LATEST ADVANCEMENTS IN IMAGING TECHNIQUES OF ORAL AND MAXILLOFACIAL SURGERY - A REVIEW ARTICLE

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***Abstract*: Reconstruction within the head and neck is challenging. Image-guided surgery is the logical extension of imaging as it integrates previously acquired radiological or nuclear medicine images with the operative field. In conventional image-guided surgery, a surgeon uses a surgical instrument or a pointer to establish correspondence between features in the preoperative images and the surgical scene. Diagnostics imaging is an essential component of patient selection and treatment planning in oral and maxillofacial surgery. Radiological considerations are detailed, including justification and optimization, with a special emphasis on the obligations that arise for those who prescribe or undergo such imaging techniques. Developments in navigation, three-dimensional imaging, stereolithographic models, and the use of custom-made implants can aid and improve the accuracy of existing reconstructive methods. During the last decades, an exciting new array of imaging modalities, such as digital imaging, CT, MRI, positron emission tomography, and cone-beam CT (CBCT), has provided astounding new images that continually contribute to the accuracy of diagnostic tasks of the maxillofacial region. The most recent, cone-beam imaging, is gaining rapid acceptance in dentistry because it provides cross-sectional imaging that is often a valuable supplement to intraoral and panoramic radiographs. The information content in such examinations is high and the dose and costs are low. Robotic surgery, which does not modify existing techniques of reconstruction, allows access, resection of tumours, and reconstruction with conventional free flap techniques in the oropharynx without the need for mandibulectomy. The additional precision and confidence that this technology provides make it a useful tool, and recent advances in image-guided surgery offer new opportunities in the field of oral and maxillofacial surgery. Here we, discuss the current advances in reconstruction within oral and maxillofacial surgery.**

***Keywords*: Image guided surgery, Oral and maxillofacial surgery, Head neck reconstruction, Navigation surgery, Stereolithographic models, Custom-made implants, Robotic surgery.**

Introduction:

100 years since William Conrad roentgen discovered the x-ray. The Radiology has transformed itself from scientific curiosity to a medical and dental necessity (1). In order to simulate complex surgery with the aid of a computer, the diagnostic image data and especially various imaging modalities including computer tomography (CT), magnetic resonance imaging (MRI) and Ultrasound (US) must be arranged in relation to each other, thus enabling a rapid switching between the various modalities as well as the viewing of superimposed images. The evolution of radiographs from peri-apical to extra oral imaging, and Cephalometric, and panoramic radiography has heralded major progress in dental radiology, providing clinicians with a single comprehensive image of the jaws and maxillofacial structures. Because it is simple to use and easily integrated into routine practice, particularly for trauma and implantology. Intra-oral radiography using the paralleling technique is recommended to visualise minute bone changes. If the paralleling technique is applied without additional devices to ensure true parallelism, radiographic evaluation of marginal bone level reaches only a precision of 0.5 mm. Digital imaging more and more reduces the use of analogue because of its comparable image

quality and additional advantages.9 In some cases anatomical features make the use of intra-oral and it is more comfortable to use extra-oral radiography, like panoramic or scanographic techniques. These intra- and extra-oral techniques produce only two-dimensional images and hide the information of the structures vestibular and oral from the implant. With the extra-oral tomographic technique one can visualise the vestibulo-oral dimension of the implant and its surrounding tissues.(2) However, the same inherent limitations of all planar two-dimensional (2D) projections: magnification, distortion, superimposition, and misrepresentation of structures were observed along with the cumulative effects of repeated radiation exposure that irreparably damaged tissues, raising questions and an urge to the discovery of something better. In this review we are going to discuss about the different types of intra oral imaging and extra oral imaging used in oral and maxillofacial surgery.

Radiographic imaging:

The nature and extent of diagnosis required for patient care constitute the only rational basis for determining the need, type, and frequency of radiographic examinations, not the concept of routine use of radiography as a part of periodic examinations of all patients. It is important to recognize that because each patient is different from the next, so should the radiographic examination be individualized for each patient. New techniques and sophisticated software tools help in better diagnosis. This radiographic information should be used to supplement other clinical information to aid the dentist in diagnosis and treatment planning. Clinicians should critically appraise the traditional role of radiographs in the diagnosis and patient management. Radiographs can help the dental practitioner evaluate and definitively diagnose many oral diseases and conditions. However, the dentist must weigh the benefits of taking dental radiographs against the risk of exposing a patient to x-rays, the effects of which accumulate from multiple sources over time. During the diagnosis of oral and maxillofacial diseases, clinical and radiological data play a major role. In this region, only a good clinical diagnosis along with a radiological examination may lead to a successful diagnosis (2). A successful diagnosis and evaluation of clinical examination are generally up to a profound knowledge of the normal anatomy of the region.

