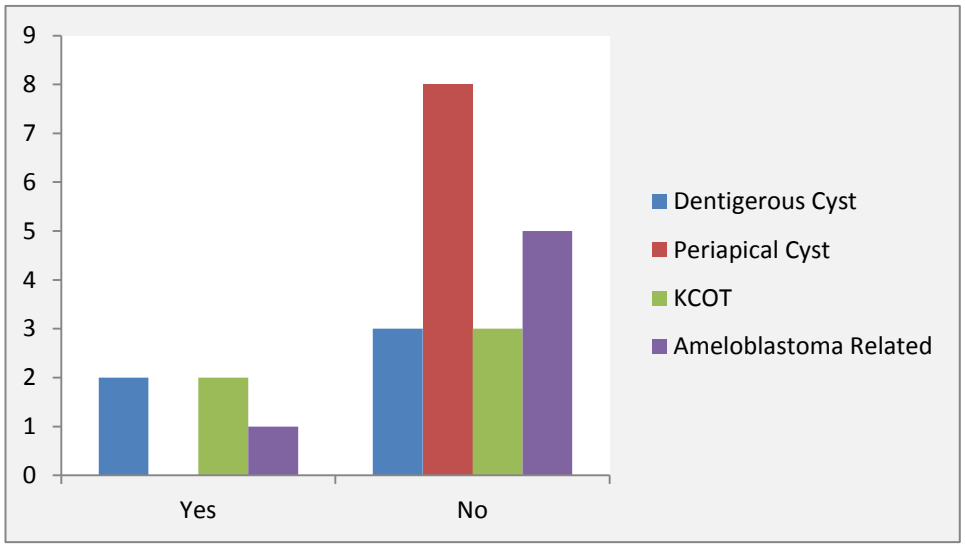


CHART 18: INVOLVEMENT OF MENTAL FORAMEN



RESULTS AND OBSERVATIONS

This clinical study was conducted among the patients attending the Department of Oral Medicine and Radiology, Tamilnadu Government Dental College and Hospital. In the present study, totally 24 cases were included and were provisionally diagnosed using clinical examination, conventional radiography and CBCT as either being an odontogenic cyst or odontogenic tumor. These were then subjected to a histopathological examination to establish the final diagnosis. Cases diagnosed were seen to be belonging to 4 sub classes of odontogenic cysts and tumors- Dentigerous Cyst, Periapical Cyst (including Residual Cyst), Keratocystic Odontogenic Tumor (KCOT) and Ameloblastoma related (Unicystic & multicystic variety) . The distribution is depicted in **Table 1 and Chart 1.** These results were found to be not significant statistically (p= 0.752). Hence there is no statistical difference between CBCT and histopathology when it comes to diagnosing the 4 groups of lesions.

Table 2 showing the age of distribution of the cases. Mean age of patients with Dentigerous Cyst, Periapical Cyst, KCOT and Ameloblastoma related was 28.4, 37, 29.6, 26.6 years respectively.

Table 3 and Chart 2 showing the distribution of the various lesions based on gender. Of the 24 cases, 18 were males and 6 females. In cases of Dentigerous Cyst 4 were males and 1 was a female patient. In Periapical Cyst 7 were males and 1 was female. In KCOT 3 were males and 2 females. In the Ameloblastoma Related 4 were males and 2 were females.

Table 4 Chart 3 showing the site predilection for each lesion. Of the 5 cases of dentigerous cyst seen, 3 cases were seen in the posterior region (distal to canine)

and 2 were seen across posterior and anterior segments. 3 of the 5 cases occurred in maxilla and the rest in mandible. 6 out of 8 cases of periapical cyst were seen in the anterior maxilla. 3 out of 5 cases of KCOT were seen in the mandible across the anterior and posterior segments. 5 out of 6 cases of Ameloblastoma were seen in the posterior mandible and 1 was seen in the anterior maxilla. **This distribution of cases based on site was found to be statistically significant (p= 0.019).**

Table 5 and Chart 4 depict the mean of maximum mesio- distal dimensions of the lesions in the axial section (A) which was found to be an average of 37.20 mm for all lesions. Ameloblastoma group had a mean measurement of 49.95 mm which was found to be more than the Dentigerous cyst group at 42.96 mm which in turn was more than KCOT group at 34.56 mm and finally the least was in the case of Periapical cyst at 27.96 mm. On one way ANOVA analysis**, these differences of means was found to be statistically significant (p=0.011).** The Post Hoc Test (Tukey HSD) revealed the difference to be between the **periapical cyst and ameloblastoma groups (p=0.011).**

Table 6 and Chart 5 depict the mean of maximum bucco- lingual width of the lesions in the axial section (B) which was found to be an average of 27.42 mm for all lesions. In decreasing order of frequency they were, Ameloblastoma group 36.43 mm, dentigerous cyst 29.44 mm, periapical cyst 25.00 mm and KCOT 18.50 mm. This difference was found to not be statistically significant (p= 0.058). The Post Hoc Test (Tukey HSD) revealed the **difference to be between the KCOT and ameloblastoma groups (p=0.045).**

