

**ASSESSMENT OF DIAGNOSTIC IMAGING MODALITIES
UTILIZED IN THE DIAGNOSIS OF THE ODONTOGENIC
MYXOMA**

EMAN AHMED KHEIR



A minithesis submitted in partial fulfilment of the requirements for the degree of Master of Sciences in Dental Sciences in the Department of Oral Medicine and Periodontics, Faculty of Dentistry University of the Western Cape

Supervisor: Professor LXG. Stephen
Co-supervisors: Professors CJ Nortjé and LJ van Rensburg

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Assessment of Diagnostic Imaging Modalities Utilized In Diagnosis of Odontogenic Myxoma

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Recurrence



ABSTRACT

Assessment of Diagnostic Imaging Modalities Utilized in Diagnosis of Odontogenic Myxoma

Eman Kheir

MSc (Dent) minithesis, Department of Oral Medicine and Periodontics, University of the Western Cape.

Odontogenic myxoma (OM) is one of the rare odontogenic tumours that affect the maxilo-facial regions. Skeletal myxomas are more common than soft tissue types in the facial regions.

Odontogenic myxomas (OM) are non metastasizing tumours and therefore are considered benign. These lesions are known for their distinctive infiltrative nature which makes complete surgical removal a challenging task.

Since the tumour occurs inside the bone and can reach a considerable size with little or no clinical manifestation, the radiologic examination remains the main method to determine the size and the extension of the tumour preoperatively.

Aim of the study To assess the different imaging techniques which are currently in use for the diagnosis of the odontogenic myxomas.

Materials and methods The images were retrieved from the library of the Department of Diagnostics and Radiology at the Tygerberg Oral Health Centre.

Initially each of the imaging modalities was assessed independently to describe the imaging features of odontogenic myxoma on conventional radiograph, Computed Tomography (CT) and Magnetic Resonance Image (MRI). Secondly the imaging features of the three techniques were correlated and contrasted to determine the most valuable imaging modality in the diagnosis of the tumour.

Results In this study we found that MRI was superior to other modalities in the ability to show and determine the true extension of the tumours. Therefore, MRI distinguished the tumour tissue from the surrounding structures and soft tissues.

Myxomas were found to display characteristic patterns of growth on MRI. These patterns include lobulations and/or budding, nodulation and crevices formation. Moreover T2 weighted images deduced the contents of the tumour by emitting different signal intensities from the various components of the tumours. Additionally, characteristic pattern of contrast uptake differentiated the myxomatous, collagenous parts and presumed the nature of the trabeculae whether it is bony or fibrous.

CT also showed the tumour and determined the subtle extension of the tumour into the adjacent structures and bone. Expansion and status of the cortical margin were reliably detected on CT. It also determined the pattern of growth in all tumours whether it is lobulation and/or budding, crevices formation or combination of them. In the present study this feature seemed to be a characteristic finding for all the tumours on CT. Moreover CT was able to compare densities of the tumours to surrounding muscles.

Conventional radiography (CR) showed great limitations with regard to diagnostic abilities. Although it displayed the existence of the abnormality in all cases, conventional radiograph failed to detect margins and extension in most of the lesions. Therefore conventional radiograph is not reliable for presurgical assessment of the tumour or in differentiation the tumour from other benign and some malignant tumour.

Conclusion In spite of the many limitations and shortcomings, conventional radiography remains the preliminary step in the diagnosis process. However digital imaging techniques provide images of great diagnostic value which is especially helpful in the diagnosis of odontogenic myxoma.

November, 2009

DECLARATION

I declare that *Assessment of Diagnostic Imaging Modalities Utilized in the Diagnosis of Odontogenic Myxoma* is my own work, that it has not been submitted before for any degree or examination at any other university, and that all the sources I have used or quoted have been indicated and acknowledged as complete references.

Eman Ahmed Kheir

November 2009



Signed.....

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This project could not have been accomplished without guidance and continued moral, technical support of many individuals.

I, therefore, wish to express my sincere appreciation and gratitude to all those who became directly or indirectly involved with this work, if someone's name has been omitted inadvertently please accept my apologies.

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DEDICATION

To the ever lasting love, supprt and encouragement

Of my Mama, Baba

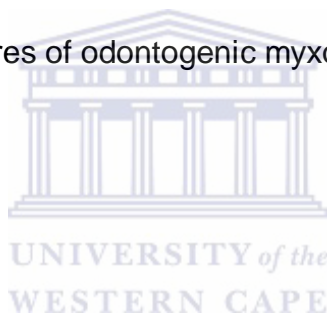
Hisham, Amir, Amira, Motaz and Aymen

Blessings...



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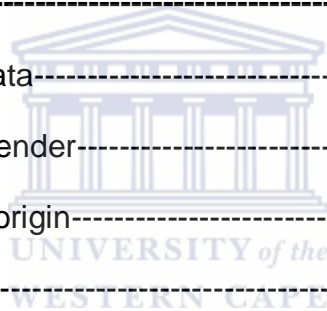


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GLOSSARY

For the purpose of the study, the following terms will be clarified:

Contrast enhancement: selective alteration of the image intensity of a particular region in the tumour by injecting contrast material into the body.

Cortication: refers to presence of bright white rim surrounding the lesion. It usually represents bone response to the tumour; as the tumour resorbs bone the latter react with deposition at the periphery resulting in opaque margin of the tumour. However on MRI it appears as dark rim.

Expansion: is the ability of the lesion to enlarge and increase in size.

Honey comb appearance: a term describing the radiographic appearance of a multilocular lesion when the compartments are small and tend to be uniform in size.

Hypodense: a term used to describe a lesion which shows lower density compared to surrounding structures (muscles) and appear dark.

Hyperintensity: is a term that describes a lesion with high signals intensity on MRI and appear bright or white in the image.

Hypointensity: is a term that describes a lesion with low signal intensity on MRI and appears dark in the image.

Hounsfield numbers (values): numbers that describe attenuation of beam by the tissues on computed Tomography (CT). Usually in a range of -1000 to +1000 with water assigned as a CT number of zero. Through Hounsfield number, the consistency of the lesion can be determined if it is cyst, tumour, or air containing cavity.

Infiltration: is a term used to describe tendency of a lesion to invade and penetrate the surrounding tissue.

Isointensity: a term describes lesions that have intermediate signal intensity on MRI and show similar intensity to surrounding structures e.g. muscles.

Isodense: a term describes a lesion that shows similar density to surrounding tissue on CT.

Loculation: describes a lesion that appears to be formed of many adjacent compartments within the bone (multilocular) or single compartment and known as unilocular.

Margin of the tumour: refers to the boundary or interface between the tumour and normal tissue.

Opacification: pathologic change in a lesion which lead to white or more radiopaque appearance on radiograph.

Planar imaging: a method of scanning and imaging in which the data is collected simultaneously from the entire layer of the body.

Precession: fast and specific type of movement that proton perform during MR image taking.

Osteolytic lesion: describe lesions that caused by lysis of bone (resorption of the bone) and appear dark (radiolucent) on radiographs.

Septae: A term used to describe bony walls within a lesion which can be fine or coarse and in some instances it may separate the tumour completely into multiple compartments.

Signal intensity: is a term used to describe the strength or power of the signals emitted by a proton during the process of MR image production.

Soap bubble appearance: describes lesions with multiple circular compartments that formed with fine trabeculae.

T1WI: T1weighted images are images in which contrast and brightness are predominantly determined by T1 signals (T1: time constant1).

TR Repetition time: the amount of time that exists between successive series of pulses applied to the same slice, variations in the value of TR have important effect in the image contrast characteristic. Short values of TR are common in

T1WI. And long values of TR are common in T2WI.

T1: means time constant during MR imaging that taken by hydrogen ions to return to baseline after removal of the stimulant (radio wave).

T2: (during MR imaging) time constant in which hydrogen ions (act as small magnets) interact with nearby nuclei after removal of the stimulant.

T2WI: T2 weighted images are image that take advantages of T2

Trabeculae: bony wall that exist within a lesion and may or may not separate the lesion completely.

TE Echo time: is another important parameter that affect contrast characteristic of the image on MRI. TE defined as time that exists between original RF pulse and the additional pulse. Short values of TR are common in T1WI and long values of TR are common in T2WI

Tennis racket appearance: a lesion that has straight trabeculae and intersects in right angles resembling the strings of tennis racket.

Wispy pattern: describes a lesion which shows radiolucency with fine trabeculae.

Chapter 1

INTRODUCTION

A German pathologist initially described myxoma in 1863 (Farman *et al* 1977); however, Thoma and Goldman (1947) were the first to describe myxomas of the jaw (Reichart and Philipsen 2004).

Odontogenic myxoma (OM) is a rare, non-encapsulated benign but locally invasive (aggressive) odontogenic tumour (Langlais *et al* 2000, Nortjé and van Rensburg 1997, Farman *et al* 1977). In some tumours a capsule may present. Characteristically, odontogenic myxomas invade the adjacent tissues but do not metastasize to the lymph nodes (Brooks 2001, Nortjé and van Rensburg 1997). In the facial region, the intraosseous myxomas are more common than the soft tissues myxomas however occurrence of skeletal myxomas in extragnathic location (outside facial regions) remains open to debate (Sciubba *et al* 2001).

The invasiveness of the tumour constitutes one of the main factors which cause frequent recurrence especially after conservative surgery. These features (invasiveness and recurrence) draw a considerable attention to the tumour.

Odontogenic myxoma represents 3%-6% of all odontogenic tumours (van Rensburg *et al* 2001) and has been reported to be the second most common odontogenic tumour after ameloblastoma in many countries. However in other areas, it may represent the third or fourth common tumour following odontomas and ameloblastoma.

In the facial regions, odontogenic myxoma occurs mostly inside bone (Kawai *et al* 1997) therefore, radiologic examination is especially important. Standard diagnosis of OM is by conventional radiographs and confirmation by histopathology. However, limitations associated with conventional radiographs invited advanced technology such as Computed Tomography and Magnetic Resonance, Imaging to validate their role in the diagnosis of the tumour. Therefore, whenever possible, advanced imaging modalities should be a complementary part of analytic imaging in the diagnosis of odontogenic myxoma.

Conventional radiography constitutes the most widely used test in the diagnosis of majority of dental and maxillofacial pathology. Therefore, it represents the standard diagnostic tool that is used in the diagnosis of odontogenic myxoma in spite of the diagnostic limitations. These limitations include the inability to determine the precise extension of some lesions such as OM, and inability to differentiate lesions that have radiographic resemblance to the tumour. Different views and various projections of the tumour may give diverse radiographic appearances, which may be interpreted and expressed by each investigator in a different way.

The complexity and non specific features of the odontogenic myxoma (OM) in radiographs may be attributed to inherent limitations of the radiographs in addition to distinctive biologic behaviour of the tumour. This fact is reflected by the broad list of lesions that mimic OM radiographically. This long list can be reduced by using more sensitive imaging modalities such as CT and MRI.

Although CT has been used widely, its role is rather complementary to conventional radiographs. Accuracy of the image obtained with possibility of three-dimensional reconstructions outweigh the disadvantage of exposure to higher radiation doses that accompany image production on CT.

On contrary to the general perception that MRI has a limited role in diagnosis of oral and maxillofacial pathology, its role in this area can not be overemphasized. van Rensburg (2003) elucidated this vital role in his series of application of advanced imaging in the diagnosis and management of maxillofacial tumours.

The aim of this study was to assess and compare the different diagnostic imaging modalities utilized at present for the diagnosis of the odontogenic myxoma.

Chapter 2

LITERATURE REVIEW

2.1. Introduction

A proper diagnosis constitutes the firm base for successful treatment. A diagnosis is comprised of a sequence of investigative steps that include detailed history, thorough clinical examination, and investigations. These investigations differ according to nature of a lesion or disease involved.

Conventional radiography represents the most widely used diagnostic tool in dental practice today. Availability, practicability by being comparatively cheap, fast, and easy interpretation are among the factors that enhance its broad application. However, conventional radiography has many limitations, particularly the two-dimensional nature of the images, poor contrast resolution, and the superimposition of other structures. In addition, conventional radiographs are inadequate to differentiate disorders that have similar features (for example osteolytic lesions).

The odontogenic myxoma, despite being a benign lesion, has an infiltrative nature into the surrounding structures. This feature results in frequent recurrence especially after conservative treatment. A need has emerged for sensitive imaging techniques that give more detail of the extent of the pathology. Advanced digital imaging e.g. Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) are excellent in this regard and seem to give a clear image of the tumour.

2.2. Computed Tomography CT

2.2.1. Introduction

According to Parks (2001) the first CT scanner was built by Godfrey Hounsfield in 1972. Developments that followed this period led to the manufacturing of the fourth generation scanner. Alan Cormark invented the mathematical computation by which images could be reconstructed from data generated by the CT scanner. Cormark based his work on computation originally devised by John Radon 1917 (Parks 2001).

CT has been used increasingly in recent years, because of its ability to detect soft tissues extension outside bone, which is a feature of aggressive benign tumours like odontogenic myxoma (OM) (Cohen and Hertzanu 1986). CT also shows degree of subtle extensions within medullary spaces inside bone (Langlais *et al* 1995).

2.2.2. Basic Principles of CT

The standard Image is an axial cross sectional view, which is produced by scanning thin slice of the body using a narrow x-ray beam that is transmitted through a patient. This beam after being transmitted through the tissues is measured with detectors which are then loaded in the computer and assembled later to reconstruct the image (Parks 2001, Mitchell and Mitchell 2005). Images are taken in succession and referred to as slices. (Parks 2001).

In some CT scanner machines, three dimensional reconstructions are possible. This overcomes the problem of superimposition of adjacent structures (Parks 2001). Three dimensional reconstructions are beneficial because they display the surface of the lesion and the relation of the object to the surrounding structures. Three dimensional reconstructions are particularly useful in planning reconstructive procedures following eradication of the tumour (Shah and Patel 2003).

The setting of the scanner can be adjusted to select a range of density and the number of grey scale to be viewed, a procedure known as windowing of an image. In other words either hard tissue (bone) or soft tissue window may be chosen (Mitchell and Mitchell 2005, Parks 2001, Langlais *et al* 1995).

Usually different tissues have different beam attenuation values which are known as Hounsfield Units (CT numbers or CT values). These numbers range between -1000 for air and +1000 for cortical bone, while water has neutral density on CT imaging and is equal to zero. Therefore, tissues have a positive CT numbers if they have higher density than water while those with lower density have negative numbers (Mitchell and Mitchell 2005, Parks 2001, Langlais *et al* 1995).

Absolute Hounsfield Numbers can not be assigned for each pathologic lesion (i.e. characteristic for specific lesion) because of variable factors such as different types of machines and variations in the anatomical structures (Langlais *et al* 1995).

2.2.3. Advantages of CT

CT is frequently chosen as a diagnostic aid because of speed and the fact that it is less expensive when compared to MRI (van Rensburg and Nortjé 1992). CT also provides surgeons with an important tool that allows evaluation of the extent of a pathological lesion in three dimensions without superimposition of the adjacent structures. In addition CT distinguishes minor differences of the tissue's densities, a property known as high contrast resolution. Modern CT units can image up to 8000 different densities in a single view. (Parks 2001)

CT also has an additional advantage as a presurgical guide for biopsy taking in the intrabony lesions by determining areas of resorbed cortical bone and extruded soft tissues. Odontogenic myxoma is an example of such a lesion in which this benefit is of use.

