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Cone Beam Computed Tomography as an Aid in Oral and Maxillofacial Surgery

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ABSTRACT
Imaging plays an important role in the diagnosis and management of various diseases and conditions in Oral and Maxillofacial Surgery. Cone Beam CT (CBCT), also called digital volume tomography, is a new type of CT imaging designed specially to image the hard tissues of the maxillofacial skeleton. CBCT imaging has revolutionized the diagnosis and treatment planning process in maxillofacial surgery. The preoperative application of CBCT using a dental three-dimensional CT as an assessment tool is described here. Information about the lesion and the relationship between the lesion and their adjacent anatomical structures are useful during surgery. A case of mandibular body fracture not visualized on Orthopantomogram (OPG) was clearly demonstrated on CBCT and various other such application of CBCT is reported. The purpose of this article is to provide an overview of the unique image display capabilities of maxillofacial CBCT.

Keywords: Cone Beam CT, Oral and Maxillofacial Surgery

INTRODUCTION

Radiology is important in the diagnostic assessment for patients suspected of having dental and maxillofacial disease. A combination of plain X-ray projections and panoramic radiography can be adequate in a number of clinical situations [11]. In addition to conventional radiography, computerized tomography (CT) and Magnetic resonance imaging (MRI) have been widely used for investigation in maxillofacial region [8]. CT developed in 1972, enabled conditions to be diagnosed with 3DCT. CT has had a profound effect on surgical and medical practice. CT is used extensively in the diagnosis of pathological conditions, traumatic injuries. CT is not ideal for diagnosis of diseases particularly to dentistry, such as impacted teeth or apical lesions. CT device are relatively large, expensive and exposes the patient to relatively high doses of radiation [4].The introduction of CBCT has led to rapid evolution of diagnostic imaging in recent years [9]. CBCT is advancement in CT imaging that has begun to emerge as a potentially low dose cross sectional technique for visualizing bony structures in the head and neck [7].CBCT was first developed for use in angiography but more recent medical applications have included radiotherapy guidance and mammography. Mozzo et al reported the first CBCT unit developed specifically for dental use, the Newton 9000 at Italy [1]. Arai et al in late 1990's also pioneered CBCT scanners independently in Japan [10].CBCT is a medical image acquisition technique based on a Cone shaped X-ray beam centered on a two dimensional (2D) detector. The source-detector system performs on rotation around the object producing a series of 2D images. The images are reconstructed in a three- dimensional(3D) data set using a modification of the original cone-

beam algorithm developed by Feldkamp et al in 1984[10].CBCT machine have two major differences compared with so called "Medical" CT scanners. First CBCT uses a low energy fixed anode tube, similar to that used in dental panoramic X-ray machine. Next, CBCT machines rotate around the patient only once, capturing the data using a cone shaped X-ray beam. These changes allow for a less expensive, smaller machine that exposes the patient to approximately 20% of the radiation of a helical CT, equivalent to the full mouth Periapical series [1]. The other advantage of CBCT is it acquires volumetric data in a short scan time, produces quality images with higher spatial resolution than multislice CT [7], easy accessibility, easy handling, less expensive, offers a real-size data set with multiplanar cross sectional and 3D reconstructions, potential for generating all 2D images, potential for vertical scanning in a natural seated position, less disturbance from metal artifacts [10].

Craniofacial fractures

Application of CBCT has been found in maxillofacial trauma. This has the advantage of depicting fractures through complex and fine bone structures including the Naso-orbital-complex and can be performed successfully even in the swollen patient. This is in contrast to conventional skull and panoramic radiography. Effective imaging on a par with CT is achieved at a fraction of the dose required for CT. Limitation of CBCT is it cannot provide good definitions of soft tissues, may be impossible to identify some less dense foreign bodies and intracranial haemorrhage/edema[8].