Table 7 and Chart 6 depict the mean ratio of A: B which was an average of 1.466 for all the lesion types. In decreasing order of frequency these were, KCOT

2.014, dentigerous cyst 1.526, ameloblastoma 1.390 and finally periapical cyst at 1.142. **This difference in mean ratios of A: B was found to be statistically significant (p= 0.035).** The Post Hoc Test (Tukey HSD) revealed the difference to be between **the periapical cyst and KCOT groups (p=0.021).**

Table 8 and Chart 7 depict the cases where expansion of the buccal and/or lingual cortical plates was seen. Of the 24 cases 23 cases had caused expansion of the cortical plates except 1 case of periapical cyst. This result was found to be not statistically significant (p= 0.555).

Table 9 and Chart 8 depict the cases where perforation of the buccal and/or lingual cortical plates was seen. Of the total 24 cases, 20 showed perforation. 3 cases of periapical cyst and 1 case of dentigerous cyst did not show any perforation in any of the CBCT sections. This result was found to be not statistically significant (p= 0.192).

Table 10 and Chart 9 depict the lesions where displacement of adjacent teeth was seen. Of the 5 cases of dentigerous cyst 2 showed displacements, out of 8 cases of periapical cyst 4 showed displacements, out of 5 cases of KCOT displacement was seen in 3 cases and finally of the 6 cases of the ameloblastoma group, displacement of teeth was seen in 5 cases. This result was found to be not statistically significant (p= 0.481).

Table 11 and Chart 10 depict cases where an impacted tooth was found to be associated with the lesion in question. All 5 cases of dentigerous cysts were seen to be associated with an impacted tooth whereas none of the 8 cases of periapical cyst were found to be associated with one. 2 out of 5 cases of KCOT and 4 out of 6 cases of the

ameloblastoma group were found to be associated with an impacted tooth. **This difference was found to be statistically different (p= 0.003).**

Table 12 and Chart 11 depict cases based on the locularity of the lesions. Cases were evaluated as to either being unilocular or multilocular on the CBCT images. 2 out of 5 cases of dentigerous cyst, 1 of the 8 periapical cysts, 2 of the 5 KCOT lesions and 2 of the 6 cases of ameloblastoma had multilocular lesions. This result was found to be not statistically significant (p= 0.638).

Table 13 and Chart 12 depict cases where resorption of the adjacent teeth was seen due to the growing lesion. 20 of the total sample of 24 cases showed evidence of resorption of adjacent teeth. 3 of the 8 cases of periapical cyst and 1 of the 6 cases of ameloblastoma group did not show any resorption. This result was found to be not statistically significant (p= 0.212).

Table 14 and Chart 13 depict the lesions based on the internal density. 5 of the total 24 cases appeared to be not homogenously radiolucent on the CBCT sections. Here 1 case of dentigerous cyst of the total 5 and 2 cases of KCOT and ameloblastoma each of a total 5 and 6 respectively were seen to have some evidence of presence of radiopaque structures within the lesion rendering them with a mixed lucency. This result was found to be not statistically significant (p= 0.285).

Table 15 and Chart 14 depict lesions where there was involvement of the maxillary sinus by the lesions. Involvement here means pushing/ perforating/ involving the structure in question. 3 of a total 5 cases of dentigerous cysts, 3 of 8 periapical cysts, 2 of 5 KCOT cases and 1 of 6 cases of ameloblastoma group showed evidence of some involvement of the maxillary sinus. This result was found to be not statistically significant (p= 0.531).

Table 16 and Chart 15 depict lesions where involvement of nasal fossa was seen. 1 of 5 cases of dentigerous cyst, 3 of 8 cases of periapical cyst, 1 of 5 cases of KCOT and 1 of 6 cases of ameloblastoma showed involvement of the nasal fossa. This result was found to be not statistically significant (p= 0.796).

Table 17 and Chart 16 depict lesions where there was involvement of the nasopalatine foramen. Of the total 24 cases, only 4 cases of periapical cyst showed involvement of this vital structure. **This result was found to be statistically significant (p= 0.022).**

Table 18 and Chart 17 depict lesions with evidence of involvement of the mandibular canal. 1 of the 5 dentigerous cysts, 1 of 5 cases of KCOT and 5 of 6 cases of the ameloblastoma group showed evidence of involvement of the mandibular canal. **This result was found to be statistically significant (p= 0.007).**

Table 19 and Chart 18 depict involvement of the mental foramen by the various lesions. 2 of 5 cases of dentigerous cyst, 2 of 5 cases of KCOT and 1 of 6 cases of ameloblastoma group showed evidence of involvement of the mental foramen. This result was found to be not statistically significant (p= 0.222).