Conventional radiographs may not be completely reliable tools to determine whether an osteolytic lesion (unilocular radiolucency with poorly defined margin) is benign (with locally invasive nature) or malignant (Kawai *et al* 1997). Therefore CT complements conventional radiographs and helps to limit the broad range of the differential diagnosis by indicating consistency of the lesion.

CT also shows anatomical delineation of the tumour and helps to demonstrate displacement of neighbouring structures, but adds no information regarding the soft tissue characterization of the lesion itself. (Buchner and Odell 2005)

2.2.4. Disadvantages and Limitations

The main disadvantage of CT is the exposure of patients to high ionizing radiation compared to conventional radiographs. Sometimes heavy artefacts may appear on the image as a result of metal dental work, especially in coronal plane.

In addition, CT needs intravenous contrast media in differentiation of soft tissues and vascular tissues (van Rensburg and Nortjé 1992). Contrast medium that is commonly used is iodine based contrast e.g. meglumine lo glycate which is contraindicated in patients with known iodine allergies (Parks 2001).

2.3. Magnetic Resonance Imaging

2.3.1. Introduction

Langlais and his team (2000) stated that in 1946 Purcell and Bloch discovered the Nuclear Magnetic Resonance technique, which can determine the electronic structures of molecules as well as producing images. The Larmor equation is used to explain image production. Imaging application of nuclear MR came into practice only in the 1980s. (Langlais *et al* 2000)

MR imaging in the facial regions offers a chance of analysing, with some accuracy, the extent of the margins and to some degree composition and contents of a lesion, or abnormal area (van Rensburg and Nortjé 1992). MRI also has greater sensitivity over CT scan in differentiating various soft tissues lesions. Therefore, MRI is capable of producing high soft tissues resolution images. Additionally MRI allows visualization of vascular tissues without a need for intravenous contrast agent (van Rensburg and Nortjé 1992).

2.3.2. Basic Principles of MRI

When producing images MRI uses other physical principles that differ significantly from conventional radiography (CR) and CT.

CT and CR depend on a beam attenuation based primarily on electron density of the object. However MR imaging uses difference in the time the tissues take to abandon external energy (Radiofrequency -RF) added to the system during the image process, and the density of hydrogen proton in those tissues (Langlais *et al* 2000, Brooks 2001). In other words MRI uses the time that the protons would take (after cessation of radio wave) to re-align themselves with main magnetic vector that originally presented before application of Radiofrequency (RF) pulse. Unlike standard radiography, in MRI systems the operator can greatly control image contrast by setting the machine (Langlais *et al* 2000, Brooks 2001).

Images eventually produced in the MR monitor result from interaction between the external magnetic field, the applied Radiofrequency (RF) pulses, and the tissue reaction to these two forces. MRI can utilize any nucleus in tissues with unpaired

nucleon i.e. having odd numbers or charged nucleus. The hydrogen ions used because they are positively charged and abundant in the body tissue, especially in water and fat (Langlais *et al* 2000, Brooks 2001). The imaging signals and features of hydrogen vary with type of molecule with which it is bound. This in turn allows difference in tissue composition to be displayed as different grey scale images (van Rensburg 1993, Brooks 2001).

To understand the basic concept in the image production we need to recapitulate certain facts. In body tissue, hydrogen nuclei are randomly oriented in normal condition so that the bulk net magnetic moment is zero. At the time the tissues placed in a strong magnetic vector (magnet or MR machine), the protons (most of them) align themselves to attain parallel orientation to magnetic field (so called longitudinal magnetization) and the minority in an anti-parallel direction. As a result of this magnetic field, protons end up spinning and precessing around same axis of the main magnetic moment of the magnet (Langlais *et al* 2000). This magnetic force of the protons (longitudinal magnetization) can not be measured because it is in the same direction of main magnetic field (parallel to the external magnetic field) (Schild 1990). Therefore, there is a need to change direction of the proton and their magnetic force.

The direction of protons can be altered by application of external source of energy such as radio wave, which should have the same frequency as protons. The phenomenon by which protons pick up energy from the radio waves is known as Resonance. The radiofrequency (RF) pulse causes the hydrogen nuclei to change their orientation from parallel to perpendicular to the main magnetic field. As a result, the longitudinal magnetization is reduced with simultaneous increase in transverse magnetization. In addition to that, Radiofrequency pulse causes the protons to precess in step (i.e. in phase) (Schild 1990). After shutting down the RF pulse, these protons tend to return to the original orientation i.e. baseline state. Protons during their return to baseline emit signals. The time needed by the protons to return to baseline state is known as T1 and this varies with different tissues and the abilities of protons to transfer the excess energy to the environment and with the strength of magnetic field.

T1 weighted images usually show anatomy with fat tissue has short T1 and appears

white or bright, while water and other tissue fluid such as CSF appear black. Diseased and healthy tissues have different T1, which make it possible to differentiate lesions on MRI when machine is set to make use of T1 differences i.e. an image in which T1 relaxation time is the major determinant.

T2 is time constant in which magnetic fields of hydrogen nuclei interfere with the fields of the adjacent nuclei after shutting down the source of external stimulant (RF pulse). This interferences cause precession (movement) of the protons to get out of the phase (i.e. they are no longer in same direction with each other). Usually T2 is equal to or less than T1 (Langlais *et al* 2000, Schild 1990). Unlike T1, water and other body fluids have long time and appear white on T2 weighted images (Langlais *et al* 2000). Since pathological tissues contain more water, this property makes T2 suitable for detection of pathological processes.

The most common MRI technique used is the spin echo (SE) pulse sequence which consist of Radiofrequency (RF) of 90 pulse followed after some delay by RF 180 pulse (which result in the detection of signals). Then accordingly tissues emit signals which are taken by the computer which in turn can assign the location of the slice and reconstruct the MR images. Conventional spin-echo time can determine contrast of image whether it is T1 or T2 weighted images or proton density weighted. T1weighted images have short time for repetition and echo time while T2 has long time for both. In proton density weighted images time of repetition is long but has short echo time (Brooks 2001).

The spin echo sequence (SE) is useful in identifying anatomy and pathology throughout the body, but has a major drawback of being slow. This slowness results in elongation of scan times that can be uncomfortable to scanned patient. In addition, it greatly reduces the number of patients scanned per day (Brooks 2001, van Rensburg 1993).

In addition the long scan time can also compromise images from certain areas of the body e.g. abdomen, because of respiratory motion. Therefore, two methods were introduced to minimize scan time. First by speeding up the spin-echo sequence or secondly by introducing a new different method e.g. gradient-echo imaging (Brooks 2001).

Gradient-echo imaging produces images rapidly in a few seconds compared to minutes with spin-echo sequence (Langlais *et al* 2000).

Generally Information provided on each Magnetic Resonance Image differs with the various machines. Typically demographic data, for instance patient's name, age and gender should be available. In addition to time and date of examination, patient's right and left sides and machine settings are usually indicated on each image.

2.3.3. Advantages of MRI

Unlike conventional radiographs, generally MR imaging has no known biologic hazards except for a few specific circumstances which will be discussed later (Brooks 2001, Langlais *et al* 2000).

2.3.4. Contra-indications of MRI

MRI is contraindicated for patients who have electrically, magnetically or mechanically activated implants such as cardiac pacemakers and infusion pumps. Risks for these include induction of electric currents, heating, also misinterpretation of an artefact as an abnormality in addition to possibility of movement and dislodgement of the implant (Langlais *et al* 2000).

Other patients with other metallic implant e.g. orthopaedic, contraceptives devices or non metallic implant e.g. Intra ocular lens implant; can safely undergo MR imaging (Shellock 1998). MRI has no known biological hazard and has been considered hazardless to a foetus. Nevertheless a cautionary approach to the use of MRI during pregnancy is recommended (Langlais *et al* 2000).

2.3.5. Disadvantages

Drawbacks of MR imaging include long acquisition times, great cost, limited availability, high risk of motion artefact and the need for technically skilled personnel in addition to the noise that accompany the process of image production (Langlais *et al* 2000, van Rensburg and Nortjé 1992). This noise can cause the patient emotional or psychological distress that is increased by the restrictive dimensions of the interior of the scanner (claustrophobia). Usually the latter problem is overcome by informing the patient about different aspect of MR imaging prior to examination with

the use of ear plugs and headphones (Brooks 2001, Langlais *et al* 2000).

2.3.6. Contrast enhancement on MRI

Sometimes more information is needed than that obtained from T1, T2, and proton density weighted images in order to determine the nature of a lesion. Therefore, signals emitted by tissues can also be altered by injecting MR contrast agents that affect T1, T2 times (Schima *et al* 1996).

Contrast agents are materials with strong magnetic force, which enhance relaxation of proton and affect the signal intensity of tissues. In other words, contrast agents shorten T1 or T2 (Schima *et al* 1996). Clinical usage of contrast agents is determined by concentration of the agent, bio-distribution of the agent in tissues and its half-life (Langlais *et al* 2000).

Many types of contrast agents are available and they are basically classified into Ferromagnetic, Paramagnetic and Supermagnetic agents (Langlais *et al* 2000). Paramagnetic agents such as Gadolinium Diethelene Triamine Pantothenic Acid (GD-DTPA) are most commonly used.

Shortening of T1 and T2 relaxation time depends on the dose of GD-DTPA administered to the body. For instance at low concentration 0.6-6 mmol/l, T1 shortening predominates producing increased signal intensity of some tissues on T1 weighted sequences while at higher concentration of 25-50 mmol/l T1 shortening is already maximal and T2 shortening becomes dominant resulting in decreased tissue signal intensity on T1 weighted image (Langlais *et al* 2000).

Contrast enhancement is mainly determined by vascularity and the interstitial vascular space of the tissues involved. A contrast agent in the jaws is added to study the presence of enhancement within a lesion or rim enhancement at the margin of a lesion such as an odontogenic cyst or tumours. A lesion will take a contrast agent if it contains vascular areas and according to intensity of contrast agent, lesions demonstrate moderate or marked contrast enhancement e.g. haemangioma (Langlais *et al* 2000).

Langlais *et al* (2000) reported that lack of enhancement usually occurs in sclerotic

osseous lesions, soft tissues, and jaw cysts except for inflamed cysts, which may show marked rim enhancement.

Since fat tissues have a high signal intensity on T1 weighted image so that a fat suppression technique e.g. STIR can be used together with paramagnetic contrast material to strengthen certainty that hyperintense signal on T1 represent contrast enhancement and not fat tissue. Fat suppression techniques can be divided into relaxation rate dependant method and chemical shift method with the latter being the most widely used.

2.4. Analysis of MRI

Different tissues show different signal intensity on T1 and T2 weighted images. High signal intensity tissues are referred to as hyperintense and appear white while low signal intensity are referred to as hypointense and appear dark or black. Isointensity refers to tissues that show similar density to surrounding structures e.g. muscles (Langlais *et al* 2000).

They differ in T1, T2 weighted images.

2.4.1. T1 Weighted Images: Images in which T1 is the major determinant.

Hyperintensity on T1 weighted images

Tissues that show hyperintensity on T1 weighted images and appear white include fat, haemorrhage, melanin, hyperproteinaceous secretion and cholesterol crystal (Yousem and Montone 1998).

Isointensity on T1 weighted images

Isointensity means that tissues show similar intensity to surrounding structures e.g. muscles. However some lesions for example, inflammation may show hypointensity compared to muscle but are not as dark as bone or air (Yousem and Montone 1998).

Lesions that show isointensity include non-mucosal soft tissues and squamous cell carcinomas (Langlais *et al* 2000).

Hypointensity

Hypointensity means tissues may appear black or dark and these include tissues like bone and teeth or lesions with dense calcification or rapidly flowing blood e.g. arteriovenous malformations; aneurysms; bone forming lesions or odontogenic masses; osteosarcomas in addition to some lesion with extremely hyperproteinaceous secretion e.g. odontogenic keratocyst (Yousem and Montone 1998).

2.4.2. T2 Weighted Images

Hyperintensity

Generally tissues and lesions which contain fluid may appear as white or bright areas. These include vitreous fluid of the eyes and CSF, most inflammatory lesions as well as fluid from sinusitis, mucosal thickening, and abscesses. Most cysts either peripheral e.g. ranula or inside bone e.g. odontogenic and developmental cyst may show hyperintensity (Langlais *et al* 2000, Yousem and Montone 1998).

Intermediate Intensity

This refers to lesions with increased numbers of cells or those which show increased nuclear to cytoplasmic ratio e.g. squamous cell carcinoma. Fat has intermediate signal intensity on SE images (Yousem and Montone 1998).

Hypointensity

Similar tissues that show hypointensity on T1 weighted images for example bone, air and dense calcification also appear hypointense in T2 weighted images (Langlais *et al* 2000, Yousem and Montone 1998).

2.5. Odontogenic Tumours

2.5.1. Origin

Odontogenic tumours are lesions derived from tissues of tooth forming apparatus namely epithelial, ectomesenchyme and/or mesenchyme (Philipsen *et al* 2005). These tumours are found exclusively within the maxillofacial area, either in bone

(Central tumours) or in soft tissues around tooth bearing area (peripheral tumours).

Odontogenic tumours constitute a heterogeneous group of lesions with different histopathological features, clinical manifestations and behaviour i.e. neoplastic to hamartomas (Slootweg 2006). All these tumours show some degree of resemblance to histology of normal tooth germ (Philipsen *et al* 2005)

These tumours are considered as relatively uncommon lesions, with most of them occurring intraosseous (inside bone). Peripheral tumours do occur but are considered rare when compared to central ones (Philipsen *et al* 2005).

2.5.2. Etiology

The etiology of odontogenic tumours remains unknown as most of them arise de novo, with no clear causes or factors (Philipsen *et al* 2005).

The spectrum of these tumours ranges from hamartomatous proliferations to benign tumours (aggressive and non-aggressive) with few additional malignant ones. This spectrum of biological behaviour was considered as the criteria for the classification of the odontogenic tumours (Philipsen *et al* 2005).

2.5.3. Classification

Many classifications were set forward in attempt to define the odontogenic criteria, but the most cited one is the revised classification 1992 of the World Health Organization (WHO) ;histological typing of odontogenic tumours (Kramer 1992).

Odontogenic tumours are classified into benign, malignant and non neoplastic hamartomas. Benign lesions are further subdivided according to the odontogenic tissues which have been involved within the tumour i.e. odontogenic epithelium with or without odontogenic ectomesenchyme, mesenchyme or ectomesenchyme with or without odontogenic epithelium. Odontogenic myxomas belong to this latter category (Philipsen *et al* 2005, Adebayo *et al* 2005)

2.6. Odontogenic Myxoma (OM)

2.6.1. Introduction

Myxoma is Latin word originate from the Greek word *muxa*, which means mucous.

Rudolph Virchow (1863) is a German pathologist who first described the histological features of myxoma (Farman *et al* 1977). However it was only in 1947 that Thoma and Goldman first described myxomas of the jaw (Reichart and Philipsen 2004).

