REVIEW ARTICLE

IMPLANT BASED REHABILITATION OPTIONS FOR THE ATROPHIC MAXILLA: A REVIEW

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ABSTRACT

The reconstruction of edentulous, atrophic jaws according to functional and esthetic factors not only restores chewing function, but leads to positive psychosocial effects and thus also improves the patient's quality of life. The placement of implants in the alveolar bone remains a challenge because of the resorption of the residual ridge resulting in insufficient bone volume in one or more dimensions. The aim of this article is to review the various options to rehabilitate atrophic maxilla with/without bone modification procedures.

KEY WORDS

atrophic maxilla, grafts, osteotomy, implants

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INTRODUCTION

Implant dentistry has growing leaps and bounds in recent years after the successful introduction of osseointegration concept by Prof. P.I Branemark in the early 1960s.[1] In maxilla, centripetal pattern of alveolar resorption, pneumatization of maxillary sinuses, presence of nasal fossae and nasopalatal duct, poor bone quality complicate implant placement[2-4]

Rehabilitation of the maxillary anterior region has been far easier than the maxillary posterior region due to various factors. The posterior maxillary region is characterized by inadequate residual bone height due to maxillary sinus expansion and/or alveolar bone resorption and poor bone density (Type III or IV) according to Lekholm and Zarb classification system Implant rehabilitation has shown higher success rates of 84-92 %, when sufficient bone is available in maxilla. But, atrophy in maxilla is not an uncommon finding and conventional implant placement gets complicated in such situations

Various techniques available for rehabilitation of atrophic maxilla with dental implants. Among the techniques proposed for such anatomical limitations, mention has been made on the following: bone augmentation using grafts, osteotomy and guided bone regeneration (GBR, elevation of the sinus floor, implant placement in alternative anatomical regions, tilted placement of implants, the use of mini-implants, zygomatic implants, pterygoid implants.

It is necessary to define case selection criteria according to the remaining crestal bone and the anatomy of the sinus cavity. The purpose of this review was to discuss the treatment options of the different techniques available for rehabilitation of atrophic maxilla

MATERIAL AND METHOD

A search was made of PubMed for articles published between 1992 and 2018 using the following key words: "pterygoid implants, pterygomaxillary implants, zygomatic implants,

MAXILLARY REHABILITATION OPTIONS

Table 1. Maxillary rehabilitation options

Augmentation of the remaining bone	Utilization of the remaining bone
Sinus floor elevation	Short implants
+/– grafting	Tuberosity implants
Onlay bone graft	Pterygoid implants
Le Fort 1 osteotomy	"All-on-4®"
+ bone graft	Zygoma implants

atrophic maxilla, maxillary tuberosity, short dental implants. According to the search result, the articles presented with the various treatment options described thoroughly along with clinical case reports were included in this review.

Retrospective study was done where 356 patients were evaluated from 1994 to 1998 through DentaScan, among them 6 patients were undergone sinus lift alveolar augmentation.[5] Thirteen articles were included, reporting a total of 1053 pterygoid implants in 676 patients.[6] retrospective analysis done in 28 patients from 1998 to 2013 with zygomatic implants.[7] 272 implants with onlay bone grafting were studied .[8]

Inclusion and Exclusion Criteria [8]

Patients' inclusion criterion was the presence of atrophic edentulous areas in the maxilla with a degree of atrophy enabling implant placement in a desired esthetic position.

Patients' exclusion criteria were as follows:

- severe kidney and/or liver disease
- congenital or acquired immunodeficiency
- ongoing chemotherapy at the time of first examination
- sequelae of radiotherapy in the head and neck area
- connective tissue disease of any kind
- poor oral hygiene
- noncompliance

RESULTS

In the articles reviewed, implant lengths ranged from 7 mm to 20 mm, and diameter 3.75-4mm.[6,7] A cumulative success rate of 88.1% was obtained from this retrospective analysis done on zygomatic implants.[7] The available length for zygoma implants range from 30 mm to 52.5 mm. After reviewed cases for sinus lifting 2 cases failed among 6, due topmost operative infection.[5] one article showed that there is 65% of cumulative survival rate of implants with onlay bone graft in the posterior atrophic maxilla after 84 months follow-up.[8]

SURGICAL PROCEDURE

AUGMENTATION OF THE REMAINING MAXILLARY BONE

A number of techniques have been described to augment maxillary alveolar ridge width and height. In severe 3-dimensional atrophy, these techniques can be combined[9]