Sensitivity and Specificity analysis for CBCT keeping histopathology as the gold standard revealed that in case of dentigerous cysts the Sensitivity was 100%, Specificity 84.2%, Positive Predictive Value (PPV) 62.5% and Negative Predictive Value (NPV) 100%, as depicted in **Table 20.**

Sensitivity and Specificity analysis in case of periapical cysts revealed that Sensitivity was 100%, Specificity 100%, Positive Predictive Value (PPV) 100% and Negative Predictive Value (NPV) 100%, as depicted in **Table 21.**

Sensitivity and Specificity analysis in case of KCOT revealed that Sensitivity was 75%, Specificity 100%, Positive Predictive Value (PPV) 100% and Negative Predictive Value (NPV) 95.23%, as depicted in **Table 22.**

Sensitivity and Specificity analysis in case of Ameloblastoma group revealed that Sensitivity was 66.7%, Specificity 100%, Positive Predictive Value (PPV) 100% and Negative Predictive Value (NPV) 90%, as depicted in **Table 23.**

DISCUSSION

Radiology is important in the diagnostic assessment, treatment planning and follow-up of patients suspected of having dental and maxillofacial lesions [1]. Several intraoral and extraoral radiographic methods such as periapical, occlusal, panoramic, and motion tomography are commonly available for evaluation of those patients. However, some of the drawbacks of these techniques are superimposition, poor visualization, and distortion of other anatomic structures. Nowadays, MDCT and CBCT provide the most accurate modalities for preoperative evaluation of the maxillofacial region [72].

Hashimoto et al. [74] concluded that for tooth and bone structures CBCT was considered to have yielded higher image quality and reproducibility than 4-row MDCT. This could be attributed to the improvement in the image receptors (from CMOS and image intensifier sensors to CCD and flat panel detectors), availability of flexible fields of view and better reconstruction algorithms and a host of software features which help in the image data analysis.

This study was conducted to evaluate the CBCT features in preoperative radiological evaluation of odontogenic cysts and tumors and this was in line with **Nakagawa et al.** [75] who reported that preoperative radiological evaluation of odontogenic lesions avoids surgical complications, post-surgical functional impairment, and reduces surgical stress. **Kobayashi et al.** [76] reported that a deeper knowledge of the diagnostic accuracy potential of different radiological modalities and their application will allow optimization of the preoperative planning.

Preoperative differentiation between these tumors is important, because ameloblastomas usually require resection [77].

A total of 24 odontogenic cysts and odontogenic tumors were assessed in the study. Out of the 24 patients, 13 (54.17%) patients had odontogenic cysts, 5 Dentigerous cysts (20.83%) and 8 Periapical Cysts (33.33%) and 11 (45.83%) patients had odontogenic tumors, 5 KCOT (20.83%) and 6 Ameloblastoma (25%) (Table 1 and Chart 1). All patients had only one lesion each and no patient with multiple cysts/ tumors was encountered. In the study by **N Johnson et al. (2014)** [78] there were 54.6% radicular cysts, 20.6% dentigerous cysts, 14.3% keratocystic odontogenic tumors and 36.9% ameloblastomas. The most frequent odontogenic cyst and tumor were the radicular cyst and ameloblastoma respectively. In the present study too, among the cysts the periapical/ radicular cyst and among the tumors the ameloblastomas were found to be in maximum frequency. This is also similar to the studies by **Jones et al.** (8) and **Daley et al.(1994)** [9].

The patients in the present study fell into the age group ranging from 5 to 61 years (mean age = 31.08 years) (Table 2, 3 and Chart 2). This is in agreement with the studies done by **Servato et al. (2013)** [35]. In the present study the mean age of the Dentigerous cyst group was 28.4 years and 37 years in case of Periapical cysts. KCOT and Ameloblastoma groups were found to be 29.6 and 26.6 years respectively (Table 2). This is also similar to the studies by **Roggan et al.** [12] and **Daley et al.** [15].

This prospective study included 24 patients (18 males and 6 females) with primary untreated pathologically proven odontogenic cysts and tumors. In cases of Dentigerous Cyst 4 were males and 1 was a female patient. In Periapical Cyst 7 were males and 1 was female. In KCOT 3 were males and 2 females. In the Ameloblastoma

Related 4 were males and 2 were females. This is in agreement with the studies done by **Shear et al.** [19], **Jones et al.** [11], **Servato et al.** [35] and **Mourshed's** US sample [16].

3 of the 5 cases of Dentigerous cysts occurred in maxilla and the rest in mandible. 6 out of 8 cases of periapical cyst were seen in the anterior maxilla. This site predilection is case of periapical cysts is similar to as reported by **Jones et al.** (2006) [11] and **Shear et al.** [19]. 3 out of 5 cases of KCOT were seen in the mandible across the anterior and posterior segments. This is in accordance with reports by **Sansare et al.** (2013) [39] who also stated that KCOT was predominantly seen in the mandible. 5 out of 6 cases of Ameloblastoma were seen in the posterior mandible and 1 was seen in the anterior maxilla. This was again in accordance in studies by **Reichart PA et al.** (1995) [40] who gave a mandibular to maxillary ratio of 5: 1 This distribution of cases based on site was found to be statistically significant in our present study (p= 0.019).

