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Different Modalities For Treatment Maxillary Free End Saddle : Preliminary 12-Month Randomized Clinical Trial

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ABSTRACT

Conventional RPD Patients with severely resorbed alveolar ridge always having problems with their conventional dentures that may be related to reduced load bearing capacity of the supporting structures with decreased biting force and poor masticatory action in addition to weakened oral sensory function related to prosthetic coverage The rehabilitation of edentulous posterior maxilla with implant supported prosthesis may be complicated by insufficient bone volume caused by continuous ridge resorption and increased maxillary sinus pneumatization. Bone augmentation of atrophic ridges is a commonly used method to place implants in compromised posterior maxillary ridges. Several techniques have been proposed, such as guided bone regeneration, sinus augmentation, block grafts and distraction osteogenesis before or during placement of the dental implant. Maxillary sinus floor elevation either by trans-alveolar or lateral window approach is considered the gold standard in augmentation of atrophic posterior maxilla where bone can be gained on the expense of the pneumatized sinus. However, the technique is associated with several problems such as increased surgical trauma, postoperative swelling, bleeding, infection and inflammation of maxillary sinus, graft resorption, and tearing or perforation of Schneiderian membrane.

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Keywords:sinus lift ;short implant;bone graft;maxillary sinus

Introduction

Distal Extension Removable Partial Denture [1] is one of the treatment modalities for bilateral edentulous areas located posterior to the remaining natural teeth [1]. However, under functional loading these cases presented problems originating from the dual supporting nature of the prosthesis from both teeth and soft tissue. With greater compressibility of soft tissue that reached 20 times of that of periodontal ligament. The greater amount of tissue compression is noticed in the most distal region away from fulcrum of rotation around the principal abutments which creates multidirectional damaging rotational forces that mostly transferred to the principal abutment teeth. [2-6]

Maxillary sinus pneumatization is a physiologic process that takes place during the growth period, with a resultant increase in volume.[7, 8] since10 weeks in utero the maxillary sinus start to develop. After birth, its pneumatization continues into the developing alveolar ridge as the permanent teeth erupt.[9] [10] Pneumatization can be so extensive as to expose tooth roots with only a thin layer of soft tissue covering them[11].

Histologically, the pneumatization occurs as a result of resorption of the sinus cortical walls combined with apposition of osteoid tissue layering inferior to it. [12]. Different factors were reported to affect the process of pneumatization, including, hereditary factors[8] , the pneumatization drive of the mucous membrane of the nose [7], craniofacial configuration, bone density, growth hormones [13], the air pressure inside the sinuses[7] [8, 14], and sinus surgery[15].

Maxillary sinus pneumatization is reported to progress following extraction of maxillary posterior teeth in adults. [12, 16] This phenomenon also named "*the fourth expansion phenomenon" [8]* and is considered as a type of disuse atrophy.[12]

Dental implant has become a common and well-accepted treatment modality in the treatment of maxillary distal extension edentulous cases. Accordingly, when implant-supported prosthetic alternatives are considered, the clinician must evaluate the patient for adequate bone volume for implant placement in the desired locations. The success of implant procedures and maintenance of long-term stability are directly related to the quality and quantity of the supporting bone.

However, the edentulous maxilla is particularly challenging with regard to augmentation because of anatomic limitations such as the nasal floor, maxillary sinus, resorption pattern, and interarch relationship [17, 18]. Implant survival rates (SRs) are generally lower in the maxilla than in the mandible, especially in the posterior maxilla where bone quality can be poor [19-21].