Evolution of X-Ray imaging:

Peri-apical radiography:

Radiographic assessment is an essential component in the diagnosis of teeth with suspected endodontic problems (Patel et al. 2009a, O¨zen et al. 2009, Yoshioka et al. 2011). The specific view of choice for endodontic assessment is a periapical (intraoral) radiograph using a beam aiming device to ensure a minimally distorted and reproducible image (Jorge et al. 2008, Patel et al. 2009a). Ideally, the radiographic image will confirm the number of root canals, their configuration together with the presence or absence of periapical lesions and their location (Lofthag-Hansen et al. 2007, Low et al. 2008, Neelakantan et al. 2010). This important information not only helps to confirm the diagnosis, but also aids treatment planning and management and is a baseline for assessing the outcome of each unique endodontic problem.(4) Periapical radiographs can be taken to examine a specific area or areas, or they may be prescribed as a Full Mouth Series of radiographs. A full mouth series of radiographs images the entire dentition and is generally composed of 20 films, including 4 bitewing radiographs and 16 periapical radiographs. Peri-apical radiography is a projection of radiographs including intra-oral radiographs which depict 3-4 teeth and the tissue around them (Whaites, 2002). There are two projection techniques for peri-apical radiography (5). The paralleling technique (Long-cone technique): The peri-apical film is stood parallel to the long axis of the teeth and the central is aimed at the right angles of the teeth and the film. The bisecting-angle technique: The peri-apical film is stood as close as possible to the palatal/lingual surface of the teeth. The film and the teeth form an angle with its apex at the point where the film is in contact with the teeth. Central ray is directed at apex of the teeth (White & Pharoah, 2004).

Guidelines for ideal film positioning

Maxillary and Mandibular Central Incisor View

- Guidelines: Contact between central incisors positioned in the center of the film.

Teeth in view: Maxillary View: Right and left central and lateral incisors.

- Guidelines: Contact between the central and lateral incisors is positioned in the center of the film.

Teeth in view: The entire central and lateral incisors are imaged and a portion of the cuspid and the contralateral central incisor is in the view. Maxillary and Mandibular Canine Views

- Guidelines: The film is positioned so that the canine is in the center of the film. In addition, the goal is to "open" the contact between the canine and the 1st premolar.

Teeth in view: The entire canine, 1st premolar and all or part of the lateral incisor. Maxillary and Mandibular 1st Molar View/Premolar View

- Guidelines: The film is positioned far enough mesially so that a portion of the canine (into dentin) is imaged. The remainder of the film will image the teeth distal to the canines.

Teeth in view: A portion of the canine (into dentin) is imaged, as well as the 1st and 2nd premolars, the 1st molar and some or the entire 2nd molar. Maxillary and Mandibular 2nd Molar View.

- Guidelines: The film is positioned so that the distal aspect of the last molar in the arch is fully imaged including its root apices. Generally, positioning the mesial edge of the film at the middle of the 2nd premolar allows the third molar region to be covered. Teeth in view: When the film is correctly positioned the anterior edge of the film usually captures either a portion of the 2nd premolar or the mesial aspect of the 1st molar. The view shows complete images of all the molars present including the distal aspect of the last molar.

Indications: Evaluation of peri-apical and periodontal tissue health. before, during and/or after surgical and endodontic treatments Assessment of the teeth and adjacent tissue after trauma. Evaluation of apical pathology within the alveolar bone. To clarify of the presence/absence of un-erupted teeth (Whaites, 2002).