1. Sinus Floor elevation

The reduced vertical bone height in the posterior maxillary region is often a major obstacle to the placement of dental implants[10]. Elevation of the maxillary sinus floor with or without grafting is the only solution for this problem. The primary purpose of sinus lift procedure is to create sufficient bone structure to allow implant placement and its prostheses in a predictable way.[1,25]

Various surgical techniques such as endoscopically controlled technique[11], hydraulic pressure technique[6], and antral membrane balloon elevation technique have been presented to access the sinus cavity and elevate the sinus membrane.[12,33]

Sinus floor elevation/direct technique using the lateral window technique was first described by Tatum over 40 years ago. In this technique, access to the maxillary sinus is obtained via a lateral bone window. The window is elevated and swung upwards and medially whilst being careful to ensure preservation of the sinus membrane.[13][fig:1, fig:4]

Sinus Intrusion Osteotomy/Indirect Technique. The technique is indicated when minimal bone height is needed and there is sufficient bone for stabilization of an implant. This technique was developed in 1994 by Summers. implant drills are used initially to create implant bed, leaving 1 mm of bone between the site and the sinus membrane. e. After preparing the site with the implant drills, sequential osteotomes with progressively increasing diameter are used to the depth of desired implant length; this compacts bone lateral and apical, and elevates the sinus membrane.[13][fig:2, fig:4]

Osteotomy/indirect technique can be recommended when more than 6 mm of residual bone height is present and an increase of 3-4 mm is expected.[14][fig:4]

The immediate primary stability is also better achieved with direct sinus lift technique.[14]

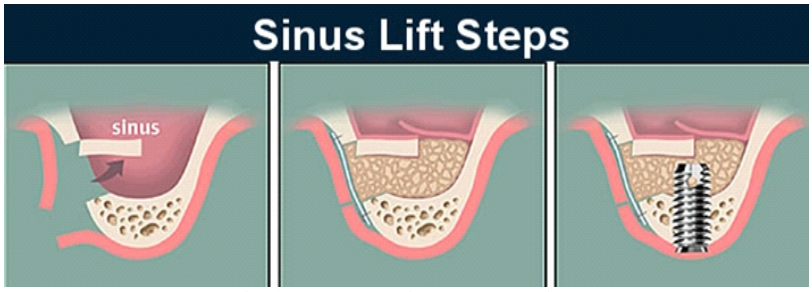


Fig 1 : lateral window technique

Fig2 : summer's technique

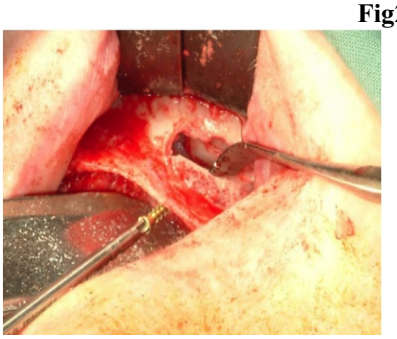


Fig 3 :sinus lift by lateral window

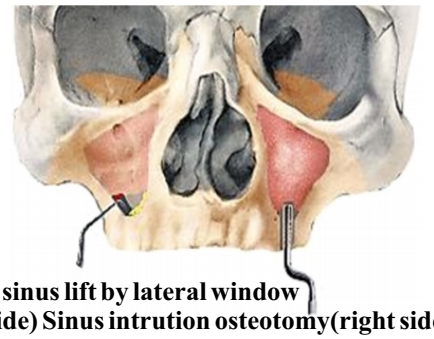


Fig 4 :sinus lift by lateral window (left side) Sinus intrution osteotomy(right side)

2. Onlay bone graft [Treatment with grafts]

Where there is a significant reduction in alveolar crest width, bone can be grafted. If necessary, this can be done in combination with sinus lifting

The definition of adequate bone width and height requirements for implant placement is based mainly on clinical experience and on physical and mechanical requirements for the actual implant placement process. A minimum width of 5 mm and a height of 7-10 mm of bone are suggested by most clinicians. The minimum height requirement of 10 mm is also supported by several implant survival studies in which higher failure rates were consistently reported for shorter implants.