This is a case of left mandibular body sagittal fracture. On clinical examination, lingual plate was expanded. No mobility was appreciated and OPG revealed no fracture. The CBCT showed the oblique fracture line extending from 33 region posteriorly and lingually till 35 region and lingual cortical plate appeared to be displaced more lingually. .(Fig.2a & 2b)

Impacted mandibular third molar

The panoramic radiograph was taken in relation to impacted mandibular right third molar. The radiograph did not clearly depict the relationship between the impacted right mandibular third molar and the mandibular canal, both of which appeared overlapped each other. CBCT showed impacted mandibular right third molar was mesially inclined; it was located at the level of the middle third of the root of second molar. Third molar had three roots mesiobuccal, distobuccal and lingual root, the later root was wide mesiodistally. The roots of impacted third molar appeared close to the canal and the canal was running in the furcation region of impacted third molar, making a difficult extraction. (Fig.3)

Impacted canines-

The panoramic radiograph in a sixteen year old girl taken for orthodontic treatment, revealed bilateral canine impaction. CBCT was taken to visualize the relationship of the teeth with the adjacent teeth, nasal floor and maxillary sinus. (Fig.4a) Impacted left canine extended from central incisor to first molar region. Crown is closer to the labial cortical plate and is placed labially. The root tip is almost in the maxillary sinus. (Fig.4b) Impacted right canine is horizontally placed. Extending from central incisor to first molar region. Crown is close to the labial cortical plate and is placed labially. The root tip appears to be in the maxillary sinus but a thin rim of bone separates' the sinus and the root. The apical third of the root is curved in a superior direction. (Fig.4c)

Oral and maxillofacial pathology-

Odontome-

The panoramic radiograph demonstrated odontome in the right mandibular third molar region. CBCT demonstrated well defined radio opacity in the right mandibular third molar region of different densities resembling that of enamel, dentine arranged in a concentric manner separated by a radiolucent rim all around and the radiolucent center resembles that of a pulp. It was concluded as compound odontome. It was placed more close to lingual cortical plate. The distal portion of the odontome appeared to be in inferior alveolar canal and in the other area the canal is displaced inferiorly. (Fig.5a & 5b)

Central giant cell granuloma

In a case of central giant cell granuloma CBCT was done to know the extent of the lesion. The image showed a huge multilocular irregular radiolucent lesion in 24, 25 regions measuring approximately 19mm mesiodistally, 30mm labiopalatally,

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anteroposteriorly extended from 22 to 26. Apically it displaced the floor of maxillary sinus in superior direction. The labial cortical plate was severely thinned out with destruction of palatal cortical plate. The lesion had displaced 24 mesially, unerupted 25 distally with no resorption of the teeth. 23 was vertically impacted with well defined oval shaped pericoronal radiolucency measuring more than 5mm. the radiolucency appeared to cause resorption of mesial root surface of 24. An impacted mesiodens was seen palatal to11 and 21 and was inverted. (fig.6a &6b)

Dentigerous cyst -

In a case of inflammatory dentigerous cyst CBCT showed, expansion of the buccal cortical plate, grossly destructed second deciduous molar, second premolar pushed inferiorly and distally with large pericoronal radiolucency. Inferior alveolar nerve is pushed inferiorly in the second premolar region. (fig. 7a &7b)

Nasopalatine duct cyst-

CBCT in relation to persistent swelling in relation to root canal treated maxillary anterior teeth revealed a large, irregular shape periapical radiolucency indicating cyst. It extended from upper right lateral incisor to upper left lateral incisor, measuring 2.4×1cm. the labial and palatal cortical plate in the Periapical region of central incisors was destroyed with the breach in the nasal floor in the left central incisor region. (fig. 8)

Implant dentistry-

The conventional intra oral Periapical and panoramic radiographs provide a two dimensional image that is mesiodistal and occluso apical dimensions of the edentulous regions where implants are planned to be placed. The buccolingual width and angulation of the available bone are the most important criteria for implant selection and success. This cannot be visualized on traditional radiographs. Cross sectional imaging techniques can be an invaluable tool during preoperative planning. CBCT images characterize three dimensionally bone morphology, visualizes maxillary sinus, incisive canal, mandibular canal, mental foramina all structures particularly important in surgical planning for dental implant placement. (fig. 9)