Odontogenic myxomas are generally rare, non-encapsulated benign but locally invasive (aggressive) odontogenic tumours (Farman *et al* 1977, Langlais *et al* 2000, Nortjé and van Rensburg 1997). Infrequently a capsule may be present. Wachter and his colleagues (2003) recognized false capsules that were formed by encapsulation of surrounding tissue around the tumour. The occurrence of the intraosseous myxoma in extragnathic location remains open to debate (Sciubba *et al* 2001).

Characteristically, odontogenic myxoma invades the surrounding tissues but does not metastasize to lymph nodes. (Brooks 2001, Nortjé and van Rensburg 1997) Aggressiveness of these tumours is sometimes reflected by the scalloping appearance of the lesion. (Theodorou *et al* 2006).

2.6.2. Nomenclature

Myxoma, odontogenic myxoma, and myxofibroma are used synonymously but usually myxofibroma is used to indicate large collagenous content of the tumour histologically (Regezi *et al* 1999), while myxoma sometimes denotes a soft tissue tumour.

2.6.3. Incidence

In spite of being rare, odontogenic myxomas have been reported by some authors to be 0.2-17.7% of all odontogenic tumours (Koseki *et al* 2003). Noffke *et al* (2007) stated that odontogenic myxomas (OM) are slightly common in Africa with relative frequencies reported 1%-19%. Odontogenic Myxomas represent the second most common odontogenic tumour after ameloblastoma in many countries. However in

other regions, myxomas follow odontomas and ameloblastoma (Sriman and Shetty 2008, Ladeinde *et al* 2005, Olgac *et al* 2006). Nevertheless, van Rensburg *et al* (2001) reported that 3%-6% of all odontogenic tumours were odontogenic myxomas.

Myxoma is generally a soft tissue lesion and found less commonly in bone than in soft tissues (Langlais *et al* 2000). The mandible and maxilla are most common bony sites (Wachter *et al* 2003). In soft tissues, they may occur in the tongue, nose, cheek, pharynx, larynx, neck musculature and parotid gland (Wachter *et al* 2003).

2.6.4. Histogenesis of odontogenic myxoma

Odontogenic myxoma is believed to originate from ectomesenchyme of tooth primordia or periodontal ligament (Jing *et al* 2007). This belief is supported by many facts which include histological resemblance to pulpal ectomesenchyme, exclusive occurrence near tooth bearing area of the jaws, its occasional association with a missing or unerupted tooth and rare occurrence in other parts of skeleton. Presence of nest or some odontogenic epithelium in histological examination of some of these tumours may also strengthen the theory of the odontogenic origin (Jing *et al* 2007, Wachter *et al* 2003).

Histochemical and immunohistochemical investigations of the odontogenic myxoma suggest another origin from fibroblast, histiocytic elements, or myofibroblastic cells (Sciubba *et al* 2001).

Although benign, odontogenic myxomas draw great attention because of their invasive nature into the surrounding tissues, which makes the tumour amenable to recur especially after conservative treatment (Noffke *et al* 2007, Simon *et al* 2004).

2.6.5. Clinical features

Many studies have reviewed different aspect of odontogenic myxoma, such as the clinical, radiographic and pathological appearances.

Signs and symptoms

Odontogenic myxoma usually presents as a painless, slow growing expansile lesion that causes asymmetry of the affected jaw (van Rensburg *et al* 2001, Farman *et al*

1977, Philipsen *et al* 2005). Usually it occurs as unilateral lesions but bilateral cases have been reported (Koseki *et al* 2003). Odontogenic myxomas may sometimes be discovered incidentally on routine radiographic examinations. However, in majority of cases; it has been found that patients report to a physician 1-5 years after development of lesion.

In Tanzania, a study of 33 cases of verified Odontogenic myxoma (OM) was conducted by Simon and co-researchers (2004) and results of the study revealed that pain, diasthesia, ulceration, invasion of soft tissue and tooth mobility were among the symptoms that patients presented with. The majority of the patients however had no clinical signs or symptoms. OMs may cause expansion of buccal and lingual plates in the mandible while perforation is comparatively rare (Regezi *et al* 1999). In the maxilla, OMs tend to involve the maxillary sinus. Sometimes the tumour may invade palate, orbit and nasal cavity with resultant symptoms related to these structures (Wachter *et al* 2003). Ulceration of overlying mucosa is uncommon and only occurs when tumour interferes with dental occlusion (Farman *et al* 1977). Since the odontogenic myxoma is a slowly growing lesion, symptoms like paresthesia, pain and others typically indicate advanced disease.

Sex predilection

Studies have shown differences in the results regarding predominance of the tumour in males and females. In some studies It has been found that odontogenic myxomas (OM) affect females more than males (Noffke *et al* 2007, Simon *et al* 2004, Sciubba *et al* 2001). An increased occurrence in males has been reported by some authors (van Rensburg *et al* 1994). While other studies reported an equal gender frequencies (Regezi *et al* 1999).

Age

Odontogenic myxomas can occur at any age. The youngest reported case was three months old (Noffke *et al* 2007, Wachter *et al* 2003), however the peak age is in the third to fourth decade of life (Noffke *et al* 2007, Simon *et al* 2004, van Rensburg *et al* 2001). It is generally believed that this tumour is rare before the age of 10 years and after the age of 50 years (van Rensburg *et al* 2001). Between 8%-12.5% of these tumours are found in persons younger than 16 years (Wachter *et al* 2003).

Location

The mandible is affected more frequently than the maxilla (Noffke *et al* 2007, Simon *et al* 2004, van Rensburg *et al* 1992) although in another series a higher incidence in the maxilla was reported. In the mandible, the posterior premolar- molar region is the most common affected site and buccal and lingual expansion is often reported (Simon *et al* 2004, Brannon 2004). In the maxilla, swelling is seen only when the sinus is not involved. Common sites in the maxilla include the alveolus and zygoma (Wachter *et al* 2003).

2.7. Microscopic Features

Histologically, myxomas consist of small stellate or spindle cells with multiple branching cytoplasmic extensions and centrally located nuclei that lie in a mucinous matrix (Slootweg 2006, Chiodo *et al* 1997). Sometimes this matrix is slightly fibrous (Sciubba *et al* 2001).

Collagen fibres of different thickness are present and interestingly they have a uniform distribution within any particular lesion (Sciubba *et al* 2001). Nests of odontogenic epithelium may present in variable amounts in some tumours. Capillaries may also be a prominent feature in the tumour.

The stroma is composed of basophilic cytoplasm that is filled with fine granules and is rich in acid mucopolysaccharides content. Shape of the nuclei ranges from rounded when cut in cross section to fusiform in longitudinal section. Binucleated cells and mitosis are also present though rare. Histologically myxomas resemble the dental follicle or dental papilla, however differentiation from the later is by the presence of dentinoid tissues, columnar ameloblastic epithelium, cuboidal cells and squamous epithelium (Sciubba *et al* 2001, Slootweg 2006, Chiodo *et al* 1997).

Histologic differential diagnosis of odontogenic myxoma should include myxomatous degeneration of an intramandibular neurofibroma and metastatic Wilms' tumour with myxoid features (Sciubba *et al* 2001). According to Brannon (2004) central odontogenic fibroma and central odontogenic granular cell tumour should be considered in the differential diagnosis.

2.8. Macroscopic Features

Gross pathological examination of the tumour specimen shows smooth glistening, mucus or gelatinous mass that is grey to white in colour, while sometimes it presents as milky white or yellow to amber (Wachter *et al* 2003). In addition, usually it shows consistency that ranges from soft to firm depending on the content of fibrous tissues of the lesion (Chiodo *et al* 1997).

2.9. Investigations

Radiological examination plays significant role in the diagnosis of odontogenic myxomas preoperatively however confirmation of the diagnosis is by histological examination of specimen after surgical removal (Nortjé and van Rensburg 1997).

2.9.1. Conventional Radiography

Classically initial radiographic examination should include intra oral views e.g. periapical and occlusal views, as well as extra oral views e.g. panoramic radiographs, and postero-anterior views of the mandible.

Peltola and colleagues (1994) studied radiographic appearance of 21 cases and based on the findings of the study they claimed that myxomas have complex radiographic appearances than generally thought.

Radiographic features

Conventional radiography remains the standard protocol in the process of diagnosis of the odontogenic myxoma; however it plays a minor role in demonstrating the extension of the tumour.

Depending on the stage of the development of the tumour, Barros and his colleagues (1969) recognize two patterns. The first stage begins with osteoporotic appearance with prominent medullary spaces separated by thin septa of bone. Increased area of osteolysis can be seen as tumour invades the surrounding tissues. During this stage, the tumour acquires its classic multilocular radiographic appearance and the forms of the lesions differ according to size and shape of trabeculae. For instance, if the locules are large with thin septa they appear as soap

bubble while in honey comb appearance they are small with thick septa (MacDonald-Jankowski *et al* 2004) In addition some of the lesions may give a wispy or spider web appearance (Brannon 2004). Some other authors have described appearance that mimics the tennis racket and is considered pathognomic for odontogenic myxoma (Simon *et al* 2004, Farman *et al* 1977)

The second stage as described by Barros and his team (1969) represents breakout or destructive phase of the tumour characterized by a loss of internal locules and appears as unilocular (Mata *et al* 2008, Noffke *et al* 2007 and Simon *et al* 2004). Frequently significant expansion may ensue, with possible perforation of the cortex and extension of the tumour into the surrounding tissues. During the early stages of the unilocular phase, some investigators recognize extension of bone septa perpendicular to the margin of the lesion, resembling hairbrush, or sunburst appearance (Barros *et al* 1969). However, some authors described the two patterns (unilocular and multilocular) to occur independently and reported that frequencies of unilocular lesions tend to be higher (Peltola *et al* 1994). Unilocular lesions tend to occur more frequently in the maxilla while multilocular ones are commoner in mandible and usually affect the posterior areas of the jaws.

Koseki and co-workers (2003) classified internal structures of odontogenic myxoma (OM) with reference to the trabeculation. Four types were described which include; unilocular with no trabeculation as type 1, type two as unilocular with few delicate trabeculation, type three is pathognomic to odontogenic myxoma with tennis racket appearance, type four includes multilocular with soap bubbles or honeycomb appearances.

Odontogenic myxoma may show either well or ill defined borders, however, lesions with ill defined borders seem to be more common and this is due to lack of bone reaction to the lesions (Farman *et al* 1997).

Outline or border of the lesion provides a great information regarding behaviour of the lesion as active process in any lesion tends to be in the periphery (Farman *et al* 1997). If a lesion reveals poor margination then conventional radiography may not be sufficient to determine if the lesion is benign (with locally invasive nature) or malignant tumour (Kawai *et al* 1997).

Interpretation of radiographs without additional information from history or clinical examination can lead to an unbiased and relatively long list of possibilities. Radiographic appearance of odontogenic myxoma (OM) may mimic the appearance of many lesions which include ameloblastoma, odontogenic keratocyst, central giant cell granuloma, cherubism.

Less common lesions that may also resemble OM radiographically include central haemangioma, calcifying odontogenic cyst, aneurysmal bone cyst, ameloblastic fibroma, fibrous dysplasia, arteriovenous malformation, histiocytosis-X and mucoepidermoid tumour (Hisatomi *et al* 2003, Farman *et al* 1997).

Rarely some other lesion like central fibroma, central chondroma and calcifying epithelial odontogenic tumour may also mimic OM radiographically (Farman *et al* 1997).

Sometimes it is possible to differentiate some of the previously mentioned lesions on clinical basis as in case of cherubism but in vast majority of them, more sensitive imaging technique is needed to shorten this list and reach on working diagnosis.

Effects on adjacent tissues

Regarding the effects of odontogenic myxoma (OM) on adjacent structures, Farman and his team (1977) reported that odontogenic myxoma can displace roots but can also grow around them with little movement or displacement. Root resorption tends to be rare, though it is relatively high in some studies (Simon *et al* 2004, Koseki *et al* 2003).

Advantages of conventional radiography (CR)

Conventional radiography (CR) has the advantage of being available, cheap and of low radiation dose compared to CT. CR also has high spatial resolution, which reveals very thin cortex in well defined lesions (MacDonald-Jankowski *et al* 2004). Moreover, it reliably shows tooth displacement and resorption of roots (Noffke *et al* 2007, MacDonald-Jankowski *et al* 2004). In spite of the limitations, Conventional radiography is an essential component of the diagnostic protocol.

Infiltrative nature of myxoma makes the tumour extends beyond the apparent margin

of the conventional radiographs. Relying on such radiograph in treatment planning makes recurrence frequently unavoidable.

Conventional radiographs are able to some extent to differentiate between benign and malignant lesions and show calcification within the lesions; however they have a limited ability in differentiating those benign lesions. In addition, conventional radiographs have the disadvantage of being two dimensional images.

A particular important requirement for the radiological evaluation of jaw lesions is the need for an image to provide accurate bone and soft tissue differentiation (van Rensburg *et al* 1992).

Because of the infiltrative nature of odontogenic myxoma and high tendency to recur, then advanced imaging modalities such as CT and MRI become useful tools in showing topography and fine structure of the lesion (Philipsen *et al* 2005). Moreover, they show excellent ability in differentiating various tissues and determination the true extent of the tumour in bone. This subsequently offers a good chance in planning proper treatment and reduces chances of recurrence.

2.9.2. CT Features of Odontogenic Myxoma

CT has the ability to show OM in different planes. On soft tissue setting odontogenic myxoma may show expansile soft tissues mass of relatively low density (hypodense) or similar density (isodense) to surrounding tissues. Whereas on bone window, the tumour may show fine trabeculations which are straight or angular, this feature is considered a characteristic finding in odontogenic myxoma (Koseki *et al* 2003). These trabeculae may sometimes separate the mass completely giving septated appearance (Defatta *et al* 2006, Wachter *et al* 2003, Koseki *et al* 2003 and Asaumi *et al* 2001).

Cortical plates may show expansion, distortion, thinning and/ or interruption. The margin of the tumour is well defined and smooth even when the tumour perforates the cortices and appear as rounded well delineated soft tissue mass (Aquilino *et al* 2006, Koseki *et al* 2003). In maxillary sinus, it appears as soft tissues mass with bone destruction and/or thinning with strands of fine lace like density representing ossifications, which is considered by some authors as a characteristic finding

(Asaumi *et al* 2001). Presence of sun ray type spicules may sometimes be seen at the margin of the tumour.

As mentioned earlier conventional radiographs may sometimes be an unreliable tools to determine whether a given osteolytic lesions is benign (with locally invasive nature) or malignant tumour. Nortjé and van Rensburg (1997) stated that CT is generally superior to plain radiograph in allowing visualization of any soft tissue extension beyond the bony margin. Koseki and his team (2003) supported the superiority of CT over the conventional radiograph and reported unilocular lesions in six patients with incomplete septa that misinterpreted as multilocular in conventional radiography. This clearly reveals the advantages of three-dimensional imaging.

2.9.3. MRI Features of Odontogenic Myxoma

MRI has the advantage of being able to aid in specific diagnosis of myxoma by showing extension into adjacent tissues and the ability to invade between the roots of teeth (Asaumi *et al* 2002).

MRI also shows great reliability in determining the vascular nature of a lesion e.g. haemangioma (van Rensburg *et al* 1994). Therefore, it differentiates haemangioma from odontogenic myxoma, which may share similar radiographic appearance.

