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APPLICATION OF COMPUTERIZED TOMOGRAPHY IN IMPLANT DENTISTRY

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ABSTRACT

In investigating an implant site, a surgeon requires information on bone volume and quality, topography and the relationship to important anatomical structures, such as nerves, vessels, roots, nasal floor, and sinus cavities. This information is obtained with a clinical examination and appropriate radiographic findings. The decision to proceed to cross-sectional imaging must be based on clearly identified needs and the clinical requirements of the clinicians involved.[13] The paper discusses the application of computerized tomography in preoperative and postoperative assessment of proposed implant site.

Key Words: Computerized tomography, Radiation exposure, Diagnosis, Maxilla, Mandible

INTRODUCTION

Implant technology has enabled the dental surgeons to rehabilitate a broad spectrum of patients with challenging needs with application of precise surgical and prosthodontic techniques.[1] A 5-year success rate of 90% or higher has been reported.[2]

Acceptance of dental implantology as an integral part of conventional practice makes it necessary for the general dentist to be knowledgeable of the implant imaging techniques and their clinical applications.[1]

Because of the increasingly important role of advanced imaging procedures in implant dentistry and the lack of comprehensive guidelines for appropriate imaging strategies, the American Academy of Oral and Maxillofacial Radiology (AAOMR) provided a position paper in the year 2000.[2] Its purpose is to inform the dental profession of the multiple imaging options available for the assessment of potential implant sites and to recommend suitable imaging modalities. The AAMOR holds the position that the success of the dental implant restorations is, in part, dependent on adequate diagnostic information about bony structures of the oral region. Acquiring this information actually requires some form of images, which may vary from simple two dimensional views, such as panoramic radiographs, to more complex views in multiple planes, depending on the case and the experience of the practitioner.

Also, in the year 2000, the Board of the European Association for Osseointegration Trinity College Dublin, concerned that the rapid adoption of these sophisticated techniques into routine practice might lead to a significant increase in the radiation burden of patients without a proper risk benefit analysis, and formulated guidelines in various clinical situations that will ensure essential diagnostic information is obtained with as low as reasonably achievable (ALARA principle) radiation exposure.[3]

HISTORY

A literature review was carried out using PubMed database. The following terms was used: *computerized tomography, alveolar bone, maxillary sinus, implant,* and *support*. The search was performed in the articles published between 1985 and 2010. After the reading of the title and abstract, 25 articles were selected, because they seemed to have a greater correlation with this study.

Cranial computed tomography (CT), introduced in the early 1970s, revolutionized the way neuroscientists viewed the brain. For the first time, it allowed an anatomic definition in the axial plane.

The tomographic angle[4] (the amplitude of the movement of the x-ray tube) determines the thickness of the image slice.

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An average thickness of approximately 3 mm, which is similar to the diameter of many dental implants, is usually used.

The measurement error for tomograms falls below 1 mm of the actual measurements made on cadaver mandibles.[5]In about 1% of the patients the inferior alveolar canal is bifurcated.[6,7,8] Diagnostically this canal may or may not be realized from periapical or panoramic radiographs. Complex motion tomography is useful aid in preoperative planning in such cases.[12]The advantages of conventional film tomography include moderate expenses (compared with CT), uniform magnification, cross-sectional views available at any location and reproducible imaging geometry when used with a cephalostat.

The disadvantages of conventional tomography include limited availability and more time needed to produce the images than the standard panoramic radiography. Significant experience and training is necessary to interpret the images.[2]

Computerized Tomography Evaluation of the Mandible:

Five anatomic parameters be assessed when mandible is evaluated for dental implants.[10]

1. The height of the alveolar bone
2. The buccolingual dimension of the ridge at the implant site
3. The contour of the ridge
4. The relative amount of bone and fat at the implant site
5. The position of the inferior alveolar nerve

Height of alveolar bone

The edentulous mandible will demonstrate generalized loss of height of the alveolar ridge because of diffuse atrophy of the bone. It may also show localized bone loss at any extraction sites. Periodontal disease can cause asymmetric destruction and remarkable localized destruction. All these components combine to produce a shrunken and deformed alveolar ridge. In partially edentulous patients who require implants near, or posterior to, the mental foramen, the measurement must be made from the occlusal surface to the superior edge of the alveolar canal. If the occlusal surface is deformed or unusually thin and tapered, the measurement is made from a point below the occlusal surface where the width of the ridge is capable of supporting an implant.