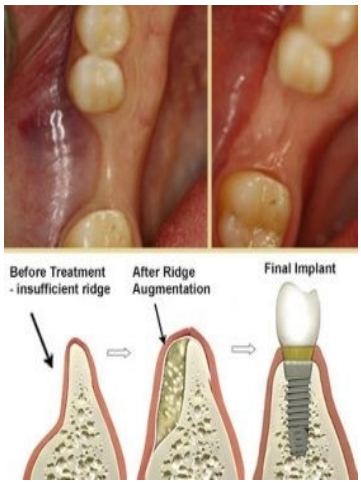
Various procedures are available like block grafts, particulate grafts and ridge expansion techniques.[15] The use of corticocancellous bone grafts for ridge augmentation in implant dentistry was first reported by Breine and Branemark. Autogenous bone has been successfully used as a grafting material to augment the site and is generally considered to be the best material for bone reconstruction surgery.[16,17] It is often obtained from intraoral sites such as chin and retromolar area or extraoral sites such as the anterior or posterior iliac crest, the calvarium and the tibia. The bone can be sourced from a variety of local and regional sites, with the largest available reservoir being the hip[18]

The main advantage of using autogenous bone is related to the osteoconductive and osteoinductive capacities of the graft; the disadvantage is the use of an additional surgical site, with the risk of donor site morbidity.

3. Osteotomy and guided bone regeneration

Various treatment options devised over the years for inadequate ridge width are, increase of width by augmentation, bone expansion and ridge splitting

The Le Fort I osteotomy, first proposed by Obwegeser [1969], was accurately described by Bell et al. [1977] as the surgical technique to move the maxilla of edentulous patients forward, making adequate prosthetic rehabilitation possible.[19] Displacement of the osseous segment results in positioning of a healthy portion of bone into a previously deficient site. A regeneration chamber is left at the natural location of the segment which has a natural capacity to heal by filling with bone instead of fibrous tissue.[20] As a result the alveolar housing including the osseous and soft tissue components are enlarged in a single process. This technique permits placement of regular sized implants through the expanded ridge crest. This bone segment is not regenerated using grafted tissue, it is native bone,



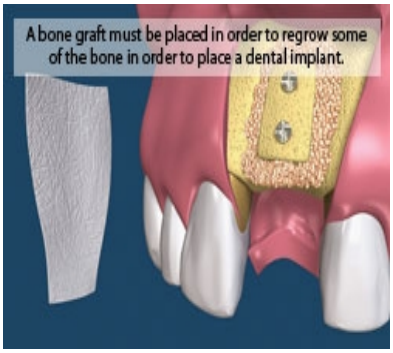


Fig 5 ; osteotomy and GBR

Fig :6, Tilted implant (left side), mini-implant(righr side)

which provides an ideal situation to deal with. Bone expansion/splitting may be done by means of osteotomes or chisels. When bone width >3-4 mm, osteotomes are used and when <3-4mm the ridge splitting is done with sharp blade like chisels.[3]

Another technique proposed with the aim of reconstructing the resorbed maxillae for more successful implant surgery was the guided bone regeneration (GBR) technique, which was developed by Dahlin et al. [1989]: The authors showed that a barrier membrane makes it possible to maintain a free space and prevents the ingrowth of surrounding soft tissue, which could disturb bone healing. Many studies have demonstrated the predictability of using both techniques in improving bone volume and reducing bone resorption after autologous or heterologous bone grafts. The combination of both techniques, namely Le Fort I osteotomy and GBR, was first attempted by Stetzer et al. during a study on rabbits; the authors reported 40% more new bone if the osteotomy site was covered with a barrier membrane than if it was left uncovered.

UTILIZATION OF THE REMAINING MAXILLARY BONE

1.Short implants

Many early studies reported lower success rates with short implants, however with improvements in implant surface technology, this is no longer the case. Finite element analysis (FEA) confirms that the maximum stress occurs along the top 5–6 mm of an implant, and that implant diameter is more important for stress distribution than length. If there is adequate alveolar width and a minimum of 5 mm of bone remaining to the maxillary sinus, the use of a short implant may avoid the need for bone augmentation.[2,21] thereby simple treatment leading to better patient compliance and less complicated implant based rehabilitation.[22]

2.Tilted implants

Since the 19th century, tilted concept in the posterior region of the maxilla was demonstrated as one of the alternatives to bone grafting. Using tilted implants, distribution of axial, shear, and transverse forces would not be harmful due to greater anterior-posterior coverage of the design, which has been proven by 3D finite element analysis of stress levels. Tilting of the implants reduces the cantilever length by increasing the inter-implant distance and decreasing compressive stress. Commonly used in all-on-4/all-on-6 cases. Multiple studies have suggested the use of tilted implants for maxillary rehabilitation using immediate loading.[23]

3..Tuberosity implants

Because of the reduced amount of bone often found in the posterior maxilla, posterior to the sinus cavity, osseointegrated implants are rarely used distally to the first molar region in maxillary tuberosity. This avoids the potential problems related to cantilevers.[35]