M. Shweel et al. [72] reported that there was no significant statistical difference between CBCT and MDCT regarding linear measurement of odontogenic cysts and tumors and were correlated with intraoperative measurements. In the present study the mesio- distal (A) and bucco- lingual (B) dimensions of the lesions in the axial planes were measured and their ratio was calculated (Tables 5, 6, 7 and Charts 4, 5, 6). The differences in the mean mesio- distal dimension and the ratio of A: B was found to be statistically significant (p= 0.011 and 0.035 respectively).This was in accordance with the study by **Tanaka et al.** [47]. Statistics revealed the difference between the periapical cyst and ameloblastoma groups was particularly significant (p=0.011). This can be helpful to differentiate these lesions based on CBCT.

The mean maximum bucco- lingual width of the lesions (B) was found to be an average of 27.42 mm for all lesions. Statistics revealed the difference to be between the KCOT and ameloblastoma groups (p=0.045). This is contrary to the study by **Tanaka et al.** [47] who stated that it was difficult to differentiate KCOT and Ameloblastoma but in accordance with studies by **Y. Ariji et al.** [79] and **Apajalahti et al.** [77]

Of the 24 cases 23 cases had caused expansion of the cortical plates except 1 case of periapical cyst. The vast majority of the KCOTs demonstrated only minimal cortical expansion. This finding is in agreement with earlier reports demonstrating the tendency of KCOTs to grow along the long axis of the body of the mandible [80] and is an important differential diagnostic characteristic of KCOT although this was not found to be statistically significant in the present study. This result was contrary to that reported by **Y. Ariji et al.** [79] and **Tanaka et al.** [47] who stated KCOT and Dentigerous cysts do not tend to expand cortical bone but was in accordance in case of Ameloblastoma.

Of the total 24 cases, 3 cases of periapical cyst and 1 case of dentigerous cyst did not show any perforation in any of the CBCT sections. **Rudolf et al.** [81] reported that CBCT could detect smaller bone defects than MDCT. **Vasconcelos et al.** [82] concluded that CBCT was the only method that allowed for an analysis of the buccal and lingual/palatal surfaces and for improved visualization of the morphology of the defect. This result was in accordance with **Singer et al.** [60] when it came to Ameloblastomas.

Of the 5 cases of dentigerous cyst 2 showed displacements, out of 8 cases of periapical cyst 4 showed displacements, out of 5 cases of KCOT displacement was

seen in 3 cases and finally of the 6 cases of the ameloblastoma group, displacement of teeth was seen in 5 cases. This is in accordance with studies by **Singer et al.** [60] and **M. Ahmad et al.** [61].

In the present study, as would be obvious, all 5 cases of dentigerous cysts were seen to be associated with an impacted tooth whereas such wasn't the case with the periapical cysts. 2 out of 5 cases of KCOT and 4 out of 6 cases of the ameloblastoma group were found to be associated with an impacted tooth. This difference was found to be statistically different (p= 0.003). This was found to be in accordance with studies by **Shear et al.** [6 19 80] and **Philipsen et al.** [41].

2 out of 5 cases of dentigerous cyst, 1 of the 8 periapical cysts, 2 of the 5 KCOT lesions and 2 of the 6 cases of ameloblastoma had multilocular lesions. This was in accordance with studies by **Tanaka et al.** [47] and **M. Ahmad et al.** [61]. As stated by **Philipsen and Reichart (1998)** [41], in the present study too the unilocular pattern was found to be more common than the multilocular, especially in cases associated with tooth impaction.

A characteristic feature of ameloblastoma is its tendency to cause distinct root resorption [83]**.** 20 of the total sample of 24 cases showed evidence of resorption of adjacent teeth. 3 of the 8 cases of periapical cyst and 1 of the 6 cases of ameloblastoma group did not show any resorption. This is in accordance with studies by **MacDonald-Jankowski DS et al.** [83], but not with **Apajalahti et al.** [77]. **Y Ariji et al.** [79] who stated that resorption was common in Ameloblastoma and rare in KCOT.

5 of the total 24 cases appeared to be not homogenously radiolucent on the CBCT sections. Here 1 case of dentigerous cyst and 2 cases of KCOT and ameloblastoma each were seen to have some evidence of presence of radiopaque

structures within the lesion rendering them with a mixed lucency. The pattern of radiopacity was not established with all cases showing septae within the lesions. This was supported by **Nakagawa et al.** [75] reported that CBCT clearly visualized the internal structure of the mandibular tumor.

In the present study, CBCT showed no statistically significant difference in assessment of effect of odontogenic lesions on surrounding structures like the involvement of the maxillary sinus, involvement of nasal fossa and the mental foramen. But in cases of involvement of the nasopalatine foramen and the mandibular canal the results were significant. These differences here maybe seen due to the site distribution and the prevalence of a particular group of lesions in particular areas of the jaws.