DISCUSSION-

The introduction of dentomaxillofacial CBCT scanners in the late 1990's has led to the wide applications in the field of oral and maxillofacial surgery, orthodontics and dentistry. Cone-beam CT is also known as "cone beam volumetric tomography". CBCT allows images to be displayed in a variety of formats. Interpretation demands an understanding of spatial relations of bony anatomic elements and extended pathologic knowledge of various maxillofacial structures. CBCT provides clinicians with sub-millimeter spatial resolution images of high diagnostic quality with relatively short scanning time(10-70) and a reported radiation dose equivalent to that needed for 4-15 panoramic radiographs(1, 2). The radiation dose is reduced by as much as four times and cost is about two thirds that of conventional high resolution spiral computed tomography (14). CBCT because of low radiation dose can provide only bony details and is unable to provide images of the soft tissues. Both in medical and dentistry CBCT has been largely adopted as an office based service (9). The traditional panoramic radiograph machines on an average produce approximately 25% magnification which must be accounted for when planning implant placement. CBCT image measurements are routinely accurate through out the maxilla and mandible. This makes CBCT an excellent modality for planning implant placement. CBCT imaging allows clinicians to make accurate diagnoses and plan presurgically for maxillofacial trauma patients' it is reported that CBCT images are used in manufacturing medical models using rapid prototyping technologies. CBCT has used in various maxillofacial trauma cases like zygomaticomaxillary complex fracture, condylar fracture, isolated orbitalfracture (7, 14, 2). CBCT offers adequate imaging of bone structures (14). The intraoperative uses of C-arm CBCT systems have been evaluated for fractures of the zygomaticomaxillary complex demonstrating the feasibility of CBCT uses in surgical navigation, localization of bony fragments and evaluation of screw anchorage and plate fitting with low levels of metal artifact(9). The limitation of CBCT are that it provides low contrast resolution and it is therefore not possible to distinguish fat, muscle and blood in the prolapsed material (2). Conventional CT is used routinely in the diagnosis of maxillofacial pathology.

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CBCT imaging with resolution lower radiation dose and lower cost can easily replace conventional CT. The three dimensional imaging with volumetric analysis of cysts and tumors of the maxillofacial region provides the surgeon vital information for planning surgery (1). In orthodontics, CBCT imaging is now being directed toward 3D cephalometry (12). In surgical procedures like removal of impacted wisdom teeth, canine, supernumerary teeth, surgical exposure of impacted teeth for orthodontic aided eruption, Periapical surgery, implant placement, fractures of maxillofacial skeleton, pathology, CBCT offers a third dimension. The interest in CBCT from all fields of dentistry is unprecendented because it has created a revolution in maxillofacial imaging, facilitating the transition of dental diagnosis to image guidance of operative and surgical procedures by way of third-party applications software.

CONCLUSIONS-

CBCT is an emerging CT technology, which has potential applications for imaging of high- contrast structures in dentomaxillofacial regions. The increased diagnostic capability combined with the lower radiation dose and lower cost will bring this technology into wide use. This area is a blooming field that provides opportunities for practioners to combine CBCT diagnosis and 3D simulations with virtual surgery and computer- assisted design and manufacture. Image guidance is an exciting advance that will undoubtedly have a substantial impact on dentistry.