4. Pterygoid implants

Considering these challenges posed by the anatomy, few techniques have been in use such as sinus lift procedures, guided bone regeneration grafting with bone autogenous and allogenous grafts; and later tilted implants (All-on-4), zygomatic implants were introduced. However, these procedures have complications such as sinus membrane perforation, rejection of graft, graft displacement into sinus cavities, and screw loosening

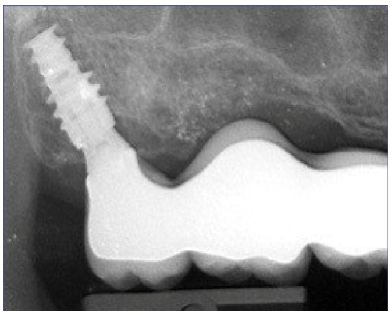


Fig 7:Tuberosity implant

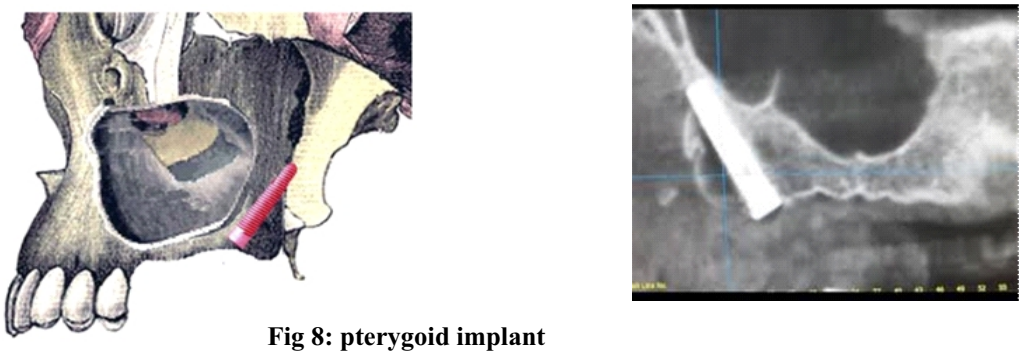


Fig 8: pterygoid implant

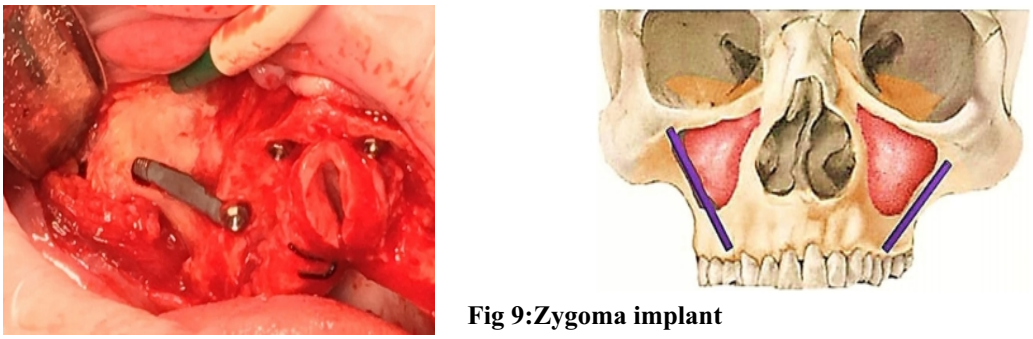


Fig 9:Zygoma implant

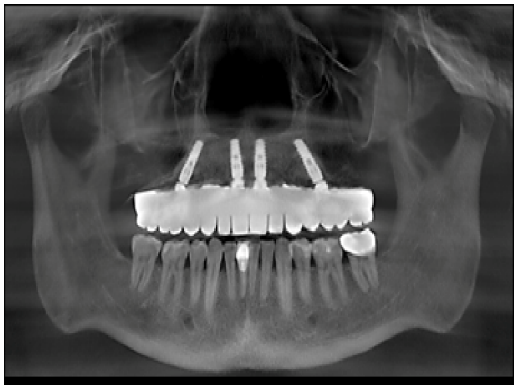


Fig10: all-on-4

of tilted implants. To prevent such problems posterior-most area of maxillary tuberosity; distal to maxillary sinus can be utilized for implant placement. Implants placed in the compact bone of the pterygomaxillary region shows ossteogration and provides retention and stability. This area is pterygoid or pterygomaxillary region. It was introduced by Tulasne (1992).[25] Tulasne (1989) credited Paul Tessier for proposing an idea of placing implants in the pterygoid region. Due to their long path, length of pterygoid implants ranges from 15 mm to 20 mm.[12,25] Pterygoid implants take bicortical anchorage, due to which the axial loading is improved and posterior cantilever is eliminated[4]