Some investigators use dynamic MRI or contrast enhancement to differentiate benign from malignant tumours and in differentiating between benign tumours for instance ameloblastoma from odontogenic myxoma (Asaumi *et al* 2002).

Many studies have been performed to describe the imaging signs of soft tissue myxoma on MRI but no such study is reported for imaging features of odontogenic variant. MRI in intramuscular myxoma appears as well defined ovoid lesion, which shows low signal intensity on T1WI and high signal intensity on T2WI. These signs on T1, T2 WI are considered the most reliable signs to distinguish intramuscular myxoma from other soft tissues myxoid lesions (Goodwin *et al* 2007)

Chiodo and his colleagues were the first who described MR imaging features of odontogenic variant in 1997, followed shortly by Kawai and his team in 1997. They analyzed MRI for a unilocular radiolucency with a poorly delineated margins which

proved later by histopathology to be odontogenic myxoma.

Kawai and his colleagues (1997) reported that Magnetic Resonance Imaging revealed well defined, well enhanced mass lesion with homogenous signal intensity on every pulse sequence. The lesion shows intermediate signal intensity on the T1, T2 weighted images with higher signal intensity on the T1 weighted images compared to muscles and lower signal intensity on T2 weighted images compared to fat. Asaumi and his team (2001) supported Kawai's results on T1 weighted images but disagree with his findings on T2 weighted images. Other reports described different features that corresponded with MRI features of soft tissues. They reported well defined, smooth walled mass lesion with high intensity on T2 weighted images and low intermediate signal intensity on T1 weighted images (Defatta *et al* 2006, Aquilino *et al* 2006, Hisatomi *et al* 2003, Wachter *et al* 2003, Sumi *et al* 2000).

Correlation of the signal intensities and the histopathology was described by Asaumi and his team (2001). They described the signal intensities of the mass and correlated them to the gross specimen postoperatively. In their case report, Asaumi and his team stated that fibrous component of the mass (collagen bundles) was depicted as intermediate signal on T1W1 and showed high signal intensity on T2W1. This fibrous part enhanced markedly with gadolinium and appeared bright. Myxomatous or mucoid matrix appeared as intermediate signal intensity on both T1, T2 weighted images and this portion of the mass did not enhance.

Frequent extension of the tumour in interroots of the teeth confirmed that odontogenic myxoma is not a consistent mass lesion and contain soft cystic component (Asaumi *et al* 2001).

2.9.4. Diagnostic Work-Up

Confirmation of diagnosis of odontogenic myxoma is by histopathological examination of deep incisional biopsy of the lesion. Access to the lesion can be through sockets of mobile teeth that need extraction or could be through sulcular or mid crestal incisions in cases of firm teeth and edentulous ridge respectively. CT has the advantage as presurgical guide for biopsy taking in the intrabony lesions by determining areas of resorbed cortical bone and infiltrated soft tissues.

2.10. Treatment

The standard treatment of odontogenic myxoma is surgical removal by local excision, curettage, enucleation or resection (Peterson *et al* 2003, Regezi *et al* 1999). The type of treatment received is one of the major determinant factors for the recurrence of OM, which is reported by some authors to be 10-33% with average of 25 % (Wachter *et al* 2003, Regezi *et al* 1999). Lo muzio and his colleagues (1996) reported recurrence rate of 43% in myxomas that were treated by curettage and local excision.

Curettage and enucleation of the tumour do not remove the whole tumour because of its loose gelatinous consistency. This usually linked to high recurrences associated with the lesion. A new approach of the treatment had been described by Wachter and his team (2003), he combined simple enucleation or curettage of the lesion with peripheral osteoectomy; this is particularly effective for paediatric cases in order to avoid disfigurement and potential interferences with growth and development of facial skeleton.

Since recurrence, follow incomplete removal of tumour and/ or conservative surgery then radical surgery is especially necessary for poorly defined lesions (Regezi *et al* 1999). Resection of the tumour denotes removal of the tumour with removal of a part of normal surrounding tissues. Resection can be marginal, partial, total resection or composite resection (Regezi *et al* 1999, Peterson *et al* 2003). Some surgeons add irradiation to the treatment regime either before or after surgical removal (Theodorou *et al* 2006).

Aggressive behaviour of odontogenic myxoma in terms of infiltration and invasion of surrounding tissues makes the tumour amenable to recur. Role of radiology in the diagnosis of OM is fundamental and advanced imaging techniques may potentially play a role in reducing recurrence associated with the tumour by aid in proper planning of surgery. Thus for no studies have reported the MRI features of OM. This prompted the researcher to assess different modes of radiological imaging techniques that are currently in use for the diagnosis of odontogenic myxoma with special references to advanced techniques.

Chapter 3

AIMS AND OBJECTIVES

Odontogenic myxoma (OM) in the facial regions occurs mostly inside the bone and may expand to a large size with little or no clinical manifestation. The tumour expands at the expense of bone marrow space or extends into the surrounding structures (e.g. maxillary sinus).

Therefore radiological examination is of paramount importance in the diagnosis of OM. Since conventional radiographs have many limitations then advanced imaging techniques are important in the diagnosis process.

Paucity of studies in this area together with the vital role of imaging in the diagnosis of the tumour provoked the author to the present study.

3.1. Aim of the Study

The aim of the study was to assess the diagnostic and radiologic features of different radiological imaging modalities currently available for the diagnosis of odontogenic myxoma.

3.2. Objectives

1. To describe the imaging features of the odontogenic myxoma as seen on conventional radiographs.
2. To analyze imaging features of the odontogenic myxoma on MRI and CT.
3. To establish the most valuable radiological imaging technique in the diagnosis of the odontogenic myxoma.

Chapter 4

MATERIALS AND METHODS

4.1. Study Design

This is a retrospective descriptive study. The study was divided into four parts; the first part described the radiological features of odontogenic myxoma as seen on conventional radiographs. Second and third parts were the analysis and study of the basic and additional radiological features provided by computed Tomography and magnetic Resonance images respectively. Finally the radiological features obtained from those three imaging modalities were evaluated and contrasted all together.

4.2. Study Population

Thirty-three records of histologically proven cases of odontogenic myxomas over a period of 42 years (1967-2009) were included in the study. All pathologic specimens were evaluated by maxillofacial pathologists. The records were retrieved from the library of the Department of Diagnostics and Radiology at the Tygerberg Oral Health Centre.

In thirty records conventional radiographs were available, ten had MRI and eight cases underwent CT. A limited number of advanced images in the study were due to the fact that many cases presented prior to the introduction of those technologies in the medical and maxillofacial field in the Republic of South Africa in addition to the high cost of these technologies that patients could not afford.

Additional records were excluded from the study due to uncertainty of the histology or having radiographs or images which were of non-diagnostic value (poor quality images).

4.3. Methodology

The panoramic radiographs were taken with a GE-3000 (General electric, Milwaukee, WI) or Cranex Tome CEPH (Soredex, Helsinki, Finland).

Images available in the thirty records were carefully studied. Two pre-calibrated observers, the principal investigator and a board certified maxillofacial radiologist (one of the co-supervisors) examined each image available for the study at different times then the results were compared. Where there was disagreement of the findings of the two observers for the same image, then a third party was consulted and the final decision was reached by consensus after discussion.

Demographic data were analysed for age, gender, and ethnic origin. In order to avoid breaching the confidentiality of the patients no form of identification other than the museum registration numbers were captured. These numbers were kept as part of the raw data.

4.3.1. Methods of Interpretation of Conventional Radiographs

Under ideal environment (dim lighting and area free from distractions) all images were examined. The radiographic library of the Department of Diagnostics and Radiology at the Tygerberg Oral Health Centre (fourth floor) fulfilled these criteria and was used by the investigators to study the images. Conventional radiographs were examined using day light colour viewbox of sufficient size that is brightly and evenly illuminated. The viewbox was placed in a position comfortable to the investigator. Adjunctive tools such as magnifying glasses and opaque masks were used to allow proper examination of the images.

The aim of the examination was to describe the radiographic features of odontogenic myxoma as seen on the conventional radiographs. These features included location, appearance of the internal structures, locularity, expansion, borders/ margins of the lesion. In addition, the effects that the tumours had on the surrounding tissues such as displacement of teeth, root resorption, association with unerupted or impacted teeth, encroachment of mandibular canal and maxillary antrum as well as the effects that some maxillary lesions had on nasal cavity and floor of the orbit.

The odontogenic myxomas were evaluated using the following criteria:

Location

Referred to the position of the tumour in the jaw either mandible or maxilla. In addition, the investigator specified the side of the jaw occupied by the tumours.

Internal structures of the tumour

The odontogenic myxomas showed five main radiographic patterns according to the appearance of internal structure and were classified as follows:

Adapted from classification of Koseki and his team (2003) (Figures 4.1 to 4.4)

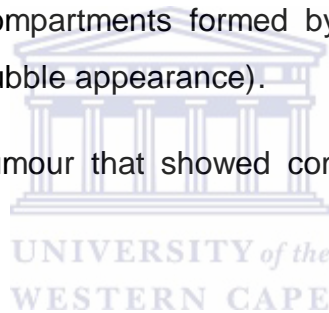
Type1: Unilocular radiolucency with no internal trabeculation.

Type2: Radiolucent lesion with few delicate or coarse trabeculation. Wispy pattern, sunray appearance, diffuse calcifications were included under this category (Fish net appearance was also included as subgroup of this category).

Type 3: Straight and angular trabeculation which frequently form square or triangular compartments (Tennis-racket appearance).

Type4: Round or oval compartments formed by curved trabeculation (honey comb appearance, soap bubble appearance).

Type 5: Described the tumour that showed combination of any two or more abovementioned types.



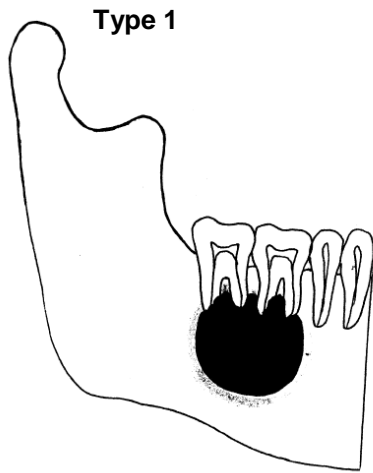


Figure 4.1: Diagram showing Unilocular radiolucent with no internal trabeculation.



Figure 4.2: Diagram showing radiolucent lesion with trabeculae.

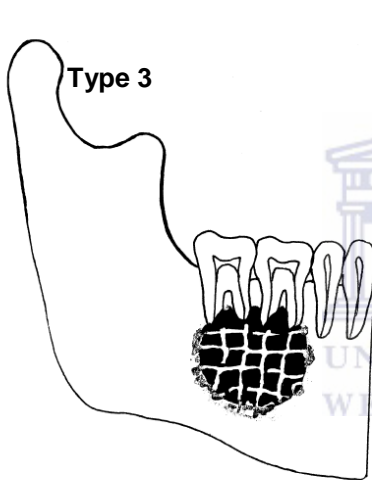


Figure 4.3: Diagram showing Straight and angular trabeculation.

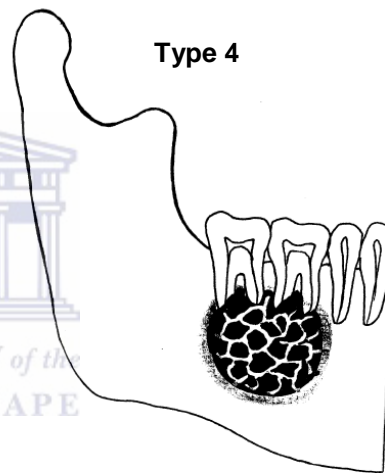


Figure 4.4: Diagram showing rounded and curved trabeculation.

Locularity

Locularity described the presence of single or multiple compartments and were referred to as unilocular or multilocular respectively.

Borders or margin of the tumour refers to the boundary or interface between the tumour and the normal tissue.

Cortication referred to presence of bright white rim surrounding the lesion on the conventional radiographs. It usually represents bone response to the tumour; as the tumour resorbs bone the latter react by bone deposition at the periphery resulting in

definite margin of the tumour.

Scale from 0-3 was given to describe status of the cortex.

Uncorticated (0): showed no cortication

Poorly corticated (1): referred to lesions in which transitional zone between the lesion and healthy bone is wide and indistinct.

Moderately corticated (2): referred to lesions, which were partially corticated (cortication is not clear and/or absent in most of areas).

Well corticated (3): referred to lesions with circumscribed, well defined radiopaque border that may be thinned and/or interrupted in localized area.

Expansion Other cortical changes included cortical expansion with or without visible margin and whether it involved destruction of the cortex and extension into the surrounding tissues.

Scale from 0-3 was given to describe these changes.

No expansion (0): means that no cortical expansion can be seen.

Expansion with visible margin (1): denoted expansion with clear sclerotic margin.

Cortical destruction (perforation) (2): denoted loss of continuity of the cortex.

Cortical destruction with extension outside the bone (3): described demolition of the cortex with signs of extension into the surrounding tissue.

Effects on adjacent structures such as teeth, mandibular canal, maxillary sinus, nasal cavity, and the orbit were reported as well.

On the teeth, effects of the tumour ranged from displacement and/ or migration (severe displacement), resorption of the roots and association of the tumour with impacted and /or unerupted teeth.

In the mandibular tumours, effects on mandibular canal were assessed for obliteration, displacement or no effects.

Effects of maxillary tumours on maxillary sinus were studied to assess extension of the tumour inside the sinus or displacement of the floor of the sinus.

Other effects that tumour may cause for instance invasion into the nasal cavity and displacement of the floor of the orbit.

4.3.2. Methods of Analysing Computed Tomography Images (CT)

Under the similar ideal examining conditions, CT images were analysed with special emphasis on additional information obtained from this technology. Aim of image examination was to determine the cortication of the tumour, expansion and cortical perforation, extension into the surrounding tissues and tumour density. Additionally, the growth pattern of the tumour was also determined whether it showed lobulation, budding, nodulation and /or crevice formation or mixed pattern.

Conventional CT helical and three dimensional reconstruction studies were performed on an RTS Twin, Excel 1800 or 2400 scanner (Elscent, Haifa, Israel), and a somatom emotion scanner (Siemens, Erlangen, Germany). Continguous axial and coronal 2- to 5-mm slices were acquired in bone and soft tissue windows. The CT examinations were oriented with lower border of the mandible (11-13 slices) and the maxillary occlusal plane (9-20 slices) respectively.

Coronal CT was oriented with the anterior border of the maxilla (15-23 slices). Helical or spiral CT examinations were acquired either at 2.7mm slice thickness, bed incrementation of 1.5 pitch, for dental reconstructions.

The odontogenic myxomas were evaluated using the following criteria:

Morphological features of the tumour: such as location of the tumour, internal structures and locularity in three-dimensions.

Locularity in three dimensions referred to the determination whether the septae separated the lesion completely into multiple compartments or represented partial or incomplete septation of the lesions.

Border or cortical margin of the tumour: described the border of the tumour, status of the cortex (for instance cortical thinning and/or perforation) and/or soft tissue extension.

Contents of the tumour: The tumour was compared to the surrounding muscles

using CT attenuation values (Hounsfield number) and accordingly the tumour was categorized as hypodense or isodense.