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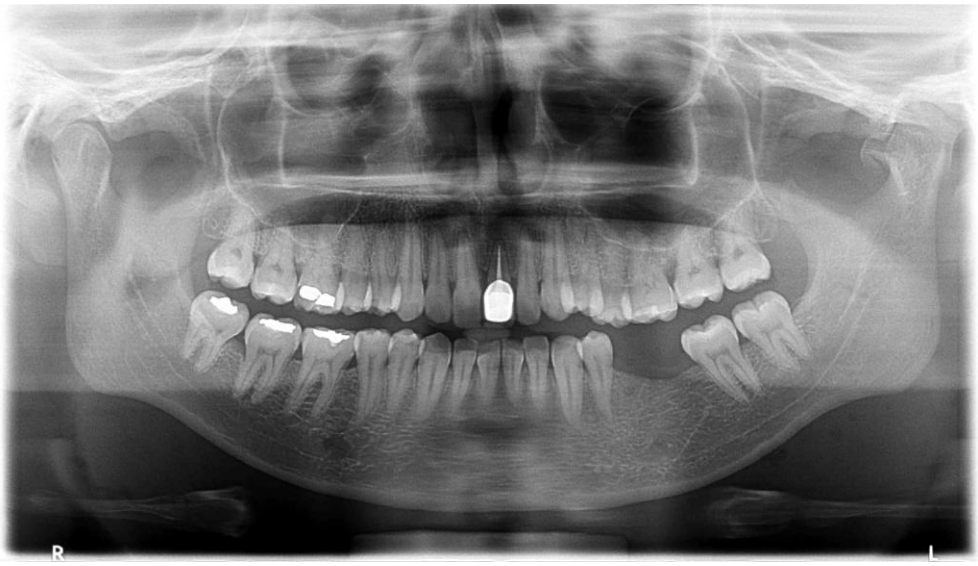
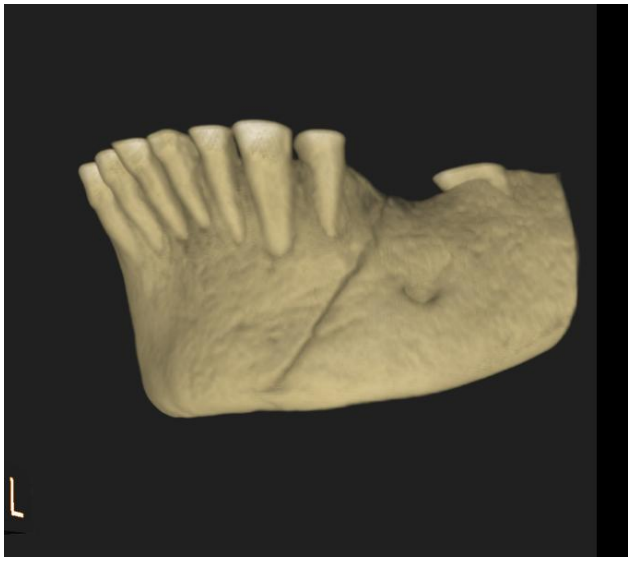


Fig.1

Panoramic radiograph showing no evidence of fracture



Fig, 2a

CBCT mandible clearly shows the oblique fracture line from 0.5 cm above the inferior border of mandible in the region of 33 extending posteriorly, superiorly and lingually upto 35

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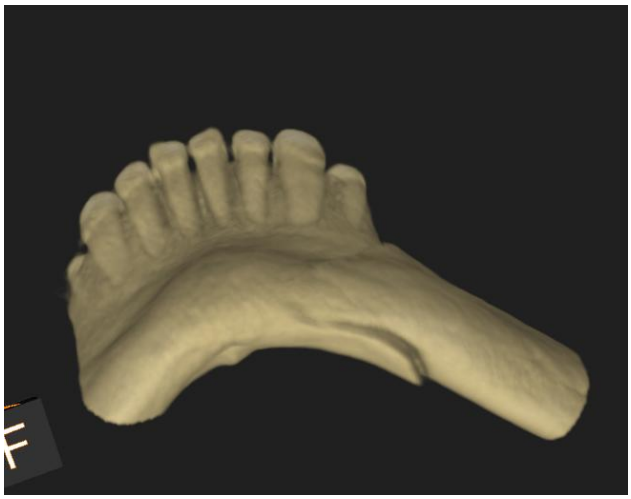

Fig.2b

CBCT mandible shows the fractured and displaced lingual cortical plate.