Buccolingual dimension of the ridge

The buccolingual dimension is measured on the cross-sectional oblique images. Even patients who appear to have adequate height to their alveolar process, may have profound buccolingual atrophy. The bone may be symmetrically atrophied and the ridge thin and knifelike. This is especially true in the anterior mandible and maxilla. Asymmetric loss of the labial bone is also very common in the anterior mandible. Usually the labial cortex is lost to periodontal disease and the medullary bone atrophies. Only the lingual cortex may remain. Implantation may not be possible in such patients.

Contour of the ridge

In addition to losing thickness as a result of atrophy, the ridge may be deformed by underlying periodontal pathosis. Apical periodontal abscesses cause local bone destruction. If an abscess is left untreated and the tooth is removed, the extraction socket may enlarge. The cavity it produces may be so large and irregular that it may preclude implantation. The full extent of the cavity is difficult to assess on conventional radiographs. It is impossible to determine whether there is adequate bone adjacent to the cavity to support an implant.

Mineralization of the mandible

In young people, the medullary space is well ossified. Medullary bone appears dense and homogeneous on the images. The mandibular canal is often visible because of a thin shell of bone that can be seen surrounding the nerve. The rim of bone is sometimes complete, but often the rim only partially encircles the nerve.

The geriatric patients and those with osteoporosis have the most demineralized mandibles. Fatty marrow has replaced most of the hematopoietic marrow by this stage in life. Osteoporosis reduces the number and size of the medullary bony trabeculae and thins the cortical bone. Periodontal disease destroys the alveolar process.

Quantitative assessment of mineral content

The mineral content of the mandible can be estimated from the CT scan. It is likely that the amount of medullary bone at the implant site is important to the overall success rate of the surgical procedure.

If the implant site has a very low CT number, the implants may benefit from being left in place longer than usual before the prosthesis is attached. If the implant site is denser than average, extra care should be taken not to heat the bone with the drill.

Position of alveolar nerve

In younger patients without total alveolar loss, there is nearly always enough bone present to implant a series of fixtures anteriorly between the mental foramina.

In older patients who have been edentulous for long duration, there may be profound bone loss. Asymmetric erosion may leave either the labial or the lingual cortex relatively intact but cause profound central loss. The lateral and posterior portions of the mandible distal to the mental foramen pose the most problems for the implant surgeon. With loss of the alveolar process, the inferior alveolar nerve may come to lie immediately below the eroded occlusal surface of the bone.

Neurologic dysfunction of the inferior alveolar nerve following implantation is generally caused by encroachment on the nerve by one of the implants. Computerized tomography is very useful in determining which of a series of implants is within the canal. If the diagnosis is made in the early post-operative period, the implant can be slightly withdrawn to relieve the neural compression.

Computerized tomography evaluation of the maxilla

Five anatomic parameters must be evaluated when maxillary implant surgery is contemplated: [11]

1. The height of the alveolar ridge
2. The buccolingual dimension of the ridge
3. The contour of the alveolar ridge
4. The maxillary sinuses
5. The incisive fossa and canals

Height of the alveolar ridge

The height of the alveolar ridge is measured on the cross-sectional oblique reformations, in the area where implantation is desired. In the maxilla, the height of the alveolar bone is measured from the external surface of the residual ridge to the level of the palate or to the lateral wall of the nasal cavity.

The desired angle of inclination of the fixture is usually not the same as the angle of the anterior portion of the alveolar process. The more prognathic the jaw, the less the angle of the implants conforms to the angle of the alveolar process. In partially edentulous patients, an attempt is made to align the implants with the residual teeth. This will improve the ultimate position of the prosthesis and optimize the esthetics of the final restoration.

In the posterior maxilla, the height of the residual alveolar process will depend on the extent of the development of the maxillary sinus. The more extensive the pneumatization of the maxillary sinus, the less alveolar bone will be present and available for implantation.