Pattern of the growth of the tumour: was investigated whether it showed lobulation, budding, nodulation and /or crevice formation or mixed pattern.

4.3.3. Methods of Analysing of MRI

MRI entered dental practice in Republic of South Africa in 1990 or few years before that. At the beginning, availability of this technology was limited in the oral and maxillofacial practice and this accounted for lack of MRI images in earlier cases. However, until now high cost may play a role in limited utilization.

MR examination at 0.5 T included 5-mm axial and coronal T2-weighted fast spin echo (long relaxation time and excitation time (TR/TE, 5336/120 ms), axial, coronal and sagittal T1weighted spin echo images (short TR/TE, 520/25 ms, Gyroscan T5-NT; Philips, Netherlands and Gyrex 5000, Elscint, Haifa, Israel) before and after intravenous GD-DTPA (Magnevist® at 0.1 mmol/kg; Schering, Berlin, Germany).

The odontogenic myxomas were evaluated on MRI using the following criteria:

Morphological features of the tumour: Signal intensities of the mass were compared to the surrounding structures and degree of homogeneity was reported in all images for instance T1WI and T2WI. Internal composition of the mass and pattern of enhancement were also assessed.

The degree of signal intensities on T1 weighted images is high for fat tissues and appears bright (high intensity) and muscle (isointensity) and fluid (low intensity), while on T2 weighted images, fluids appear bright (high intensity) and muscle (low intensity).

Border or cortical margin of the tumour: described the border of the tumour, status of the cortex (for instance cortical thinning and/ perforation) and/or soft tissue extension.

Extension and expansion of the lesions in all directions and in different planes were examined.

Internal structure of the tumour to determine the presence of trabeculae and whether it is fibrous or bony.

Pattern of the growth of the tumour: was investigated whether it showed lobulation, budding, nodulation and /or crevice formation or mixed pattern.

Findings and results for those three modalities were analysed carefully to elucidate the radiological technique that provide valuable diagnostic information and pre-surgical assessment of the precise extent of the odontogenic myxoma (OM).



Chapter 5

RESULTS

The results of the study were divided into 4 parts. The first part was the radiologic features of OM on the conventional radiographs. The second and third were the radiologic findings on CT and MRI respectively. The final or fourth part was the correlation of the radiologic features for the three imaging modalities.

5.1. Demographic Data

5.1.1. Age and Gender

A total of thirty-three records were reviewed. Twenty-three cases (69.7%) were reported in females and 10 cases (30.3%) occurred in males (Figure 5.1). For females age ranged from 12 to 44 years (average of 23.7), while in males 8 years was the youngest and 28 was the maximum age (average of 24.6 years). (Table 5.1)

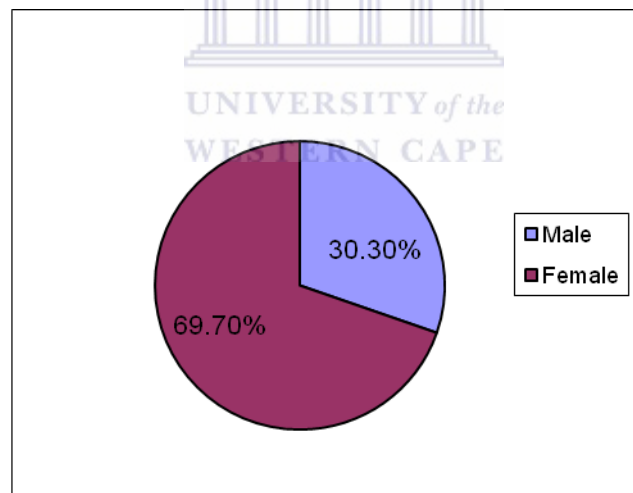


Figure 5.1. Gender predilection of odontogenic myxoma

1.2. Ethnic origin

Five of the patients (15.2%) were of Caucasian origin, all of them were females and their age ranged from 19 years as youngest and 31 years as oldest.

Table 5.1: Distribution of Odontogenic Myxoma by age, gender and ethnic groups

Age group (Years)	Male	Female	Ethnic		Total
0-10	2	0	Negroid	2	2 (6.1%)
11-20	5	5	Caucasian Mixed Negroid	1 6 3	10(30.3%)
21-30	3	10	Caucasian Mixed Negroid	3 7 3	13 (39.4%)
31-40	0	6	Caucasian Mixed	1 5	6 (18.1%)
41-50	0	2	Mixed	2	2 (6.1%)
Total	10 (30.3%)	23 (69.7)			33 (100%)

Mixed origin (coloured) predominated over the others with 20 patients (60.6%) reported in this category, 13 of them were females and 7 were males. Age of the patients with mixed ethnic origin ranged from 11-44 years.

Eight patients (24.2%) were negroids, of whom 5 females and 3 males reported (Figure 5.2). Age of the patients ranged from 8 years as youngest and 29 years as oldest.

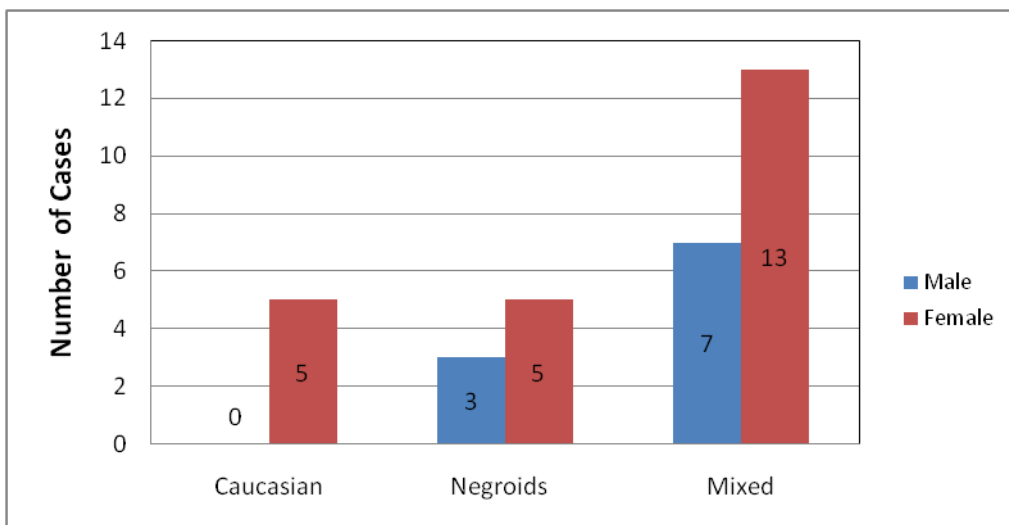


Figure 5.2. Distribution of OM by gender and race groups

5.2. Location

In the mandible 17 cases (51.5%) were reported, 9 of them (52.9%) occurred on the right side and 7 cases (41.2%) were reported on the left. In one case (5.9%) the tumour crossed the midline to the right side (Figure 5.3).

In the maxilla 16 cases (48.5%) were reported, half of these lesions were on the left (50%) and half were reported (50%) on the right side (Figure 5.3).

The majority of the cases occurred in the posterior regions of the jaws (body and ramus for the mandible and for maxilla it involved the premolars, molars areas and tuberosity).

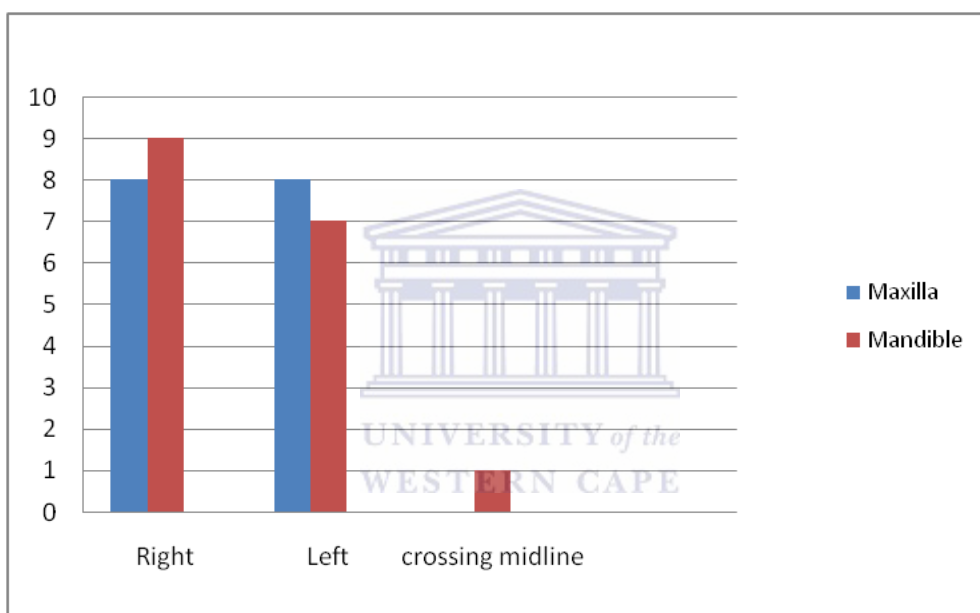


Figure 5.3: Distribution of OM according to location

5.3. Radiographic Features of Odontogenic Myxoma on Conventional Radiographs

The interpretation of all images was done retrospectively with knowledge of the histological diagnosis.

Thirty cases were examined radiographically using panoramic radiographs and/ or PA mandible, occipitontal and/ or occlusal views. No single radiographic feature could be designated for all cases of OM.

Summary of the radiographic features was listed in Table 5.2

Table 5 2: Radiographic features of odontogenic myxoma (N: 30)

Radiological feature	Maxilla	Mandible	Total
Internal structure of the tumour			
Unilocular radiolucency	1	1	2 (6.7%)
Unilocular with trabeculae	10	5	15 (50%)
Multilocular	3	10	13 (43.3%)
Cortication			
Uncorticated	7	2	9 (30%)
Poorly corticated	3	5	8 (26.7%)
Moderately corticated	4	8	12 (40%)
Well corticated	1	0	1 (3.3%)
Presence of tooth displacement	9	12	21(70%)
Presence of tooth migration*	2	1	3 (10%)
Presence of root resorption	1	2	3 (10%)
Association with impacted teeth	2	1	3 (10%)
Association with unerupted teeth	2	3	5 (16.7%)
Extension into the maxillary antrum	12	NA	12 (40%)
Obliteration and displacement of inferior alveolar canal	NA	14	14 (46.7%)
Extension into the surrounding tissues:			
Orbit	1	0	1 (3.3%)
Nasal cavity	1	0	1 (3.3%)

* Migration denotes severe displacement

NA: Not applicable

Internal structure of the tumour

The internal structure of the tumours showed varying radiographic appearances (Figure 5.4) and appeared as clear unilocular in 2cases (6.7%), multilocular in 13 cases (43.3%), while radiolucent with fine delicate (Figure 5.5) or sometimes coarse trabeculae appeared to be the most common form in this regard and reported in 50% of the cases (15 cases) (Table 5.3).

Cortication

Tumours appeared uncorticated in 9 cases (30%), poorly corticated in 8 cases (26.7%) and 12 cases (40% of the lesions) showed moderate cortication with a cortex that surrounded only part of the tumour. However one lesion (3.3%) was reported as well corticated.

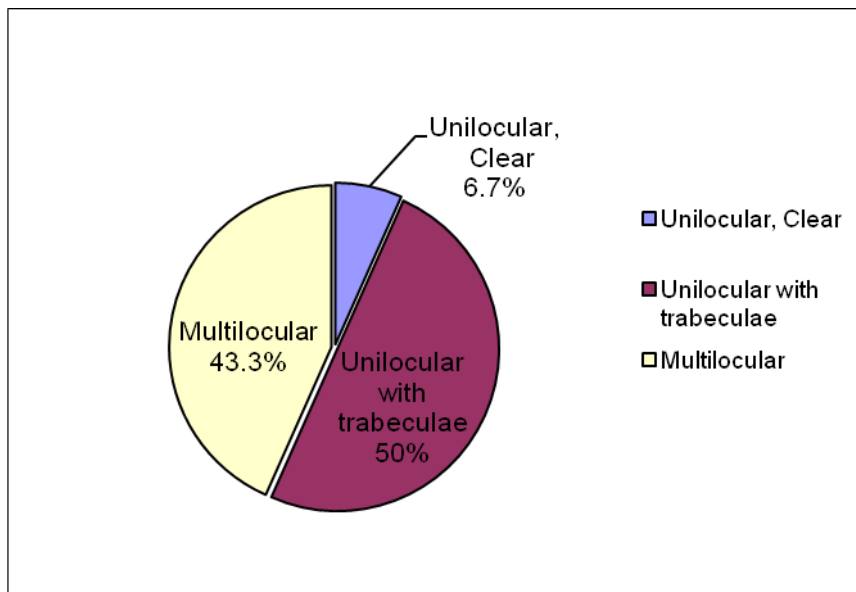


Figure 5.4: Internal structure of the tumour

Displacement of the teeth and root resorption

OM is an expansile lesion that showed tendency to displace the teeth in 24 cases (80%) (Figure 5.5), 3 of the 24 cases showed migration and severe displacement of the teeth. Eleven of these lesions were in the maxilla and 13 reported in the mandible. Root resorption appeared to be uncommon in the present study and was reported in only 3 cases (10%).

Association with impacted and/or unerupted teeth

Involvement of impacted or unerupted teeth within the tumours was common feature and panoramic radiographs showed association with impacted teeth in 3 cases (10%) (2 of them were in the maxilla and one in the mandible). Whereas in 5 cases (16.7%) involvement of unerupted teeth was reported. (3 cases were in the mandible and 2 in maxilla) both unerupted and impacted teeth showed some degree of displacement.

Table 5.3: Classification of OM according to internal structures of the tumours

Radiographic features	Maxilla	Mandible	Number of cases
Type I Radiolucent with no trabeculation	1	1	2 (6.7%)
Type II Radiolucent with trabeculation (mostly fine, sometimes coarse)	10	5	15 (50%)
Type III Straight and angular trabeculation which frequently form square or triangular compartments.	0	1	1 (3.3%)
Type IV Round or oval compartments formed by curved trabeculation	2	1	3 (10%)
Type V Tumour that shows combination of any two or more of the types described above.	1	8	9 (30%)

Effects on the mandibular canal

Effects on mandibular canal varied from displacement in 8 of 17 cases (47.1%), obliteration in 6 cases (35.3%), while 3 cases (17.6%) showed no effect.

Effects on the maxillary antrum

Maxillary lesions showed extension into the neighbouring structures such as maxillary antrum in 12 of the 16 cases (75%).

Effects on other structures

Extension into the orbit was shown in one case (6.25%) and into the nasal cavity in one case (6.25%).