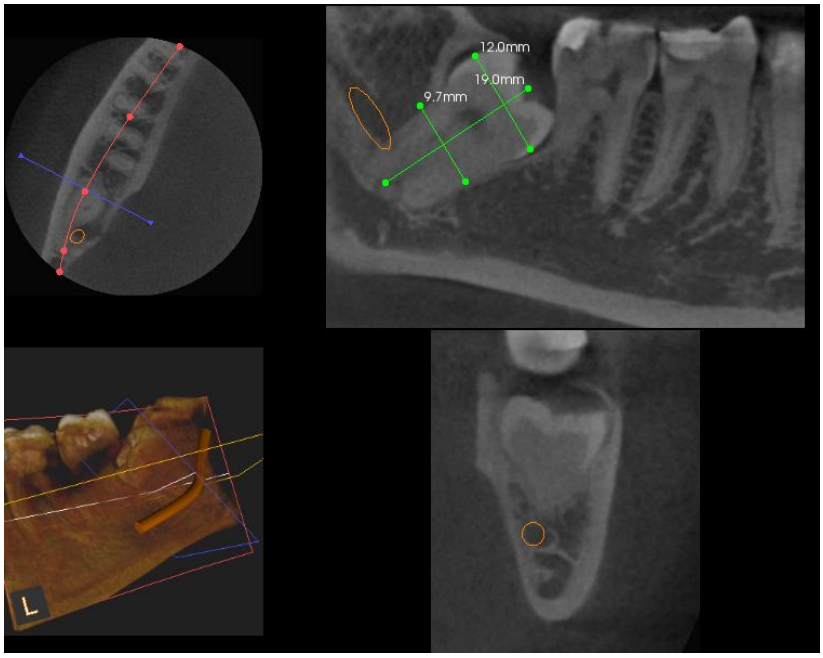

Fig.3

CBCT mandible showing the mesially impacted 48.The mesial cusp tip of 48 is located at the level of the middle third of the root of 47. The roots of impacted 48 is close to the inferior alveolar canal which is at the furcation of 48.

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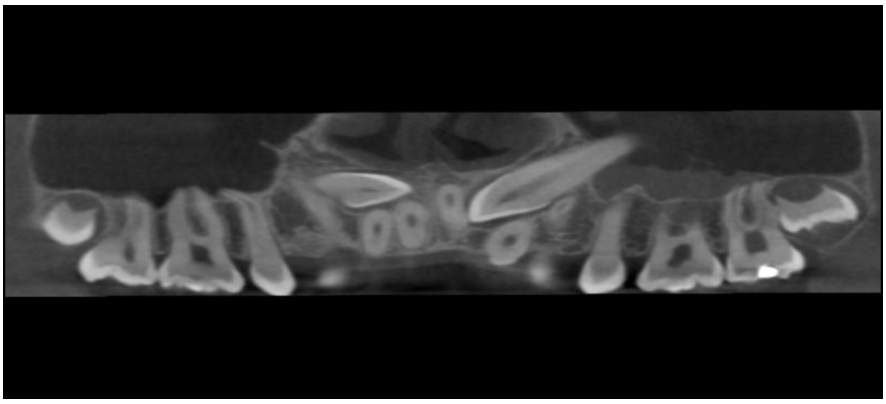

Fig.4a

The CBCT panoramic view showing bilateral maxillary canine impaction

Fig.4b

CBCT of maxilla showing horizontally impacted 13.The crown is superimposing the apices of 11, 12 and 13 it is closer to the labial cortical plate and is placed labially. The curved root tip is separated from the maxillary sinus by a thin rim of bone.

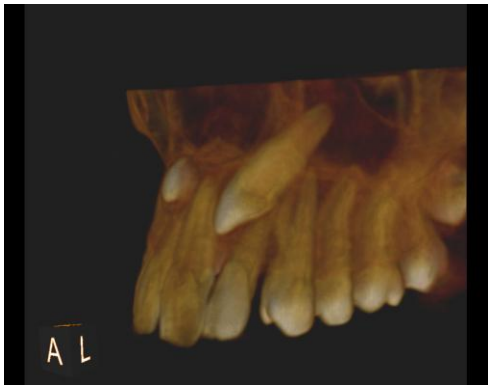

Fig.4c

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CBCT of maxilla showing impacted 23 extending from 21 to 26. Crown is closer to the labial cortical plate and is placed labially. The root tip is almost in the maxillary sinus.