As was stated by **Philipsen and Reichart (1998)** [41], in the present study, in the Ameloblastoma group the unilocular pattern was found to be more common than the multilocular, especially in cases associated with tooth impaction. Location wise the lesion seemed to favour the mandible more than the maxilla. 66% of cases were associated with tooth impaction, the mandibular third molar being most often involved. Histologically, the minimum criterion for diagnosing a lesion as UA is the demonstration of a single cystic sac lined by odontogenic (ameloblastomatous) epithelium often seen only in focal areas.

Sensitivity and Specificity analysis was done for CBCT keeping histopathology as the gold standard in diagnosing the specific group of lesions. This revealed that CBCT was 100% sensitive in diagnosing cases of dentigerous cysts and periapical cysts and 75% and 66.7% in case of KCOT and Ameloblastomas

respectively. CBCT was found to be 100% specific in diagnosing Periapical cysts, KCOT and Ameloblastoma.

The positive and negative predictive values (PPV and NPV respectively) are the proportions of positive and negative results in statistics and diagnostic tests that are true positive and true negative results [84]. A high result can be interpreted as indicating the accuracy of such a statistic. The Positive Predictive Value (PPV) was 100% in cases of Periapical cysts, KCOT and Ameloblastoma group. This indicates CBCT is very good when it comes to correctly diagnosing whether these conditions are actually present or not. The Negative Predictive Value (NPV) was 100% in cases of Dentigerous cysts and Periapical cysts. This indicates that CBCT was very good in providing information on when actually these conditions were not present in a patient. These findings appear high probably because of the small sample size of the study.

In the present study, CBCT showed no statistically significant difference in assessment of these odontogenic lesions in terms of bucco- lingual dimensions, expansion and perforation of cortical plates, displacement and resorption of adjacent teeth, locularity and internal density of the lesion, and in terms of involvement of the maxillary sinus, nasal fossa and mental foramen ($p<0.005$). However there was an overall higher accuracy (statistically significant, $p<0.005$) for CBCT for the diagnosis based on site, measurement of mesio- distal dimension, ratio of A: B, presence of impacted tooth and in cases of involvement of the nasopalatine foramen and mandibular canal.

The advantage of low effective dose for CBCT due to using a small FOV has limitation in the form of increased artifacts and lack of beam-hardening correction.

SUMMARY AND CONCLUSION

This study was conducted to evaluate the CBCT features in preoperative radiological evaluation of odontogenic cysts and tumors. This prospective study included 24 patients (18 males and 6 females) with primary untreated pathologically proven odontogenic cysts and tumors Out of the 24 patients, 13 had odontogenic cysts (5 Dentigerous cysts and 8 Periapical Cysts) and 11 had odontogenic tumors (5 KCOT and 6 Ameloblastoma). The patients in the present study fell into the age group ranging from 5 to 61 years. The difference in maximum mesio- distal dimension between the periapical cyst and ameloblastoma groups was significant (p= 0.011) and so was difference in maximum bucco- lingual dimension between the KCOT and ameloblastoma groups (p=0.045). This study revealed that CBCT was 100% sensitive in diagnosing cases of dentigerous cysts and periapical cysts and was found to be 100% specific in diagnosing Periapical cysts, KCOT and Ameloblastoma.

These findings in the present study appear high probably because of the small sample size and are in no way undermining the diagnostic efficiency of the histopathology test which serves as the gold standard. CBCT diagnosis was not solely based on the imaging findings but was helped by the clinical and conventional radiological examination as well, which are always the initial modalities to evaluate a patient. But again, CBCT here appears to be a great adjunctive diagnostic test with very promising results and further studies are needed with a much larger sample size to correctly confirm our findings.

Apart from diagnosing, going by way of aim of the study, CBCT appears to be excellent when it comes to preoperative assessment of odontogenic cysts and tumors. It gives a clear visualisation of the lesion in question, its margins and relationship to

the adjacent structures in all three planes and the 3 D reformatted images. This information proves to be vital since most of these lesions grow to a large size before being diagnosed and hence any surgical treatment (enucleation, resection etc.) can cause considerable loss of tissue to the patient affecting his/ her further management and rehabilitation.

In the present study CBCT was very helpful in good preoperative planning and preparation as it helped in deciding the best approach for lesion enucleation and the incisions were precise to include the lesions. It allowed a careful assessment of the relationship between the large lesions and close vital structures such as maxillary sinus, nasal cavity, and mandibular neurovascular bundle. These findings are consistent with previous studies that described the preoperative application of cone beam computed tomography as an assessment tool before oral surgeries. **Marques et al.** [85] reported that CBCT provided the surgeon with vital information necessary for planning surgery. **Nakagawa et al.** [75] reported that cone beam CT accurately assessed the relationship between the lesions and their adjacent anatomical structures, it was useful in estimating the relationship of the lesion to the adjacent teeth and nasal floor and gave superior information for preoperative evaluation of dentoalveolar surgery.