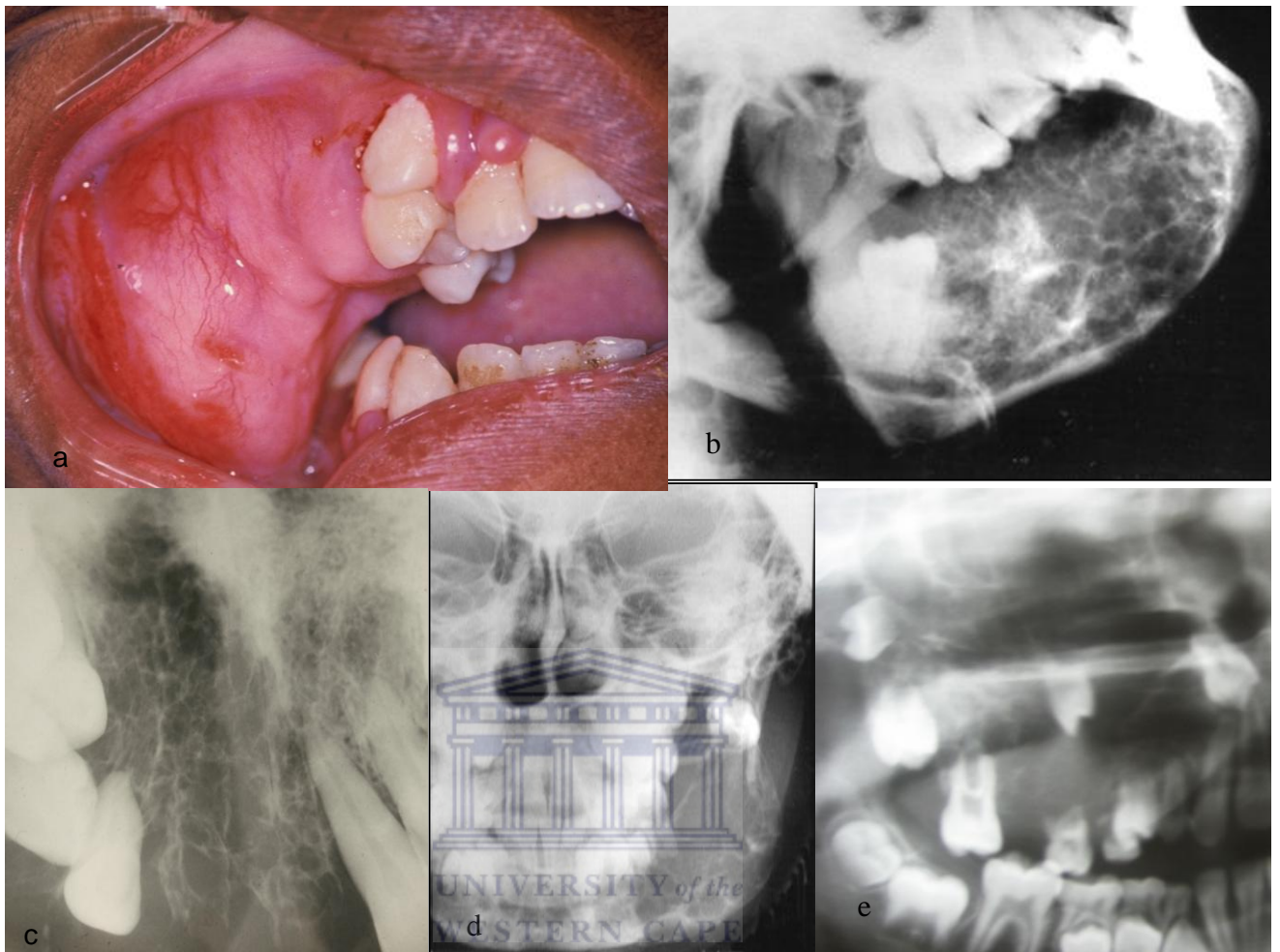


Figure 5.5 a. Clinical picture showing involvement of odontogenic myxoma in premolar-molar region and tuberosity of the maxilla. b demonstrating a multilocular appearance. c showing a fine delicate trabecular pattern. d demonstrating coarse trabecular pattern. e demonstrating extensive migration of teeth and involvement of maxillary sinus.

5.4. Radiologic Features on Computed Tomography (CT)

CT images were available in eight of the 33 records.

Density

On soft tissue window settings, attenuation values of OM were compared to the surrounding muscles and appeared as hypodense in 4 cases (50%) and isodense masses in 4 cases (50%).

Expansion

On CT, expansion of the tumours were detected in 7 of the 8 cases (87.5%), 5 of them (62.5%) showed expansion with interruption in the cortical margin and 2 cases (25%) showed expansion with visible cortical margin. In one of the 8 cases it was completely indistinct (12.5%).

In maxillary lesions especially at the level of maxillary antrum, expansion of the lesions seemed to be limited as the tumour tended to fill the maxillary sinus (Figures 5.6; 5.7; 5.8).



Cortication

Cortical margin of the tumours were detected on bone window settings in 87.5% of the cases (7 cases), 3 cases of these tumours (42.9%) showed moderate cortication while 4 of the 7 cases (57.1%) were well corticated. One of the 8 tumours lacks the cortical margin and appeared indistinct.

Corticated lesions showed thinning of cortex (Figure 5.7) and/ or interruption in some areas (Figure 5.8).

Internal structure of the tumour (locularity)

Multilocularity of the lesions was shown in 4 of the 8 cases while in 3 cases (37.5%) the tumour appeared as unilocular with fine lace like trabeculae most of them were observed toward the wall of the tumour. One of the 8 cases (12.5%) appeared as indistinct lesion with coarse trabeculae.

The growth pattern

Odontogenic myxoma is known for the distinctive growth behaviour. In the present study we found in 7 of 8 lesions (87.5%) with 95% exact confidence interval (0.4735, 0.9968) there is distinctive pattern of growth. The patterns ranged from lobulations (Figure 5.7) (2 cases) budding (2 cases) (Figure 5.9) and crevices formation in 3 cases (Figures 5.6, 5.8).

Extension into the surrounding tissues

CT displayed extension of the tumours into the surrounding structures in 6 of the cases (75%) with 95% exact confidence interval (0.3491, 0.9681). These structures included maxillary sinus (Figures 5.7; 5.8) orbit, nasal cavity (Figure 5.7) and air sinuses.

In two lesions, it was difficult to delineate the tumours from the surrounding tissues.

List of the imaging features of odontogenic myxoma on CT is shown in Table (5.4)

Table 5.4: Radiologic features of the odontogenic myxoma as seen on CT (N8)

#	Attenuation value	Expansion	Cortication	Locularity and internal structure	Growth pattern	Extension into the surrounding tissues
1	Hypodense	Visible margin	Well corticated	Multilocular	Budding	Yes
2	Isodense	Interruption	Moderate corticated	Multilocular	Crevices	Yes
3	Hypodense	None	Uncorticated	Coarse trabeculae	Indistinct	Indistinct
4	Isodense	Visible margin	Well corticated	Uni + FT	Budding	No
5	Isodense	Interruption	Moderately corticated	Multilocular	Crevices	Yes
6	Isodense	Interruption	Moderately corticated	Multilocular	Lobulation	Yes
7	Hypodense	Interruption	Well corticated	Uni + FT*	Crevices	Yes
8	Hypodense	Interruption	Well corticated	Uni + FT*	Lobulation	Yes

FT: fine trabeculae Uni: Unilocular



Figure 5.6. Axial CT image showing tumour on the right side of maxilla. Note the tumour is smooth walled on the buccal side while medially it showed tongue like projections (crevices) of the tumour into the bone (white arrows).



Figure 5.7. Axial CT (bone window) showing the tumour on the left side of the maxilla. The tumour obliterates the maxillary sinus and part of the nasal cavity. Note the scalloping nature of the periphery of the tumour (white arrows).

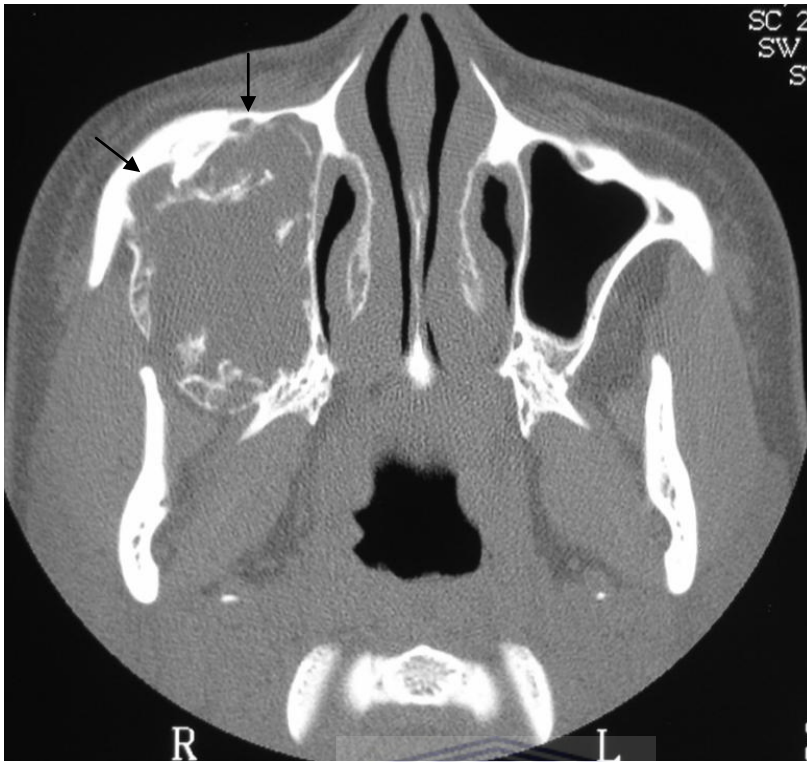


Figure 5.8 Axial CT (bone window) showing tumour on the right side of the maxilla. The tumour shows crevices formation on the buccal wall anteriorly (black arrows).



Figure 5.9. Axial CT at bone window setting showing a large expansile mass. Note the budding of the tumour into the right side of the alveolus (The white A).

5.5. Radiologic Features on Magnetic Resonance Image (MRI)

On MRI all tumours were detected vividly. In 90% of cases, the tumours appeared as well defined expansile multiloculated/lobulated masses with or without scalloping, small crevices and/or partial septation.

MRI morphology

The internal composition of the tumours was deduced based upon analysis and interpretation of signal intensities characteristics and pattern of contrast uptake.

On T1WI (Figure 5.10) the odontogenic myxomas appeared as heterogeneous lesions with mixed hypo/ isointensity in 90% of the cases with 95% exact confidence interval (0.5550, 0.9975).

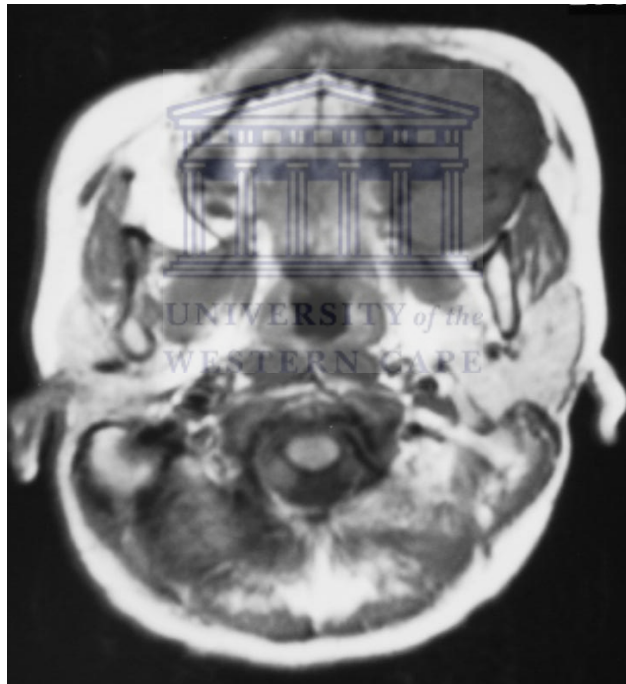


Fig 5.10 T1W1 axial MR image through the mouth at the level of the upper alveolus showing the tumour as a predominantly hypointense signal with focal areas of isointensity.

On T1WI with gadolinium (Figures 5.11) the images displayed various patterns of contrast uptake/ enhancement. Some areas of the tumours enhanced markedly and were assumed to be collagenous. While in other areas we found that tumour tissue did not enhance and were accordingly deduced as myxomatous and/or bony septae. In the present study 9 of the lesions (90%) with 95% exact confidence interval (0.5550, 0.9975) appeared to contain both components while in one case it

appeared as predominantly myxomatous tumour. T2W images clearly defined the extent of the lesions in all tumours. The tumours appeared heterogeneous with mixed areas of high signal intensity and Hypointensity in 90% of cases (Figures 5.14, 5.15). In one case the lesion appeared homogeneously hyperintense.

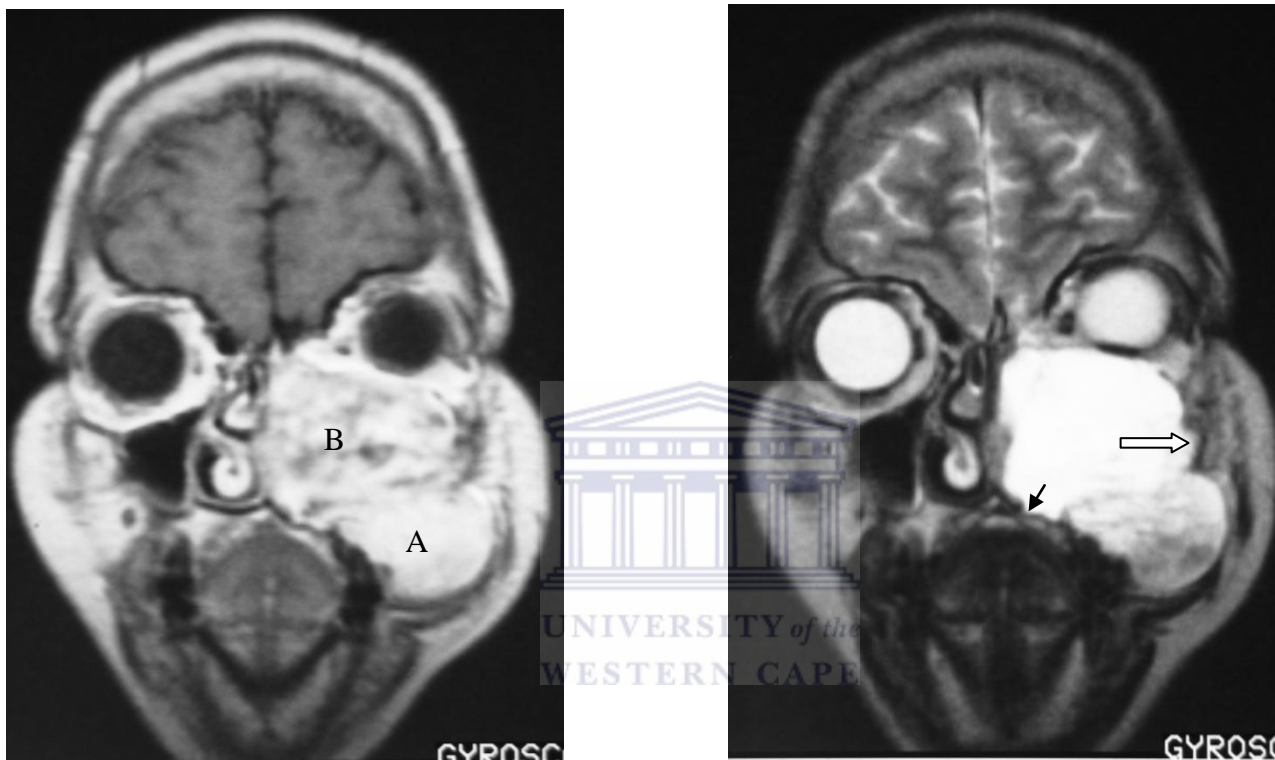


Figure 5.11.* (Left) T1 post-contrast MR images displayed various patterns of contrast uptake/ enhancement. Some areas of the tumours enhanced markedly and were assumed to be collagenous (**A**). While in other areas we found that tumour tissue did not enhance and were accordingly deduced as myxomatous and/or bony septae (**B**). **Figure 5.12.* (Right)** T2 coronal MR image showing the tumour on the left side of the maxilla. Extension of the tumour is defined precisely. The tumour is well-defined with scalloping in the lateral wall (white arrow) while the palatal wall showed some degree of budding (black arrow). Note that upper part of the tumour (**A**) shows homogenous (myxomatous component) while the lower part (**B**) showed the solid (collagenous) component of the tumour.