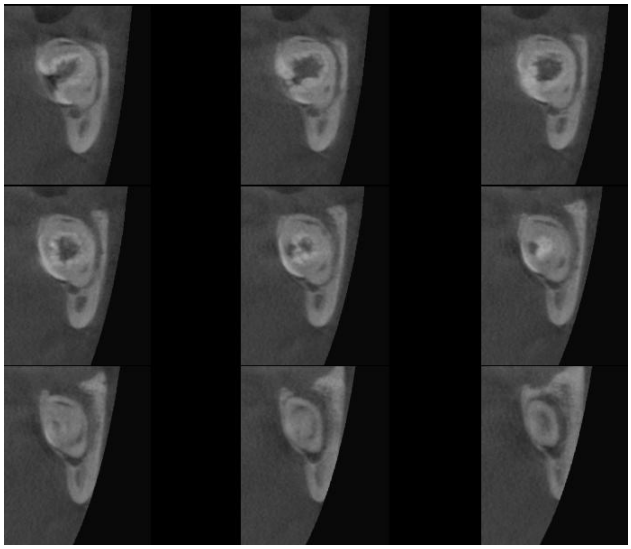

Fig.5a

CBCT demonstrating a well defined radio opacity in the right mandibular third molar region. Areas with different densities arranged in a concentric manner separated by a radiolucent rim all around and the radiolucent centre resembles that of a tooth like structure can be seen. It was diagnosed as compound odontome.

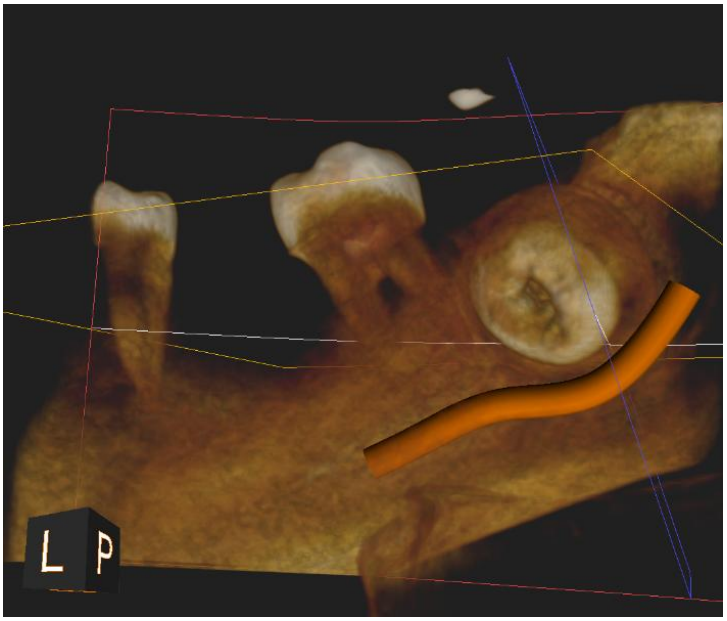

Fig.5b

CBCT shows the distal portion of the compound odontome encroaching the inferior alveolar canal which is displaced inferiorly.

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Fig. 6a

CBCT of central giant cell granuloma of maxilla showing extensive destruction of labial and palatal cortical plates, displacement of premolars, mesiodens