In the study it was found that CBCT had inferior soft tissue contrast resolution. This was in accordance with **Suomalainen A et al.** [86] who reported that flat-panel detector, significant scattering effect and lack of beam-hardening correction explained inferior soft tissue contrast resolution and overall decreased image quality of CBCT relative to that of MDCT. The observed advantages of CBCT included: low cost, easy accessibility and low radiation dose, submillimeter resolution, high speed scanning and comfortable patient position, and its disadvantage included inferior soft tissue contrast resolution.

Limitations in the present study lie on the small sample size, limited fields of view, high radiation exposure to patients and correlation of duration of lesion with lesion dimensions. Image analysis done by two radiologists at the same sitting with consensus, may result in lack of inter-observer variability testing. The significant imaging features contributing to a correct diagnosis according to logistic regression analysis was not done.

In the overall preoperative radiological assessment of odontogenic cysts and tumors, CBCT was accurate in diagnosis based on site, measurement of mesio- distal dimension, ratio of A: B, presence of impacted tooth and in cases of involvement of the nasopalatine foramen and mandibular canal. It is a reliable tool for pre- operative radiological assessment of odontogenic cyst and tumors.

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INSTITUTIONAL ETHICAL COMMITTEE

Tamil Nadu Government Dental College and Hospital, Chennai - 3
Telephone No. 044 2534 0343
Fax 044 2530 0681

Ref.No.0430/ DE/ 2010 Date: 21.02.2014

Title of the work: "Cone beam computed tomography in pre- operative analysis of odontogenic cysts and tumours of the maxillofacial region"

Principal investigator: **Dr.Aatman Sharma,**
II Year MDS

Department : Oral Medicine and Radiology,
Tamil Nadu Government Dental College and Hospital, Chennai - 3

The request for an approval from the Institutional Ethical Committee (IEC) considered on the IEC meeting held on **29.01.2014** at the Principal's Chambers Tamil Nadu Government Dental College and Hospital, Chennai – 3

"Advised to proceed with the study"

The Members of the Committee, the secretary and the Chairman are pleased to approve the proposed work mentioned above , submitted by the principal investigator.

The principal investigator and their team are directed to adhere the guidelines given below:

1 .You should get detailed informed consent from the patients / participants and maintain confidentiality

2. you should carry out the work without detrimental to regular activities as well as without extra expenditure to the Institution or Government.

3 You should inform the IEC in case of any change of study procedure , site and investigation or guide.

4. You should not deviate from the area of work for which you have applied for ethical clearance

5. You should inform the IEC immediately in case of any adverse events or serious adverse reactions. You should abide to the rules and regulations of the institution (s)

6. You should complete the work within the specific period and if any extension of time is required, you should apply for permission again and do the work.

7 .You should submit the summary of the work to the ethical committee on completion of the work.

8. You should not claim funds from the Institution while doing the work or on completion.

9.You should understand that the members of IEC have the right to monitor the work with prior intimation

10. Your work should be carried out under the direct supervision of your Guide / Professor.

21/02/14.

SECRETARY **CHAIRMAN**

INFORMATION SHEET

- We are conducting a study on **"CONE BEAM COMPUTED TOMOGRAPHY IN PRE- OPERATIVE ANALYSIS OF ODONTOGENIC CYSTS AND TUMOURS OF THE MAXILLOFACIAL REGION".** For that study, we are selecting patients.
- The purpose of this study is to analyse the various benign odontogenic cysts and tumours using cone beam computed tomography.
- The identity of the patients participating in the research will be kept confidential throughout the study. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared.
- Taking part in the study is voluntary. You are free to decide whether to participate in the study or to withdraw at any time; your decision will not result in any loss of benefits to which you are otherwise entitled.
- The results of the special study may be intimated to you at the end of the study period or during the study if anything is found abnormal which may aid in the management or treatment.

Name of the patient Signature / Thumb impression

Name of the investigator Signature
Date

INFORMED CONSENT FORM

STUDY TITLE:

"CONE BEAM COMPUTED TOMOGRAPHY IN PRE- OPERATIVE ANALYSIS OF ODONTOGENIC CYSTS AND TUMOURS OF THE MAXILLOFACIAL REGION"

Name: O.P.No:

Address: Serial No:

Age / Sex:

Tel. no:

I, _____age____years
Exercising my free power of choice, hereby give my consent to be included as a participant in the
"CONE BEAM COMPUTED TOMOGRAPHY IN PRE- OPERATIVE ANALYSIS OF ODONTOGENIC CYSTS AND TUMOURS OF THE MAXILLOFACIAL REGION" I agree to the following:

- I have been informed to my satisfaction about the purpose of the study and study procedures including investigations to monitor and safeguard my body function.
- I agree to give my full participation for the study.
- I agree to cooperate fully and to inform my doctor immediately if I suffer any unusual symptom.
- I agree to report to the doctor for a regular follow-up as and when required for the research.
- I hereby give permission to use my medical records for research purpose. I am told that the investigating doctor and institution will keep my identity confidential.