Additionally, patients with advanced alveolar bone resorption or adjacent vital structures, the provision of dental implants with standard dimensions often becomes an arduous task. This is particularly true in the atrophic posterior maxilla, where there are risks of penetrating the maxillary sinuses. Thus, implant therapy in patients with reduced alveolar bone quantity may be compromised [22]. Advanced surgical techniques for implant placement, such as horizontal and vertical osseous ridge augmentations and sinus elevation, are therefore utilized to increase the quantity of alveolar bone. Although there is considerable chance for success [23, 24] these additional surgical interventions inevitably increase treatment duration and cost with limited volume of intraoral bone grafts. In cases with grafting from extra-oral sites to increase amount of autogenous graft hospital care is needed. As well as morbidity of both the donor and recipient sites in addition to pain and infection at the donor site that may occur especially with older people. [25].

To overcome these drawbacks and lessen the morbidity of the donor site, allogeneic, xenogenous, alloplastic, or composite materials were utilized. However, there are considerable disadvantages including compromised vascular environment and the absence of living cells, which elongate the healing time compared to autogenous grafts.[26, 27]

- **Management of maxillary distal extension free end saddle:**

There are many rehabilitation options for free end maxillary cases including removable partial dentures, implant assisted partial removable overdentures, and implant supported fixed partial dentures. Cases that complicated with pneumatized maxillary sinus increase the difficulty of posterior implants placement. Many options are available for posterior implants placement like using short implants, sinus lifting with long implants placement, zygomatic implants, and sub periosteal implant.

The wise selection of proper treatment plan for these cases is dependent on the status of the residual bone and maxillary sinus. **[28]** Rehabilitation of the maxilla can present a challenging dilemma. This is attributed to the nature of the alveolar bone, which is of inferior density, [29] and to the deficient volume resulting from post-extraction resorption and sinus pneumatization. [30, 31] **[28]**

In the Misch SA classification, the treatment modality is dependent on the available bone height between the floor of the antrum and the crest of the residual ridge in the region of the ideal implant locations

1-RPD

The use of a Removable Partial Denture (RPD) in clinical practice remains a viable treatment modality. Various advancements have improved the quality of a RPD, subsequently improving the quality of life for the individuals that use them.

Previous longitudinal studies and cross-sectional surveys have established the long-term effects of RPDs on the periodontal health of abutment teeth. Most studies have also shown that partial dentures promote an increase in periodontal breakdown in patients' fitted with RPDs[32].

Distal extension RPDs are complex cases because of the teeth and mucosa support, requiring better load distribution for both tissues to avoid vertical, horizontal and torsional forces that may have adverse effects. Dual impression technique is one of the methods used in the construction of DERPD free end cases in order to equalize the different amount of supporting tissues compressibility during functional loading [6].

2-Implant:

Clinical studies have revealed high success rates for different kinds of implant-supported prosthetic rehabilitations, confirming the advantages of dental implant treatment.[33]

A- Implant-assisted RPD:

The use of implants to support and retain RPDs (implant-assisted distal extension partial overdentures) has been reported to minimize RPD dislodgement, provide additional retention and stability, and improve patient satisfaction in a cost-effective manner[34] Moreover, implant-assisted distal extension partial overdenture provides a stable and durable occlusion, prevents alveolar bone resorption beneath the RPD. Base, reduces stress on the natural abutment teeth, and reduces the need of unaesthetic buccal retentive arm clasp[35, 36]Implant-assisted distal extension partial overdenture also converts Kennedy class I to tooth- implant supported and retained prosthesis (Kennedy class III)[37]

partial overdenture is preferred to positioned distally to provide maximal support and stability and to convert the Kennedy Class I RPDs to Kennedy Class III which is favorable from biomechanical point of view However, limited height of the posterior ridge may restrict implant placement to a more mesial location (distal to the remaining abutment)

B- Implant-supported fixed partial dentures:

1- Short implants:

Short implants are sometimes used to overcome the problem of insufficient alveolar bone length. However, this technique is reported to have a high failure rate of up to 44%, which is attributed mainly to the decreased implant-to-crown ratio. [38] To overcome this failure rate, wide-diameter implants are usually used. However, their long-term success rate has not been sufficiently established and sometimes, due to insufficient ridge width, such implants cannot be used.