Anatomical landmarks:
1. Alveolar bone
2. Anterior nasal spine
3. Burn-out effect
4. Coronoid process
5. Genial tubercle
6. Incisive foramen
7. Inferior nasal concha

Panoramic radiograph:
New technologies are continually being developed and one of the most useful for clinical picture is the development of the digital panoramic radiograph. Panoramic radiography, also known as an ortho-pantograph, is a panoramic scanning dental X-ray of the two-dimensional view of the jaws and their supporting structures from ear to ear. It is obtained with patient, whose head stands between X-ray generator and the film (6). Panoramic radiographs allow visualization of regions that cannot be captured, such as the temporomandibular joints, or are difficult to image on intraoral images, such as the third molar regions. Their larger coverage is also often important in imaging pathology or trauma of the jaws and surrounding tissues, since assessment of the entire abnormality is critical for interpretation and treatment planning. An additional advantage of this technique is that it is more comfortable for patients since they do not need to open their mouth wide and no bulky instruments are placed intraorally. Although panoramic radiography covers a relatively large area, panoramic radiographs have a lower spatial resolution compared to intraoral radiographs, which makes visualization of fine detail and some dental diseases, such as caries and periodontal bone loss, difficult. Panoramic images should not be used as a substitute for intraoral radiography, or as a means of surveying the jaw for quiescent pathoses. However, Production of good quality panoramic radiographs is technique sensitive and unfortunately many panoramic radiographs produced are of less than optimal quality. Understanding the principles of panoramic tomography and proper patient positioning is critical to obtaining ideal images. The main advantage of panoramic radiography is the fact that it is clinically useful for diagnostic problems associated with maxilla and mandible. One of the disadvantages of it is that the images do not exhibit a fine anatomically detailed outfit gained from peri-apical radiographs. Another problem related to ortho-pantograph includes unequal magnification (Lurie, 2004).

Materials of a Panoramic radiographs are the following:
Panoramic cassette.
Panoramic film/sensor.
Patient positioning device such as bite stick (depends on machine design).
Lead apron.
Materials necessary for infection control procedures.

Indications of panoramic radiographies are included in the following cases:
Detection of the presence/absence of un-erupted teeth. Evaluation of relationship of the upper posterior teeth with maxillary sinus. Evaluation of relationship of the lower posterior teeth with Canalis alveolar-is inferior (7). Suspicion of asymptomatic swellings. Radiographic examination of temporomandibular joint disturbances. Examination of odontogenic, nonodontogenic cysts and tumors. Evaluation of alveolar crest for insertion dental implants. Evaluation of maxillomandibular region following trauma. Examination of maxillary/mandibular surgical interventions.

Anatomical landmarks:
1. Dentoalveolar Region
2. Maxillary Region
3. Mandibular Region
4. Temporomandibular
5. Retromaxillary and
6. Crevice

Computed tomography:
Computed tomography was discovered by Hounsfield in 1974. After improvements, nowadays, dental computed tomography is performed for diagnosis of oral and maxillofacial pathology in most patients. Its advantage over 2D radiography is the fact that it can eliminate the superimposition of images of adjacent tissues (8). Since it provides bone images at the highest quality, it is the most widely used imaging technique (Curtain et al., 1998; Karjodkar, 2006). Tomographic images are taken as trans-axial cross sections. These images are stored on the computer and then recreated from the cross sections passing through the surfaces which are desired to be observed. This is called multi-planar reformation. This way, axial, sagittal and coronal planes of the material that was imaged can be obtained. When these planes are combined by means of a software application, a 3D image may also be obtained. The images are obtained with the patient supine and during quite respiration (9). Contrast agent injection may be needed to evaluate

soft tissues. When taking a computed tomography of oral and maxillofacial region, images are acquired from the top of the frontal sinus to the sub mental region (Hermans et al., 2006). Computerized tomography is used in maxillofacial surgery, reconstructive surgery, orthognatic surgery, dental implant applications, and detection of lesions like cyst/tumour, trauma and temporomandibular joint diseases (10). Dental computed tomography has a number of advantages over other conventional radiography: Undesired superimposition of other tissues in the region is eliminated. Thanks to the high-resolution of computerized tomography, differences between the tissues with different physical densities can be distinguished better. It is possible to obtain images of the tissues which are located on axial, coronal sagittal planes. It is especially a very useful tool for the planning of dental implant insertion. It has no magnification and no distortion. In the presence of formations like cysts/tumours, it can be determined whether this formation has a solid or a liquid structure by means of density measurements (Frederiksen, 2004). Dental computed tomography has also disadvantages over other conventional radiography: Administration of contrast agent is necessary for imaging soft tissue More radiation exposure Degradation of image quality by metallic objects, like as dental crown, fillings.