A small number of adult patients fail to fully pneumatize the maxillary sinuses during their youth. The majority of the maxilla, therefore, is bony rather than pneumatized sinus. In patients with these juvenile-type sinuses, it may be possible to place sufficiently long implants in the alveolar process posteriorly.

The availability of adequate bone for implantation of the anterior portion of the alveolar process is considerably less problematic than in the area below the pneumatized sinus. In the great majority of patients, there is a dense pyramid of bone suitable for implantation at the base of the lateral wall of the nasal cavity, where the nasal cavity meets the anterior wall of the maxillary sinus.

Implants placed in this area anchor into a wedge of cortical bone at the base of the lateral wall of the nasal cavity. These implants tend to be longer than implants placed anywhere else in the maxilla.

Buccolingual dimension of the ridge

The buccolingual width of the alveolar process is extremely important in planning implant placement, especially in the maxilla. Periodontal erosion within the anterior maxilla tends to be more prominent along the buccal surface of the teeth, because the bone tends to be extremely thin. A relatively modest amount of buccal bone loss may cause the thin buccal plate to resorb dramatically.

In completely edentulous patients and those with a long segment of anterior maxillary tooth loss, there may be a disproportionate decrease in the buccolingual dimension, limiting implant placement even when the height of the ridge would otherwise be adequate to support implants.

Routine radiographs and panoramic radiographs routinely overestimate the amount of bone available for implantation. Even manual palpation of the ridge overestimates the amount of bone present. The soft tissues are hard and feel bony. It is often impossible to distinguish bone from soft tissue callus resulting from years of denture use.

Contour of the ridge

Abnormalities of the contour of the maxillary alveolar ridge are caused by localized erosion or the presence of extraction sockets. This is due to buccal bone erosion resulting from loss of several teeth. It is much more likely that craters from dental extractions will persist in the alveolar bone in the posterior maxilla. There are more root sockets posteriorly because of the molars. These residual craters in the bone also tend to be larger posteriorly. In most patients with long-term edentulousness, the posterior maxillary bone is incapable of supporting any implants.

Maxillary sinuses

Chronic inflammation within the maxillary sinuses leads to thickening of the mucosa of the sinus. Normally, the mucosa of the sinus is invisible on computerized tomography (CT) scans because it is much thinner than the resolution of the best scanners. Chronically inflamed mucosa, however, is visible on CT scans. The soft tissue appears dark on the CT scan, easily differentiated from the white-appearing bone of the sinus wall and the very black air within the remainder of the sinus.

Cysts and polyps tend to be asymptomatic and are found incidentally on the CT images. When they become very large they may obstruct the sinus and produce symptoms. The bony floor is intact beneath a retention cyst but is locally de-

stroyed by the associated dental abscess. A retention cyst is a quiescent process that will generally not complicate implantation. Contiguous inflammation from a periapical abscess should be treated prior to implantation so that implants are not placed in a zone of smoldering infection.

Anatomic variations of the incisive foramen and canal

In most patients, there are two fairly symmetric incisive foramina piercing the palate. The nasopalatine nerves traverse these foramina. The nasopalatine (incisive) canal appears on the CT scan as a conical tube that is wider towards its oral opening.

If there is a large, common foramen for the two nerves, there may be too little space to place the desired number of implants. In some instances, there may be a lateral outpouching of the neurovascular structures, producing a grossly asymmetric canal. This may also limit the number of possible implants.

DISCUSSION

Various parameters should be considered before planning for implants for successful outcome. Dental implants have revolutionized conventional prosthodontics treatment for patients of all age groups and need meticulous assessment and examination of supporting tissues. Surgeons need to evaluate all surrounding anatomical structure with various diagnostic aids for better prognosis and longevity of the prosthesis. Geriatric patients are a great challenge but not a contraindication.

CONCLUSION

Conventional imaging, such as panoramic and periapical radiographs, are generally useful and cost effective but cannot provide the cross sectional visualization or interactive image analysis that can be obtained from more sophisticated imaging techniques. CT offers considerable diagnostic advantage in acute cases of implant failure, paresthesis or infection.

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