2- Sinus lifting with long implants supported fixed partial denture:

Sinus floor elevation using a trans-alveolar or a lateral window approach[39], is considered the gold standard to augment the trophic posterior maxilla in a cranial direction. Sinus floor elevation procedures using the lateral window approach have proven to be predictable, providing high implant survival rates, either using simultaneous implant placement or a staged approach disadvantage of this approach is that, patients tend to not accept surgical augmentation because of the risks involved, for example post-operative morbidity, higher cost and pain.

Various grafting procedures and materials are available to aid the implant surgeon in providing the ideal foundation for prosthetic rehabilitation.[21, 30, 31, 40] Autologous bone graft has been considered as the gold standard for bone grafting.[41] It is the only graft material that heals by osteoinduction. [26] It contains living cells and growth factors, and at the same time have osteoconductive potential (provides a scaffold for new bone formation)[42, 43].

The use of graft materials for the sinus lift procedure has several risks. like displacement of the material inside the membrane can result in temporary or chronic sinusitis, which is reported to occur in 10% to 20% of cases, provoking the need for added treatment.[44]

Another concern the postoperative sinus infection, that it could destroy the graft material and threaten implant success even if early intervention with antibiotics and saline rinsing was undertaken. [45]

3- Angulated implants:

The idea has been developed in a trial to reduce the need of sinus and ridge augmentation to overcome the bone insufficiency. Depending on the concept of placing implants anterior to the anatomical structures (e.g. maxillary sinus) with an angle of 30-45 degree. Many practitioners decline this modality due to weak long-term clinical results.[46]

4- Zygomatic implants:

One of the main indications to use these implants for restoring posterior maxilla is the unfeasibility to place conventional implants in some cases as maxillary sinus pneumatization, the deficient bone volume or maxillectomy.[47]

Several complications have been reported to be associated with this technique, including pain, sinusitis, peri-implantitis and bone resorption following the implants loading.[47, 48]

It is considered a challenging technique due to the limited intraoperative visibility **[47, 48]** and the possible risk of injuring critical anatomical vital structures which are close to the drill way including the nasal cavity and the maxillary sinus.[31]

5- Sub periosteal implant:

The main problems of Sub-periosteal implant are gingival laceration, two stages technique and more aggressive.

Clinical and Radiographic Evaluation of Peri-implant tissues

Assessment of clinical parameters

Similar to the periodontal tissues of the natural teeth, periodontal parameters can be applied to evaluate the condition of peri-implant tissues. Modified plaque index (MPI), Modified Gingival index (MGI), width of keratinized mucosa [49], peri-implant probing depth (PD), implant mobility using Periotest are factors that evaluate the condition of peri-implant tissues[50]

Modified Plaque Index (MPI)

This index measures the amount of plaque accumulation on the gingival third Silness and Loe in 1963[51] introduce the Plaque Index (PI) with Score Criteria;(0) i.e. no detected plaque, (1) A film of plaque detected by using disclosing solution or the probe and cannot be detected with the naked eye[2] Moderate accumulation of plaque in the gingival pocket which can be detected by the naked eye, [2, 52] Abundanc of soft material[50].

Mombelli et al. modified the original plaque index to evaluate formation of the biofilm around the implants in the marginal area at four areas; labial, lingual, mesial and distal, Score of this index are as follows:

score (0) [52] [52] [52] [54] (Shah) no detected plaque, score (1); plaque detected only by a probe running across the implant smooth margin, score[2]; plaque detected by the naked eye, and score[2] ; abundance of soft material.

Increased plaque accumulation leads to a greater susceptibility of peri-implant tissue inflammation which increased the probing depths similar to the process occurring around natural teeth. This due to the significant difference between the natural and peri-implant tissue in the presence of less blood vessels also absence of connective tissue fiber insertion and diminished vascular supply[49].