Anatomical landmarks:
1. Anterior nasal spine
2. Carotid canal
3. Concha bullosa
4. Coronoid process
5. Crista galli
6. Dens axis
7. Ethmoid sinus

Applications in oral and maxillofacial surgery:

Trauma and Exodontia:

• Radiography is invaluable for diagnosing and planning the treatment of fractured teeth or bones and the surrounding tissues
• Radiographs can be used to distinguish between complicated crown fractures (with the pulp exposed) and uncomplicated crown fractures (pulp not exposed)
• For true representation of root fractures, radiographs should be taken with the primary beam parallel to the angle of fracture. This will allow visualization of the beginning and end of the fracture line
• Pre extraction radiographs ensure that a procedure can be properly planned and that no developmental abnormalities, resorptive lesions or ankylosis will surprise the operator • Post extraction radiographs ensure that all root fragments are removed and that no collateral damage has been caused.

Swellings, Cysts and Neoplasms:

• Cysts present as well demarcated and expansive lytic lesions
• Neoplasms may present as increased or decreased densities. They are often irregular and poorly demarcated, with lysis of bone. Close examination of the periphery of the lesion will help, as this is often the most active zone in a pathological process (11)
• Craniomandibular osteopathy (CMO) is usually a lesion of the mandibular body, occasionally the base of the cranium or TMJ's, and produces a proliferative periosteal reaction
• Osteomyelitis will often present with a proliferative reaction at the periphery, with decreased density at the centre of the lesion. (12,13,14,15,16)

Impacted teeth:

Dental CT offers superb visualization of impacted teeth and can help the clinician to plan his treatment preoperatively or prior to orthodontic therapy. The position of the tooth within the alveolar crest as well as the relation to surrounding structures is clearly disclosed. Resorption of adjacent roots and hooks, in particular, are easily detected and quantified by dental CT.

Measurement of implants:

Evaluation of bone quantity is performed by measuring the height and width of the alveolar crest for a specified region (17). These values serve as an overview of the avail- able bone quantity and do not serve as a suggested implant size. This is because the oral surgeon has multiple choices of implant sites and implantation directions using different angulations and different diameters. The choice is not solely based on the available amount of bone (bone-demanded implantation), but must take prosthodontic and cosmetic factors into account. Moreover, immediately prior to implant placement a canal is drilled, this usually is 1–2 mm longer than the final inserted implant. Thus, injury of anatomic structures can occur even if the final implant does not reach these structures.

Temporomandibular joint disorders:

The use of computed tomography (CT) as a diagnostic tool has been an indispensable routine in medicine for many years, its application in dentistry. The imaging offered by current CBCT machines has been shown to provide a complete radio- graphic evaluation of the bony components of the jaw. The resulting images are of high diagnostic quality. Given the significantly reduced radiation dose and cost compared with conventional CT. CT scans are now widely used for the examination of pathological conditions and trauma in the maxillofacial region, in pre- surgical implant treatment planning and the assessment of the temporomandibular joint. CT provides images of the bony components only. However, this can be sufficient for the final diagnosis in a number of pathological conditions. Pathological changes such as formation of osteophytes, erosion, fractures, ankylosis, developmental abnormalities, as well as the position of the condyle in the fossa in open- and closed-mouth conditions can be detected on CT images. The presented technique provides a complete radio- graphic investigation of the bony components of the

TMJ. The reconstructed images are of high diagnostic quality, the examination time is shorter, and patient dose is lower than that with conventional CT. It may therefore be considered as the imaging technique of choice when investigation of bony changes of the TMJ is the task at hand.(18)

Cranio facial surgery:
CBCT should allow better evaluation of dental age, arch segment positioning, and cleft size compared with traditional radiography. Volumetric analysis promises to offer better prediction in terms of the morphology of the defect, as well as the volume of graft material necessary for repair. CBCT provides a means to investigate these issues in depth**.** CT scans are now widely used for the examination of pathological conditions and trauma in the maxillofacial region, in pre- surgical implant treatment planning and the assessment of the temporomandibular joint. (18, 19, 20, 21, 22, 23)

Conclusion:
This review summarizes the capabilities imaging techniques for dentistry. Anatomic features as well as the appearance of frequent dental pathologies are described with their typical findings. There has been a growing interest in three-dimensional (3D) surface imaging devices over the last few years.(2)

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