(*Images published with kind permission of professor LJ.van Rensburg)

Expansion

Expansion of all the tumours were clearly shown on MRI, 60% showed cortical perforation in some areas with extension into the surrounding tissues. While 40% showed expansion with preservation of the cortical margin in most areas of the tumour.

Cortication

The tumours were well corticated in 30% (3 cases) and 7 cases (70%) showed moderate cortication.

Internal structures of the tumours

Lesions appeared as multilocular in 6 of the cases (60%). While 30% (3 cases) showed unilocular with fibrous or bony trabeculae, one of the cases (10%) appeared as unilocular lesion.

The growth pattern

In the present study, we found that all odontogenic myxomas (100%) with 95% exact confidence interval (0.6915, 1.0000) showed distinctive patterns of growth. Growth pattern of odontogenic myxomas ranged from lobulations (4 cases) (Figures 5.12; 5.13), crevices formation (2 cases) (Figures 5.13), and budding (1 case). In 4 of the tumours, the pattern of growth was reported as mixed with two or more types of the patterns (3 cases) (Figure 5.15)

Extension into the surrounding structures

On MRI, all lesions (100%) with 95% exact confidence interval (0.6915, 1.0000) showed some degree of extension into the surrounding structures. In the maxillary lesions, the tumour extended into maxillary sinus (Figures 5.11, 5.12) nasal cavity (Figures 5.12; 5.13) nasal turbinate, infratemporal fossa, and floor of the orbit. In the mandibular lesions, the tumours extended into floor of the mouth (Figure 5.16), pterygoid space (Figures 5.16).

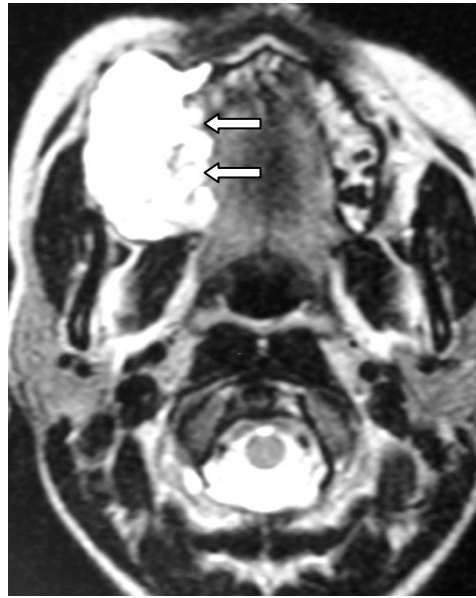


Figure 5.13. (Left) Axial T1- post (gadolinium) contrast MR image-at the level of the alveolus-peripheral areas markedly enhanced while the centre and anterior area of the mass enhanced weakly. Differences in the pattern of contrast uptake reflect different composition of the mass which is mostly collagenous to the periphery and myxomatous toward the centre and anterior area at this level. **Figure 5.14. (Right)** Axial T2 MR Image of the same level showing a hyperintense mass. The tumour showed scalloped margins with crevices on the palatal side (white arrows).



Figure 5.15. (Left) Axial T2 MR image showing a large mass that extends lingually into the floor of the mouth and extends buccally, posteriorly and involving the ramus of the mandible. Small locule of the tumour (**A**) presented as hyperintense area in the ramus of the mandible and extends lingually in the pterygoid muscle. **Figure 5.16. (Right)** Axial T1WI section through the tongue showing a mass which appear as mixed areas of hypo/isointensity. The mass extends into the floor of the mouth and extends within the mandible with bucco-lingual expansion.

NO.	Cortication	Expansion	locularity	T1	T2	Enhancement	Composition of the tumour	Extension into the surrounding tissue	Growth pattern
1	Moderately corticated:	Interruption	Multilocular	Mixed	IH	Yes (periphery)	Mixed	Yes (FOM)	Lobulations and Crevices
2		Interruption	Multilocular	Hypointense	H2	No	Myxomatous	Yes	Crevices+ Budding
3		Visible margin	Multilocular	Mixed	IH	Yes(periphery)	Mixed	Yes	Lobulation
4	Moderately corticated	Visible margin	Multilocular	Mixed	IH	Yes(mild)		Yes	Lobulations
5	Well corticated	Interruption	Fine trabeculae	Mixed	IH	Yes(periphery)		Yes(MA)	Crevices
6		Visible margin	Multilocular	Mixed	IH	Yes (Periphery)		Yes(MA, NC)	Lobulations
7		Visible margin	Fine trabeculae	Mixed	IH	Yes (mild)		Yes(ITF)	Budding
8	Moderately corticated	Interruption	Multilocular	Mixed	IH	Yes(periphery)		Yes(MA,FOO, NC, AS)	Crevices formation
9		Interruption	Fine trabeculae	Mixed	IH	Yes (bottom)		Yes (MA. Maxilla)	Budding and Crevices formation
10		interruption	Unilocular	Mixed	IH	Yes (bottom)	Yes (MA,FOO,NC,AS)	lobulations	

Table5.5: Imaging features of odontogenic myxoma on MRI (N10)

- Well corticated cortex may be thinned or even interrupted in localized area.
- Moderately corticated cortex is interrupted in most of areas).
- Poorly corticated transitional zone is wide and/or indistinct.
- Fine trabeculae denotes unilocular lesion with fine trabeculae

IH: Inhomogeneous hyperintense, H2: Hyperintense, FOM: floor of the mouth, MA: maxillary antrum, NC: nasal cavity, ITF: infra temporal fossa, FOO: floor of the orbit, AS: air sinuses.

5.6. Evaluation of the Three Imaging Modalities

In the present study five records had complete set of panoramic radiographs, CT and MR images. These images were evaluated and contrasted with regard to the demarcation, cortication, expansion, extension into the surrounding tissues, locularity, effects on the teeth,

Demarcation

On both CT and MRI, 4 of the lesions (80%) showed well demarcation and definition and one case (20%) was moderately demarcated. While on panoramic radiographs 80% of the lesions appeared as poorly or undemarcated lesions and 20% (1 case) was moderately demarcated.

Cortication

On CT and MRI, all tumours (5 cases) showed moderate to well cortication. While on panoramic radiograph 60% of the tumours were moderately corticated and 40% showed no cortication.

Expansion

All tumours, on CT and MRI, showed some degree of the expansion and 80% of them (4 cases) displayed cortical perforation. However on panoramic radiograph, 40% of the tumours showed no expansion and 20% showed expansion of the tumour with cortical perforation.

Locularity

One of the cases that appeared as multilocular on panoramic radiograph was found to be unilocular on CT, MRI.

Effects on the teeth

Displacement and migration of the teeth were shown easily on panoramic radiograph. However on CT and MRI, they were shown only in specific slices and planes.



Consistency of the tumours

The contents of all tumours were deduced on MRI as it gave different signal intensities to different compositions. While Hounsfield numbers on CT illuminate the densities of the tumours compared to muscles. However CR was deficient in this regard.

Pattern of the tumour growth

MRI displayed distinctive pattern of the growth in all tumours, while CT showed it in 4 of the 5 cases. However, panoramic radiograph was unable to display such a feature.



Chapter 6

DISCUSSION

6.1. Introduction

Odontogenic myxoma of the facial bones is the most common head and neck myxoma (Wachter *et al* 2003). Since it mostly occurs inside bone therefore radiological examination is especially important to diagnose the tumour and differentiate it from other tumours (especially malignant ones), and to allow proper planning of the surgical treatment.

The reasons that may explain the recurrence of the tumour include frequent invasion of the tumour into the adjacent tissues, incomplete removal and/ or spillage of the tumour tissue in the operating field due to gelatinous nature of the tumour (Noffke *et al* 2007, Brannon 2004, Wachter *et al* 2003, Regezi *et al* 1999).

In our study we could not determine exactly the rate of recurrence for majority of the cases as most of the patients were living at distant areas from our centre and did not enrol in regular follow up regime. However for all the patients treated in the last 15 years at Tygerberg hospital there have been no reports of recurrence. Nevertheless the possibility that patients might report to other centres can not be excluded. In addition to the fact that recurrence has been reported as long as 15 years or may be more after the removal of the primary tumour (Wachter *et al* 2003).

Odontogenic myxoma is a rare condition, a fact that may explain scanty studies with comparatively few numbers of the cases. Moreover the general believe that MRI has limited rule in the diagnosis of facial and jaw pathology contributes to paucity of the studies in this field. The present study is unique in that in addition to conventional radiographs in 30 records, it also included eight CT and ten MRI records. This number of MRI records was considered relatively large compared to the sporadic case reports described in English literature. It also described the imaging features of OM as seen on CT. To our knowledge only two studies with significant number of patients were reported. One of them (multi-centre study) with 17 patients was done in Japan by Koseki and his colleagues (2003) and the other involved 8 patients and

was done in China by MacDonald-Jankowski and co-researchers (2004).

6.2. Demographic Data

Age

Odontogenic myxoma (OM) was reported to occur in wide age range. In our study we found that the common age was younger than the age reported by other series with prevalence in the second (10 cases) and third (13 cases) decades of life. However corresponding to the other studies we noticed that OM was rare before the age of ten years (only two cases reported in the first decade) and after 50 years. An interesting observation is that in children and young adult, OM appeared to be extensive and more aggressive compared to those observed in older age. The reason for this is unknown however structure of the bone and/or vascularity of the bone may play role.

Gender Predilection

In the present study we found that OM had predilection to female (69.7%) compared to males (30.3%). This finding is in agreement with the results obtained by many authors (Noffke *et al* 2007, Simon *et al* 2004, Peltola *et al* 1994 and others) and it contradicted the results of equal gender frequency reported by Regezi *et al* (1999) and male predominance by van Rensburg *et al* (1994) and Brannon (2004).

Ethnic Origin

OM was found to predominate in people of mixed ethnic origin (coloured) (60.6%) followed by Negroid patients (24.2%) while 15.2% of cases were reported in Caucasian people.

6.3. Location

Considering the location, the difference was insignificant and 17 cases reported in the mandible compared to 16 reported in the maxilla. These results are consistent with those available in the literature (Noffke *et al* 2007, Simon *et al* 2004, van Rensburg *et al* 1992). In both jaw most of the tumours predominated in the posterior regions, this result concurs with the finding obtained by Simon *et al* (2004) and Brannon (2004).

6.4. Radiographic Appearances of Odontogenic Myxoma

In view of radiographic appearances of OM, the author supported Peltola and colleagues (2003) in their claim that radiographic appearance of the odontogenic myxoma is more complicated than generally thought.

There is a lot of debate and controversies regarding the internal structure and locularity of the tumour. Some authors (Brannon 2004, Barros *et al* 1969) claimed that occurrence and absence of loculation describes the stage of tumour development. They assumed that tumours started as multilocular lesions that increase in size with ongoing resorption of the trabeculae and subsequent conversion of the tumour to unilocular lesion. This concept seemed attractive and logic and in some way it may explain the appearance, for instance, of a lesion with combined appearance of honey comb and radiolucent with fine trabeculae. However, on MRI and CT some trabeculae appeared as fibrous or collagenous and may suggest that these trabeculae developed within the lesion. On the other hand some investigators believed that these two forms occur independently and this may be supported by the fact that in our study some tumours appeared as small radiolucent with no trabeculae while other appeared as large multilocular lesions. Therefore based on the findings of the study the investigator agreed to the postulation that both forms occur independently. Furthermore the author assumed that trabeculae can develop within unilocular lesion and convert it into multilocular lesion.

In our study we have chosen to describe radiographic features of the internal structure of the tumour as radiolucent lesion that contain no trabeculae (clear-cystic), or compose of trabeculae that can be thin or thick, those trabeculae differ in shape and can be straight or curved and may extend to divide the mass completely into adjacent compartments. This classification (Table 2) was adapted from Koseki et al, (2003) and modified by the investigator to include the other features in the literature for instance the appearance of fish net, wispy pattern and others. Furthermore the investigator developed a new category (Type 5) in which a combination of two or more types were present (Table 2). For instance type 5 in which two features were present, radiolucent with some trabeculae and multilocular part.

Various interpretation and description by different authors should be treated with

caution as different projections of the images would give different shape. Moreover different terms may indicate the same appearance, for instance unilocular lesion and radiolucent with no trabeculae.

In the present study the radiolucent lesion with trabeculation (Type 2) appeared to predominate over the other forms (50% of the cases examined with radiographs).

The boundary between the tumour and surrounding normal tissues represent a critical zone that reflects the biological behaviour of the tumour. In this regards results from the radiographs available for 30 of the cases seemed consistent with the distinctive invasive behaviour of odontogenic myxoma (OM) as it showed frequent interruption of the cortex. The tumour appeared moderately corticated (40%), poorly corticated (26.7%), and uncorticated (30%) whereas well corticated was reported in only 3.3% of the cases.

Majority of the tumours were associated with partial anadontia (i.e. missing teeth) in the area of the tumour. The reason for that is uncertain because the study was a retrospective study. Looseness and mobility of the teeth by the mass itself could be an explanation for this finding. Nevertheless misdiagnosis of the swelling to be of dental origin and necessity to remove the teeth subsequently should also be considered as a possible reason.

On panoramic radiographs, expansion of the lesion was assessed taking in consideration the two dimensional nature of radiographs and was evaluated by degree of associated teeth movement. In the present study we found that expansion with/or without cortical margin was detected in 25 cases (83.3%) and expansion ranged from minimal which led to mild displacement of the teeth to large expansile mass which associated with severe displacement and migration of teeth. However in the maxillary lesions corresponding to the findings by some authors (Wachter *et al* 2003) the tumours grew silently inside the maxillary sinus and resulted in opacification of the sinus.

Teeth displacement was common finding and detected in 80 % of the cases, while root resorption was found in only 10% of the cases. These findings corresponded to results obtained by Noffke *et al* (2007), Peltola *et al* (1994) and many other authors and correlated well with the fact that OM is slowly growing tumour. Nevertheless

these findings contradicted the results of high occurrence of root resorption reported by Simon *et al* (2004).

Encroachment of the maxillary sinus was reported in 12 lesions of the 14 maxillary cases that underwent radiographic examination. Corresponded to literature radiographic involvement of the nose and orbit were rare and detected in only 2 cases for each (Noffke *et al* 2007).

Effects in the mandibular canal include obliteration and displacement of the canal and were found in 14 of 17 reported mandibular lesions.