Modified Gingival index (MGI)

Loe and Silness in 1963 also introduce the Gingival Index (GI). Using blunt probe to evaluate the gingival condition. Score [52]; no inflammation, score(1); slight inflammation, mild change in color, mild edema, absence of bleeding on probing score[2]moderate inflammation, moderate redness, moderate glazing, bleeding on probing, score[2]; severe inflammation, increased redness and hypertrophy, ulceration, spontaneous bleeding. Modification to the GI was introduced as Modified Gingival Index (MGI) and was performed as follows: Score(0) [52] ; normal mucosa, score(1) ; slight inflammation with slight change in color and slight edema, score[2]2) ; moderate inflammation with marked redness, more edema and glazing, and Score[2], severe inflammation, ulceration, marked redness and edema.[51]

Peri-implant Probing Depth (PD)

Measurements were taken by a calibrated periodontal probe. Probing is useful to detect early bone loss on the buccal and lingual aspect of the implant. Probing is important to measure increasing sulcus depths, also to assess the peri-implant tissue condition[53].

As the conventional probing applies exaggerated force result in damaging the fragile attachment, pressure sensitive probes was introduced for probing.[54] During probing the natural teeth, the probe measures the sulcus depth and a portion of the junctional epithelium attachment. While in the implant, the probe reaches closer to crest of the bone going through the junctional epithelial attachment[55]. In the implants, it has been found that probing depth may be a reflection of the thickness of the original soft tissue before implant placement in this area[53, 56, 57].

Implant stability

The degree of osseointegration and the initial bone quality evaluated by many methods, including histology and histomorphometry,[58] removal torque analysis[59], pull- and push-through tests, and radiographic examination, However, these methods are not accurate for long-term clinical assessment due to problems of invasiveness. So a noninvasive device called the Periotest was introduced and used to evaluate the implant stability[60]. The range in Periotest values (PTV) evaluated by clinically osseointegrated implants depends on the surrounding tissues damping characteristics, fibrous tissues in failed implants and bone in successful implants. As the implant slightest clinical mobility is considered a sign of failure, the assessment of PTV is of clinical interest [61].

Also implant stability can be evaluated using resonance frequency analysis (RFA). The Osstell® device measure the resonance frequencies and expressed with implant stability quotient (ISQ) measurement scale[62]. Meredith et al.[63], suggested that the RFA technique is also sensitive to the length of the implant over the bone crest. So when the distance from the transducer to the first bone contact increases, the RF and ISQ value decrease.

Radiographic Evaluation:

From incent to modern dentistry, continuous improvement of radiographs and software programs simplify implant management and follow up process, starting with planning the type and size of the implants for specific implantation sites according to all given needed diagnostic data (bone quality and quantity and its relationship to anatomical vital structures) passing through monitoring of the bone health around the implants and finally simulation and navigation of the surgery[64]. The peri-implant alveolar bone at the implant crystal region is an important indicator for implant health[65] Radiographic interpretation is a standard method used to evaluate the available bone height changes[66]

After implants abutment pick up, Marginal bone level was detected. When follow the maximum distance from the implant abutment same level on the implant side to the marginal bone that means you record the marginal bone level exactly. for each implant, mesial and distal areas were measured. By the X-ray film using a millimeter ruler (digitally or manually), mesial and distal bone levels were recorded, also the same millimeter ruler was used to calibrate the implant size. If the bone level was over the samevloeiing a positive value was assigned, whereas the bone level was below the samevloeiing a negative value was assigned. So, positive values express bone gain, whereas negative values express bone loss. The changes was compared between the base line or reference value (T0) and the rest of the interval periods[67]

As a general role standardization of periapical radiographs by fixing both the angulation of the x-ray film and the distance between the x-ray cone and the implant, provides excellent evaluation of peri-implant bone height changes. Calculation of the magnification factor facilitates the actual measuring of the peri-implant bone loss and it is easily carried out by comparing the real implant size and the radiographic implant size in both vertical and horizontal planes[68].