A pterygoid implant is anchored in the pterygoid plate of the sphenoid bone, through the maxillary and palatine bones with an angulation of between 35° and 55°. . Pterygoid implants may have an advantage over tuberosity implants as they engage dense cortical bone, however they may be difficult to restore due to their posterior location, and the patient must have a minimum of 35 mm of mouth opening[2,26]

5. Zygoma implants

The use of long implants to engage the bone stock within the zygoma was first described by Branemark[14] in 1998.[27] The original technique utilised bilateral zygoma implants in combination with four conventional dental implants in the anterior maxilla. The technique has since undergone several modifications. Following the 'All-on-4' concept, two zygoma fixtures are now combined with two conventional implants, and in cases where there is insufficient anterior maxillary bone, four zygoma fixtures are placed (quad zygoma). As with conventional 'All-on-4', the fixtures are placed into immediate function and the surgery can be performed as a conventional or guided procedure.In the original Branemark technique, the fixtures entered the sinus cavity from a more palatal position. One of the criticisms of this method of placement was that the head of the fixture was placed too far towards the palate leading to a bulky prosthesis, which was difficult to clean

6.Contemporary maxillary "All-on-4" and "all-on-6"

This evolved from the original 1977 work of Branemark in which 4-6 vertically orientated implants were placed into the premaxilla, however in many cases this resulted in a too long distal cantilever. In order to overcome this problem, Matteson et al.[10] in 1999, described a modification of the technique in which the posterior implants were placed at an angle parallel to the anterior wall of the maxillary sinus. The all-on -4 concept was developed by Paulo Malo : two straight anterior fixtures are combined with two distal fixtures which are tilted posteriorly and, placed anterior to the maxillary sinuses. The implants are inserted at a torque of >35 Ncm [28,29,30]

6 implants can also be placed in edentulous arch with a well balanced prosthetic support for immediate loading and immediate function.[31]

LIMITATIONS

This review article does not represent the indication, contraindication and surgical aspects of each procedure in details, and also the complications related to that.

DISCUSSION

The ultimate goal of implant placement is to generate long-lasting anchorage in the best possible position for a functionally and aesthetically optimal prosthetic solution.[36,37] The posterior maxilla has been described as the most difficult and problematic intraoral area confronting the implant placement. Solutions like sinus lifts often involves a longer healing period, possibility of perforation of the sinus membrane along with the risk of infection.[33] In such cases, when patients who are unwilling or unable to undergo extensive bone grafting, Zygoma fixtures can be given, but Zygoma fixtures also shows tendency to bend under horizontal loads jeopardizing the long-term stability of implant supported restorations. Several articles have assigned various labels to the posteriorly placed maxillary implant. Implants in this region have been described as tuberosity implants, pterygoid plate implants, and pterygomaxillary implants. As far as the treatment planning is concerned, Preoperative evaluation is designed to confirm the appropriateness of treatment with osseointegrated implants. It is also necessary to select the proper implant site, and identify all problems that require correction before the implant is placed. The factors to be considered are the anatomy and condition of the site and its relation to other structures; the position, quantity, and quality of the bone; the relation of the ridge to the adjacent and opposing teeth; and the quality and dimensions of the soft tissues. The main disadvantage with these procedures are that the site of implant placement is very critical from anatomic point of view and also the mouth opening of the patient. Restoration of the pterygomaxillary implants is a challenge to the prosthodontist as the site is inaccessible and high possibility of aspiration of the components. Instead of these difficulties, over the last decade, patient driven demand for an immediate single stage treatment with low morbidity has seen a significant increase in 'graftless' procedures such as 'All-on-4', and now longer term datas are available to support the validity of these approaches. With all the advantages and disadvantages still more clinical trials and studies comparing each procedure are needed further.

CONCLUSION

Maxilla is different in its function, physiology, and bone density from the mandible. These differences, along with its varied anatomy, challenge the implant placement in harmony with planned prosthetic restoration. Appropriate treatment planning is crucial and various factors need to be considered before placing implants in atrophic alveolar bone. There is no consensus as to which treatment modality is superior to other. However, a thorough knowledge of various procedures, materials and proper patient selection, ultimately, the expertise and skill of the clinician will result effective long-term solutions in the management of the atrophied maxilla.

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