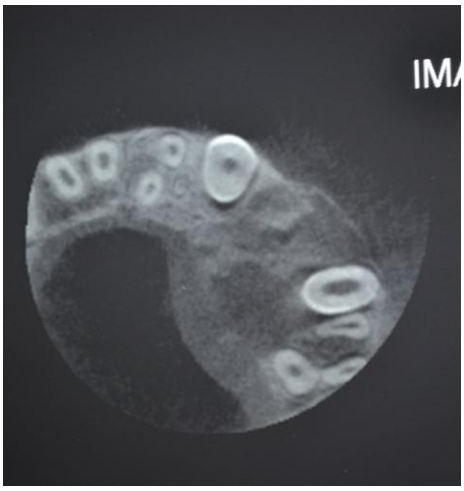

Fig.6b

CBCT axial view showing expansion of cortical plates

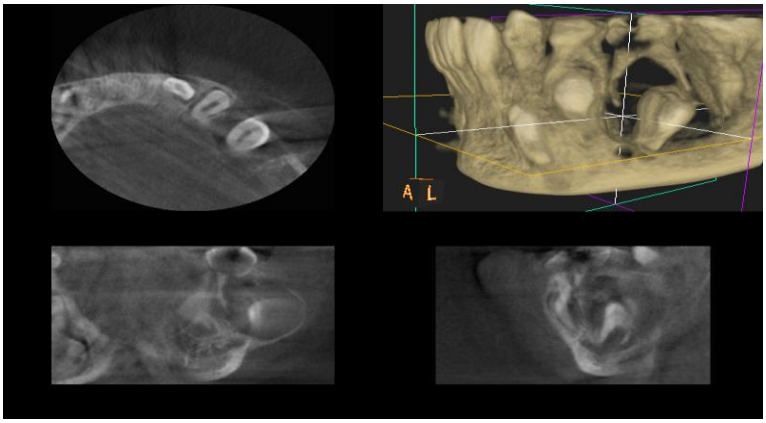

Fig.7a

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CBCT of dentigerous cyst, showing grossly destructed deciduous second molar, displaced second premolar with a large pericoronal radiolucency

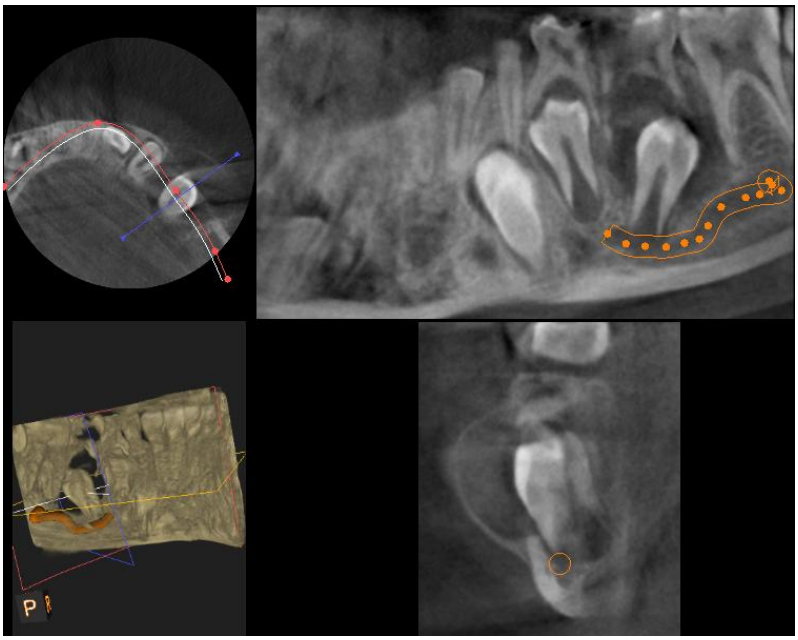

Fig. 7b

Axial view showing expansion of buccal cortical plate, displacement of inferior alveolar nerve.

Fig.8

CBCT showing nasopalatine cystwith expansion of cortical plates

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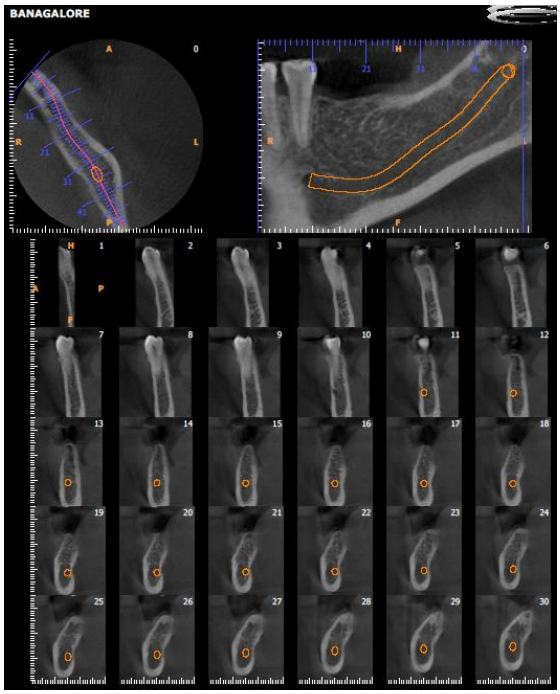

Fig.9

CBCT taken prior to implant placement shows height, width of the bone available above the inferior alveolar nerve.

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