Radiographs are essential for diagnosis, treatment planning and monitoring treatment. However, on study exposure to x ray for the patients and clinical staff must be considered. No exposure to x-ray can be considered completely free of risk so appropriate protection should be followed. The desire for imaging information should be balanced with the radiation dose and number of exposures when more than one technique suitable in a particular case[69]

Radiographic Assesment of peri-implant bone loss

A lot of radiographic imaging techniques are available, (which may be extra oral or intraoral equine) that can be used for the different stages of implant treatment[70, 71]

1-periapical radiographs

One of the most appropriate suitable technique is the standardized periapical radiograph, which is still the most appropriate technique to evaluate the peri-implant alveolar bone height changes during long term treatment with minimal radiation dose, readily available, inexpensive, high resolution capture of the implant location. Long cone paralleling technique is the technique of choice to overcome the projection errors associated with a 2D (two dimensional) with a true relation between the alveolar bone height and implants [72, 73]

The use of a film holding system ensures accuracy in measurements, that happened if most of these precautions are taken; the film should be parallel to the implant long axis and the central x-ray axis at right angle to them to avoid the image distortion, the images should be reproducible to permit comparing between the measurements on serial radiographs, the system should be cost effective and easy to be used in reasonable time. The film holder system has to be appropriate for the different using of the long cone paralleling technique, with an index that may be made from silicone[74] or acrylic materials[73]

The main negative feedback of the intraoral radiography is distortions, no reproducible imaging geometry and lack of cross sectional information, which is very important in implant bone height evaluation[72]

The comparison advocated that using of radiographic techniques for measuring marginal bone height loss should enable detection of variations in bone height to a resolution of 0.1 mm. It is clear that if the threads of the implant are not clearly defined on the radiograph, so the reliable measurements cannot be performed. Therefore, any method applied to assess marginal bone height changes two factors should be considered; the parallelism between the examined fixture and x-ray film plane and the reproducibility of the projection at each follow up evaluation for the same implant[75, 76]

In new digital technique, a digital subtraction method is a technique that uses digital program which able to detect the smallest changes between two standardized conventional radiographs of the same object, by fabricating radiographic stent, the software subtract all the identical structure in pre and postoperative x ray, this method able to detect the smallest changes in the compact and cancellous bone and allow detection to early changes in bone during healing after treatment than in the conventional morphometric analysis by outlining and area calculation[77]

2. Panoramic radiograph:

All the oral tissue and surrounding structure can detect by this type of extra oral radiographic images, because it acts as general surveying to the maxilla and mandible and their surrounding structures like TMJ, sinuses and nasal cavity. In the other hand it is not so precise like periapical films in determination of small changes so it is not recommended in revealing details in caries diagnostics, periodontal bone assessment, and apical pathosis or as tool to follow up in healing of radiolucency. Panoramic radiography affords a favorable overall view of the teeth and the bone with radiation in small dose[78]

One of its advantage is its standardized projection in the vertical plane, so it is well suited for vertical measurements. Panoramic radiographs were used for measuring the marginal bone loss around dental implants in patient implants overdenture. The authors used the known distance between implant threads and the number of exposed threads in the panoramic radiograph for calculating the amount of bone loss around every implants[79]

Finally, there are some disadvantages of panoramic x-ray such as, The panoramic radiographs have shadows of the airway and the soft tissue superimposition and the ghost images which can interfere with the radiographic interpretation[78]. For detailed evaluation and quantification, panoramic radiographs are not suitable because of distortion, magnification, less x-ray sharpness and superimposition of the vertebral column which make panoramic radiographs with a limited diagnostic data specially in the anterior of the symphysial area[80]

3. Cone beam computed tomography:

CBCT was introduced to the dental field to replace the cumbersome, expensive, and high-radiation–producing medical CT scans around a decade ago[81].