Name of the patient Signature / Thumb impression

Name of the investigator Signature Date

DEPARTMENT OF ORAL MEDICINE AND RADIOLOGY,

TAMIL NADU GOVERNMENT DENTAL COLLEGE AND HOSPITAL,

CHENNAI- 600 003

PROFORMA

"CONE BEAM COMPUTED TOMOGRAPHY IN PRE- OPERATIVE ANALYSIS OF ODONTOGENIC CYSTS AND TUMOURS OF THE MAXILLOFACIAL REGION"

Patient's name :

Age/sex :

Contact address :

Contact number :

Occupation :

Income :

Institution : Tamil Nadu Government Dental College and Hospital,

Chennai- 600 003.

Centre Dept. of Oral Medicine and Radiology,

Tamil Nadu Govt. Dental College and Hospital,

Chennai- 600 003.

Patient's Dental OPD No. : Date :

Chief complaint :

Medical history :

Clinical examination :

Radiographic investigation :

Panoramic radiograph findings:

CBCT findings :

1. Location
2. Size (mm)
3. Number of locules- Unilocular □
   Multilocular □
4. Bone expansion
5. Bone perforation
6. Internal density
7. Displacement of teeth
8. Resorption of teeth
9. Impacted tooth
10. Involvement of proximal structures

Histopathological report:

Inferences :

Signature of PG student Signature of Guide

Date:

TRIPARTITE AGREEMENT

This agreement herein after the "Agreement" is entered into on this day ……. between the Tamil Nadu Government Dental College and Hospital represented by its **Principal** having address at Tamil Nadu Government Dental College and Hospital, Chennai- 600 003 , (hereinafter referred to as, 'the college')

And

Dr. S. JAYACHANDRAN, M.D.S., PhD., aged 50 years working as **Professor** in Department of Oral medicine and Radiology at the college, having residence address at A.M -16, TNHB quarters, Tod Hunter Nagar, Saidapet, Chennai – 15.(herein after referred to as the 'Principal Investigator')

And

Dr. AATMAN SHARMA, aged 26 years currently studying as final year **Post graduate student** in the Department of Oral Medicine and Radiology, Tamil Nadu Government Dental College and Hospital, Chennai -3 (hereafter referred to as the 'PG and co- investigator') residing at no. 4259, Vasant Kunj, B- 5&6, New Delhi- 10.

Whereas the 'PG student as part of her curriculum undertakes to research on **"CONE BEAM COMPUTED TOMOGRAPHY IN PRE- OPERATIVE ANALYSIS OF ODONTOGENIC CYSTS AND TUMOURS OF THE MAXILLOFACIAL REGION"** for which purpose the Principal investigator shall act as Principal investigator and the College shall provide the requisite infrastructure based on availability and also provide facility to the PG student as to the extent possible as a Co-investigator

Whereas the parties, by this agreement have mutually agreed to the various issues including in particular the copyright and confidentiality issues that arise in this regard

Now this agreement witnessed as follows:

1. The parties agree that all the Research material and ownership therein shall become the vested right of the college, including in particular all the copyright in the literature including the study, research and all other related papers.
2. To the extent that the college has legal right to do go, shall grant to license or assign the copyright so vested with it for medical and/or commercial usage of interested persons/entities subject to a reasonable terms/conditions including royalty as deemed by the college.

3. The Royalty so received by the college shall be shared equally by all the three parties.
4. The PG/Research student and PG/Principal Investigator shall under no circumstances deal with the copyright, Confidential information and know-how-generated during the course of research/study in any manner whatsoever, while shall sole west with the college.
5. The PG student and Principal Investigator undertake not to divulge (or) cause to be divulged any of the confidential information or, know-how to anyone in any manner whatsoever and for any purpose without the express written consent of the college.
6. All expenses pertaining to the research shall be decided upon by the principal investigator/Co-investigator or borne sole by the PG student.(co-investigator)
7. The college shall provide all infrastructure and access facilities within and in other institutes to the extent possible. This includes patient interactions, introductory letters, recommendation letters and such other acts required in this regard.
8. The Principal Investigator shall suitably guide the Student Research right from selection of the Research Topic and Area till its completion. However the selection and conduct of research, topic and area research by the Student Researcher under guidance from the Principal Investigator shall be subject to the prior approval, recommendations and comments of the Ethical Committee of the College constituted for this purpose.
9. It is agreed that as regards other aspects not covered under this agreement, but which pertain to the research undertaken by the PG student, under guidance

from the Principal Investigator, the decision of the College shall be binding and final.

10. If any dispute arises as to the matters related or connected to this agreement herein, it shall be referred to arbitration in accordance with the provisions of the Arbitration and Conciliation Act, 1996.