Involvement of impacted and unerupted teeth was reported in 26.7% of the cases (8 cases). The occasional association with missing and/or unerupted teeth support the assumption by Noffke *et al* 2007, Simon *et al* 2004 and many others that intraosseous myxoma is odontogenic in origin.

6.5. Radiologic Features of Odontogenic Myxoma on CT

Radiological appearances of the odontogenic myxoma on CT were reported for 8 lesions. To best of our knowledge only two studies had significant number, 17 cases by Koseki *et al* (2003) and 8 cases by MacDonald-Jankowski *et al* (2004).

Density of the tumours when compared to muscles were found as hypodense in 4 cases (50 %) and isodense masses in 4 cases (50 %) these results differ from the findings obtained by Koseki *et al* (2003), he found isodensity to occur in 23.1% compared to 76.9% hypodense lesion.

On contrary to the results obtained by Koseki *et al* (2003) in his study, the investigator found that multilocularity with definite bony septae is a common finding and was reported in 50% of the cases. However unilocular lesions were reported in 3 cases (37.5%) and showed some trabeculae that observed mostly toward the periphery of the tumour. This finding is in agreement with previous observation by many authors (Koseki *et al* 2003, Asami *et al* 2001, Chiodo *et al* 1997) that on CT, a characteristic finding of odontogenic myxoma is strands of fine lace like density. This finding was supported by Noffke *et al* 2007 who described that bony septae were found in the peripheral portion of the tumour in histological examination. This

feature was found to a lesser degree in multilocular lesions as well (Figure 5.8).

Odontogenic tumour is an expansile lesion, 87.5% of the cases showed expansion with or without complete cortical margin and 12.5% of the tumours appeared indistinct. Expansion of the lesion ranged from minimal where the mass enlarge at the expense of the marrow spaces especially in mandibular lesions. However in the maxilla the lesions partially or completely filled the maxillary sinus (Figures 5.7, 5.8). In our study we found that some of the tumours had reached large size with buccal and lingual/ palatal expansion that accompanied with distortion, thinning, and /or perforation of the cortex (Figure 5.7, 5.8).

Since the definitive invasion of the tumour into the surrounding tissues could only be confirmed histologically and as we examined images retrospectively therefore in this text we preferred the term extension rather than invasion.

On CT, all the tumours had cortical interruption in-at least- focal or localized area however 6 of the 8 cases (75%) were well delineated from the surrounding tissue. Therefore it should be clear that not all cases with cortical interruption denote soft tissue invasion. This observation was explained by van Rensburg (2003) for ameloblastomas which virtually share the same biologic behaviour with odontogenic myxoma. Van Rensburg stated that periosteum act as a barrier and prevent extension of the tumour into the soft tissue. This may result in compression of soft tissue and consequently the compressed tissue may act as pseudocapsule and the tumour can be easily defined from surrounding tissues even in the absence of cortex. Accordingly he stated that soft tissue invasion of the tumours is diagnosed by presence of focal interruption and absence of the smooth pseudocapsule.

On CT, two lesions that showed cortical incontinuity were difficult to delineate from surrounding soft tissues. This finding opposed the claim by Koseki *et al* 2003 that myxomas are completely distinguished from surrounding structures at the area of cortical disruption with a smooth margin.

Hounsfield values (HN) were evaluated for 4 of the 8 cases and ranged from 10 to 121 this gave a clue about consistency of the tumour. According to Parks (2001) these 4 lesions ranged from thick watery consistency (HN for water 0, CSF15) to a tissue that is denser than the muscle which has HN 50 and less the bone marrow

(HN 300).

Another advantage on CT is the ability for 3-dimensional reconstructions and the investigator agree with Shah and Patel (2003) in their statement that three-dimensional reconstructions are valuable in assessing the true extent of the tumour, particularly with reference to planning reconstructive procedures. And on 3D-CT it was found that on one of the tumours that the cortex was interrupted (perforated) but the tumour was contained within the bone. Another case that underwent 3D reconstruction the macroscopic appearance of the tumour and relation to surrounding tissues were vividly demonstrated. The procedure of the image reconstruction is complicated and performed by the computer system of the CT scanner. However the explanation of the procedure is beyond the scope of this study.

6.6. Radiologic Features of Odontogenic Myxoma on MRI

To our knowledge this study is the first one to describe the radiological features of odontogenic myxoma as seen on MRI. Although the number of cases is comparatively few nevertheless it is almost equal to the sum of all the case reports in English literature from 1994 up to date.

MRI has the ability to demonstrate the lesions vividly with determination of the margins. All the tumours appeared as well to moderately defined lesions, these findings corresponded to observations made by Sumi *et al* 2000 and Kawai *et al* 1997.

On MRI, 7 lesions were moderately corticated and 3 were well corticated.

MRI and enhanced MRI were found to differentiate myxomatous and collagenous parts within the tumour by assigning different signal intensities to different tissues. In the present study we found that majority of the cases (90%) showed a mixture of both tissues while only one tumour appeared as predominantly myxomatous in the composition.

On contrary to the findings reported by Kawai and his team (1997) the results in the present study showed mixed low/intermediate signal intensity on T1 weighted

images. While on T2 weighted images the tumours appeared as hyperintense mass which were heterogeneous in 90% of the cases. These results corresponded to the findings obtained by many authors (Defatta *et al* 2006, Aquilino *et al* 2006, Hisatomi *et al* 2003, Wachter *et al* 2002, Asaumi *et al* 2001 and Sumi *et al* 2000) Variation in the contrast uptake (enhancement) of the various parts of the tumour reflected different histological composition within the tumours. Asaumi *et al* (2001) stated that collagen bundles enhanced markedly. In the present study 50% showed marked enhancement in the periphery while the centre did not enhance. This finding is consistent with the results obtained by Asaumi *et al* (2001). In 3 of the tumours, enhancement appeared on the bottom of the tumour on the coronal section (Figure 5.10)

On the basis of histologic examination and according to amount of fibrous or myxomatous tissue within the tumour many terms had been assigned like myxofibroma, fibromyxomas and odontogenic myxoma. However it is generally believed that all types of the tumour share similar biologic behaviour and differentiation appeared to be of academic interest. This concept is not totally accepted by the investigator as we found that fibrous part is usually to the periphery or bottom of the tumour (Figure 5.12). Since the biological behaviour of a tumour is toward the periphery we assumed that the aggressiveness is inversely related to the fibrous component of the tumour. However this assumption needs further studies to be confirmed.

Asaumi *et al* (2001) claimed that unlike ameloblastoma, odontogenic myxoma is not a consistent mass and is able to invade between the roots of the teeth. This finding was also reported by the investigator in two of the cases. However collagenous part of the tumour appeared to cause displacement and resorption in other lesions.

On MRI we found that 6 of 10 cases were multilocular while 4 cases (40%) appeared as unilocular with trabeculae inside some of them. These trabeculae ranged from fibrous which enhanced after gadolinium to bony which appeared as areas of hypointensity and appeared dark.

All lesions, on MRI, showed extension of the tumour into the adjacent structures. These structures include maxillary antrum (5 cases) (Figures 5.11), air sinuses

(Figures 5.11), displacement of floor of the orbit (4cases)(Figures 5.12) nasal turbinate and palate and in some cases the tumour may extends into the infratemporal fossa (Figure 5.7) for maxillary lesion. While for mandibular lesions extensions into the floor of the mouth (Figures 5.15) and pterygoid spaces (Figure 5.16) were reported. However even in cases where the tumour extended into soft tissues such as floor of the mouth, MRI was able to differentiate between various soft tissues for instance tumour tissue and tissue in the floor of the mouth. This finding is one of the major advantages of MRI over the other techniques.

On MRI, the walls of the tumours and patterns of the growth were clearly depicted. Although the tumours displayed predominantly smooth wall, however in focal areas scalloping (Figure 5.10), crevices budding of the tumour and /or lobulations (Figure 5.15) were detected. These features supported the distinctive infiltrative nature of the tumour. However a prospective correlative (radiologic-histologic) study is needed to confirm the assumption that areas of crevices, scalloping, and budding represent the imaging feature for invasive part of the tumour.

6.7. Correlation of the Three Imaging Techniques

For 5 of the patients complete sets of CR, CT, MRI were available. These images were evaluated and contrasted according to radiological information obtained by each of them.

The three imaging modalities were able to detect the presence of the pathology; however MRI and CT exclusively detected the tumours with determination of the extension. On MRI and CT all lesions appeared as well or moderately defined. While on panoramic radiograph only 20% were well defined and 80% of the cases appeared as poorly or undefined lesions.

Multiplanar facility of the CT and MRI offered the advantage of determining extension of the tumour in the different planes. This benefit greatly affects management in maxillary lesions where extension of the mass is possible to cranial base or to the floor of the orbit and/or air sinuses.

Cortication was best shown on CT with 80% appeared as well circumscribed lesion with radiopaque margin while on MRI it appeared as dark. Panoramic radiograph

showed well cortication in 60% of the cases.

Panoramic radiographs displayed the general topography of the tumour and surrounding area, therefore they showed the displacement of the teeth easily. While on MRI, CT because of the different slices and planes they only showed the displacement in its plane.

Moreover high spatial resolution on CR accounted for the ability of the radiograph to show resorption of the teeth. On MRI it was possible to show extension of some tumours between the roots.

Expansion and extension of the tumour is a feature that revealed great aptitude of digital imaging. MRI showed the expansion, exact extension of the tumours in all cases and/or infiltration into surrounding structures. On CR 40 % of the cases showed no expansion while only 60% showed expansion of the tumour with or without cortical perforation.

Regarding locularity of the tumour 20% of the cases which appeared as multilocular on CR, were found on MRI and CT as unilocular lesions with trabeculae that did not separate the tumour completely. This finding concurs with the claim by Koseki *et al* (2003) that digital imaging showed the tumours in three-dimensions unlike conventional radiography which has the shortcoming of two dimensions.

The contents of the tumours were deduced in all cases by MRI which has the advantage of giving different signals to various tissues. CT in the other hand was able to determine densities of the tumours. However CR lacks this advantage and failed to differentiate various components of the tumours.

Distinctive patterns of growth of the tumours were observed in all cases on MRI and CT and appeared as lobulations, budding, crevice formation. We assume that these parts of the lesions may account for high recurrence rate associated with OM especially after conservative surgery. Since the conventional radiographs failed to show the growth pattern of the tumours, this also confirm superiority of digital imaging and may dictate the necessity of using digital imaging in diagnosis and presurgical assessment of the tumour.

Chapter 7

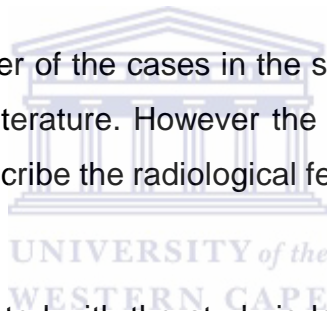
LIMITATIONS OF THE STUDY

This retrospective study has inherent limitations such as lack of some information. For instance in this study it was difficult to determine the clinical symptoms and sign of the tumour especially for earlier cases where the files were destroyed and only images and histopathological reports with personal data were kept in the museum of the Department of Diagnostics and Radiology at the Tygerberg Oral Health Centre.

One of the signs that couldn't determine was the reason for partially edentulous area associated with majority of the tumours. It was not possible to determine reason for this and whether the looseness of the teeth by the tumour itself or misdiagnosis that swelling was of dental origin and subsequently teeth were extracted.

Another limitation is the number of the cases in the study though large compared to other available series in the literature. However the sample is not large enough to generalize and confidently describe the radiological features of odontogenic myxoma as seen on MRI and CT.

Another limitation that associated with the study is lack of the follow up reports for many of the patients. The reason for that is the failure of the patients to report for follow up visits due to the fact that most of them live at distant areas from Tygerberg oral health centre.



Chapter 8

CONCLUSIONS AND RECOMMENDATIONS

Odontogenic myxoma (OM) is benign tumour that is important because of its aggressive biologic behaviour and recurrence associated with this tumour. These factors (distinctive biologic behaviour and recurrence) in addition to paucity of such studies prompted the author to study various imaging techniques currently in use for the diagnosis of the tumour.

Role of radiology in the diagnosis of OM cannot be overemphasized due to the fact that the tumour occurs inside bone and can reach a considerable size with little or no clinical manifestations. In addition to necessity of clear image that show the tumour boundaries prior to treatment in order to avoid incomplete or deficient surgical removal.

Conventional radiography being accessible, feasible, cheap and easy in interpretation makes it a basic and essential tool in the investigation process. However conventional radiography has many limitations especially with regard to a tumour such as OM which infiltrate into the surrounding structures. These limitations were greatly overcome by advanced technology such as CT and MRI.

In the present study, CT was found to show the extension of the tumours, status of cortication, expansion, locularity, and extension into the surrounding structures. Moreover CT -by determining the attenuation values of the lesions- was able to compare the densities of the tumour to the surrounding muscles. In addition to that advantage of three dimensional reconstructions (3D-CT) will improve treatment outcome and allow proper preoperative planning of reconstructive treatment such as graft in order to replace the resected disease tissue.

MRI reliably showed the extension of the tumour, contents, and pattern of the growth of the tumour. Additionally MRI was found to differentiate between various soft tissues and to determine invasion of the tumour into adjacent soft tissues.

Based on the facts that presence of invasion into the surrounding tissue may account for recurrence associated with the tumour and supported by the findings of

our study we assume that use of digital imaging (MRI, CT) will allow proper planning of the surgical treatment. This subsequently improves the treatment outcome by adopting one successful surgery with complete removal of the tumour and the crevices. In addition, 3D-CT facilitates reconstruction of the lost part of the facial regions if immediate graft is planned. This will minimize the psychological distress of the patients postoperatively bearing in mind that the tumour usually affect young age (less than 40 years) and mostly females are the victims. In addition to that it reduces the overall treatment cost by lessening the need for second operation with the accompanying risks of general anaesthesia.

The present study met the objectives set for it with regard to the following:

1. Description of the imaging features of OM as seen on conventional radiograph for 30 cases and the results compared to findings available in the literature.
2. Analysis of CT images to describe the imaging features of the odontogenic myxoma (8 /33 cases).
3. Analysis and study of the imaging features of the odontogenic myxoma on MRI for 10 /33 cases and it is the first study in this regard.
4. Radiological information obtained by each of three modalities was correlated and contrasted with each others and the results reported.

On the basis of the findings and results of the study the author recommend the following

1. Use of the three imaging modalities (CR, MRI and CT) - whenever possible- should be a routine in the process of diagnosis of any pathology especially those that may mimic the malignant tumour radiographically or if any suspicion arose regarding invasion of the tumour into the surrounding tissue.
2. Relying on conventional radiographs only for presurgical assessment of the tumour make the recurrence an inevitable result and absolutely discouraged by the author.

3. As CT shows distinctive imaging features that may suggest the odontogenic myxoma in addition to display fine details of the tumour then a minimum regime of diagnosis should include CR and CT.
4. There is a need for a prospective study that correlate the radiologic and histologic features of the odontogenic myxoma in order to confirm the characteristic features on CT and MRI that may indicate the tumour.
5. With regard to the limitation of the study the next step should be a multi-centre study with a large number of the patients.



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