First CBCT was introduced to a dental field with An Italian group in1998,[82] and with some advanced idea with a Japanese group in 1999.[83] .With the first introduce of CBCT units in dentistry in the late 90s. many advantages gained acceptance in the fields of orthodontics, endodontic, implant field, oral and maxillofacial surgery followed by restorative dentistry and finally for the periodontal field[84, 85].

In 2-dimensional imaging, each 2-dimensional pixel represents a 3-dimensional cube or voxel. Each pixel measures the total X-ray absorption throughout each voxel. This 2-dimensional limitation has been overcome by low dosage cone-beam computed tomography, which employs a cone-shaped X-ray beam rather than the flat fan shaped beam used in conventional CT[86].

The overall effective dosage is 0.035 to 0.10 mSv, which is equivalent to between two and eight panoramic radiographs. Individual voxels are much smaller than conventional CT voxels, resulting in greater resolution. Examples of such machines include NewTom DVT 9000 (Quantitative Radiology, Verona, Italy), iCAT (Imaging Sciences International, Hatfield, USA), and 3D Accuitomo (J. Morita, Kyoto, Japan)[87]

Benefits of CBCT are three-dimensional (3D) dataset, real-size data, the potential for generating all 2D images ,potential for vertical scanning in a natural seated position, isotropic voxel size, high-resolution imaging, lower dose of radiation than Multi Slice CT, less disturbance from metal artifacts, reduced costs compared with MSCT, easier accessibility, in-office imaging, easier handling, small footprint, Digital Imaging and Communications in Medicine (DICOM) compatibility, user-friendly post processing and viewing software, and better saving of energy compared with MSCT[52].

Limitations are low contrast range, limited detector size causing limited field of view and limited scanned volume, limited inner soft tissue information, increased noise from scatter radiation and concomitant loss of contrast resolution, movement of artifacts affecting the whole dataset, truncation artifacts (caused by the fact that projections acquired with the region of interest selection do not contain the entire object), and that they cannot be used for estimation of Hounsfield units (HUs).[81]

In the posterior mandibular region, a deep lingual undercut is a common finding and can be difficult to manage, especially when a lingual plate perforation is suspected. It is essential to check the angulations and positioning of the drills or implant fixtures via radiographs and clinical detection of a possible perforation in the osteotomy site. For preoperative implants, CTs are preferred because cross-sectional views bring a clearer visualization of the anatomy of the surgical site[88].

The main disadvantages of CBCT was high doses of radiation and extra costs if compared with conventional imaging techniques, and beam hardening artefacts of metals that do not justify its routine use for implant treatment follow up stages[89, 90]

Measurement of patient satisfaction

In the past, dental researchers considered clinician based outcome measures to be more important than subjective patient-based measures[91, 92]. Recently, however, researchers have begun to focus more on patient perceptions of oral health and oral treatment to better understand the effect of treatment on patients' quality of life[93].

Strassburger and coworkers[94] found that the use of broad questions about general satisfaction were generally supplemented with more specific questions on patient factors such as comfort, esthetics, ease of cleaning, and chewing function

Spilker [95] classify the Quality of life into three levels; 1, an overall level (an individual's total satisfaction with life and one's general sense of personal well-being)**.** 2, a middle level (broad domain including the four categories; physical state and functional abilities, psychologic state and well-being, social interactions, and economic status and factors), 3. lower level (indicating specific aspects for various diseases). A lower level of QOL has been found to be oral health related

Conclusions

There is different modalities for treatment of maxillary free end saddle but it could be concluded that; fixed restorations supported with either long or short implants for rehabilitation of posterior atrophied maxillary ridges were associated with improved implant stability, reduced crestal bone loss, and increased patient satisfaction compared to implant assisted partial dentures. However, implant-assisted partial dentures were associated with favorable peri-implant soft tissue health and increased satisfaction with surgery, healing, and cleaning compared to fixed restorations.

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Not Applicable

Disclosure

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