In witness where of the parties herein above mentioned have on this the day month and year herein above mentioned set their hands to this agreement in the presence of the following two witnesses.

College represented by its **Principal** **PG Student**

Witnesses **Student Guide**

1.

2.

ஆராய்ச்சி தகவல் தாள்

தாடையில் வரும் புற்றுநோய் மற்றும் நீர் கட்டியை கூம்பு வளைவு வரைக்கற்றை மூலம் சிகிச்சைக்கு முன் செய்யப்படும் ஆராய்ச்சி செய்யும் பொருட்டு தமிழ்நாடு அரசு பல் மருத்துவக் கல்லூரி மற்றும் மருத்துவமனைக்கு வரும் நோயாளிகளை நாங்கள் தேர்வு செய்கிறோம்.

இந்த ஆராய்ச்சியில் பங்கேற்கும் நோயாளிகளின் விபரங்கள் ஆய்வு முடிவும் வரை இரகசியமாக வைக்கப்படும். ஆராய்ச்சியின் முடிவு பற்றிய பாதிப்புகள் அல்லது வெளியீடுகள் யாருடைய தனிப்பட்ட விவரங்களும் பகிர்ந்து கொள்ளப்படமாட்டாது.

இந்த ஆராய்ச்சியில் பங்கேற்கும் உங்கள் முடிவு தன்னிச்சையானது. இந்த ஆராய்ச்சியில் பங்கேற்கும் நீங்கள் எந்தநேரத்திலும் விலகிக் கொள்வதற்கும் உங்களுக்கு வாய்ப்பு உள்ளது. உங்கள்ின் இந்த தீர்மானத்தினால் உங்களுக்கு இம்மருத்துவமனையில் வழங்கப்படும் பயன்களில் எவ்வித மாற்றமும் இருக்காது.

இந்த சிறப்பு ஆய்வின் முடிவுகள், இந்த ஆய்வின் முடிவில் அல்லது ஆய்வின்போது ஏற்படும் எதிர்மறையான விளைவுகளை அந்நோயாளிகளின் நலன்கருதியோ அல்லது சிகிச்சையளிக்கும் பொருட்டோ நோயாளிக்கு தெரிவிக்கப்படும்.

ஆய்வாளரின் கையொப்பம் **பங்கேற்பாளர் கையொப்பம்**

தேதி :
இடம் :

சுய ஒப்புதல் படிவம்

<u>ஆய்வு செய்யப்படும் தலைப்பு</u>

தாடையில் வரும் புற்றுநோய் மற்றும் நீர் கட்டியை கூம்பு வளைவு வரைக்கற்றை மூலம் சிகிச்சைக்கு முன் செய்யப்படும் ஆராய்ச்சி

ஆராய்ச்சி நிலையம் : அரசு பல் மருத்துவக் கல்லூரி
சென்னை - 600 003

பங்கு பெறுபவரின் பெயர் :

பங்கு பெறுபவரின் எண் :

பங்கு பெறுவரின் பிறந்த தேதி : _____ / _____ /_____
தேதி மாதம் வருடம்

இந்த ஆராய்ச்சி சம்பந்தமாக நான் மேலே கூறப்பட்ட தகவல் படிவத்தை முழுமையாக படித்துப் பார்த்தேன் என்று உறுதி கூறுகிறேன்.

நான் இது தொடர்பான அனைத்து கேள்விகளுக்கும் நிறைவான பதில்கள் பெறப்பட்டேன்.

இந்த ஆய்வின் எனது பங்கு தன்னிச்சையானது என்றும் எந்த நேரத்திலும் இந்த ஆய்வில் இருந்து சட்ட உரிமைகள் பாதிக்கப்படாமல் விலகிக் கொள்ள சம்மதிக்கிறேன்.

மருத்துவ ஆய்வு அதிகாரிகள், எனது சிகிச்சை தொடர்பான பதிவேடுகளை பார்வையிடவும் எந்த நேரத்திலும், ஆய்வில் இருந்து நான் விலகினாலும் பார்வையிட சம்மதிக்கிறேன். எனது அடையாள குறிப்புகள் மூன்றாவது நபருக்கு தெரிவிக்கப்படமாட்டாது என்று புரிந்து கொண்டேன்.

இந்த ஆய்வு அறிக்கைகளை பயன்படுத்தவும், வெளியிடவும், நான் சம்மதிக்கிறேன். ஆய்வாளர் எனது மருத்துவக் குறிப்புகளை வெளியிட தடையாக இருக்கமாட்டேன் என உண்மையாக சம்மதிக்கிறேன்.

பங்கேற்பவரின் கையொப்பம் ..... இடம்..... தேதி.....

கட்டைவிரல் ரேகை

பங்கேற்பவரின் பெயர் மற்றும் விலாசம் .....

ஆய்வாளரின் கையொப்பம் ..... இடம்..... தேதி.....

ஆய்வாளரின் பெயர் .....