Review Article

Anatomy of Pterygoid Area, Classification System, and Treatment Options of Posterior Maxillary Rehabilitation: An Article Review

Rajasekhar Buddiga*, Ch. Siddesh Kumar, Jagadish Konchada, L. Srikanth, M. Sai Bhargav, A. Madhusudhan
Department of Prosthodontics and Crown and Bridge, Sree Sai Dental College and Research Institute, Andhra Pradesh, India.

Abstract

Implant treatment in the extremely atrophic maxilla typically presents a challenge because of anatomical and clinical factors like inadequate residual bone height because of maxillary sinus expansion and/or alveolar bone resorption and poor bone density. Pterygoid implants, which engage the pterygoid process of the sphenoid bone, offer a solution by providing anchorage in dense cortical bone, eliminating the need for sinus lifts and grafting procedures. This article reviews the placement protocol, including diagnostic, surgical, and prosthetic phases. Surgical guides and stereolithographic models are crucial for accurate implant placement, minimizing risks to vital anatomical structures. The technique, often employing a tilted approach (tall and tilted pin hole immediately loaded), aims for primary stability with torque values exceeding 40 N cm, enabling immediate loading. This method provides a stable, cantilever-free prosthetic solution, particularly beneficial for atrophic maxillae, with reported success rates of 90–100%.

Keywords: Atrophic maxilla, Posterior maxillary rehabilitation, Pterygoid implant.

Introduction

Placement of implants in the posterior maxilla is known to be challenging due to the quality and quantity of available bone and the presence of the maxillary sinus.[1] In an attempt to solve these problems, pterygoid implants were introduced. They were first described by TULASNE in 1989, who credited Paul Tessier with the idea of placing implants in this region.[1,2] The pterygoid implant is intended to pass through the maxillary tuberosity, pyramidal process of palatine bone, and then engage the pterygoid process of the sphenoid bone.[1,3]

Owing to their long path, the length of pterygoid implants ranges from 15 to 20 mm[1,2] (Figure 1). The implant enters the region of the former maxillary first or second molar and follows an oblique mesio-cranial direction proceeding posteriorly, toward the pyramidal process. It subsequently proceeds upward between both wings of the pterygoid processes and finds its encroachment in the pterygoid or scaphoid fossa of the sphenoid bone.[3,4]

The primary reason for using pterygoid implants is the availability of dense cortical bone for engagement of the implant.[1-3,5] It also helps to overcome the need for maxillary sinus lift and grafting procedures.[2,5] This can shorten the treatment time and may allow immediate loading of the pterygoid implant.[6] It allows a prosthesis to have sufficient posterior extensions, which eliminates the need for detrimental distal cantilevers.[3,6]

The disadvantages of the pterygoid implant are the learning curve and technique sensitivity associated with the procedure, proximity to vital anatomic structures, and access difficulty for clinicians and patients.[1,2,5] It is radiographically difficult to assess the marginal bone loss around these implants due to the nature of their position.[7]

Anatomy of Pterygoid Area

The tuberosity of maxilla is made out of Type III and Type IV cancellous bone. The pyramidal course of palatine and

Address for correspondence: Dr.Rajasekhar Buddiga,
2nd yr Mds PG Student, Department of Prosthodontics and Crown and Bridge,
Sree Sai Dental College and Research Institute, Andhra Pradesh, India.
Email: dr.rajbuddi@gmail.com

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pterygoid cycle of the sphenoid are principally made out of thick cortical bone. The pterygoid fossa is lined by middle and parallel pterygoid plates.[3]

The pterygopalatine fossa (PPF) is considered a vital region in the profound space, which needs to be assessed cautiously during head and neck imaging. The PPF is restricted by the intersection of three bones (maxilla, palatine, what's more, and sphenoid). Fat, the pterygopalatine ganglion, the "maxillary division (V2) of the trigeminal nerve and its branches, the Vidian" (pterygoid) nerve, the distal parts of the maxillary supply route, also, a couple of emissary veins are the substance of the PPF.[8,9]

The thickest buttress of bone is average to the alveolar edge. The ideal arrangement for the implant is through the pterygoid cycle into the pterygoid fossa.[7] The thickest space of supporting bone is situated in the center of some portion of the pterygoid process between plates. This 3–4 mm average to the alveolar edge, the implant should point somewhat medially to divide the thick place of bone in the pterygoid area.

The hamular process on the average pterygoid plate is substantial in the oropharynx. Implants are set horizontally to this landmark.[7] The pterygoid implants, when utilized in full arch recovery, remove distal cantilevers, an expansion of posterior impediment, also, the best circulation of useful loads.[10-13]

Pterygoid Anatomic Radiographic Prediction (PARP)

Luis *et al*. proposed the classification of diagnostic prediction PARP for implantology in the pterygomaxillary region. Through the PARP, the choice of implant is individualized for each patient, acting as a guide to make implantology accessible in the pterygomaxillary region to the greatest number of specialists. From the degree of sinus invasion obtained after a three-dimensional (3D) computerized tomography (CT), the PARP establishes the prediction of the difficulty implied by implantology in this anatomical region, as well as the appropriate choice of the type of implant and length with which to approach it.

The PARP classification (Figure 2) allows working only in the pterygomaxillary region with retromolar implants[14]

- PARP 1. It is the simplest scenario when there is no sinus invasion, and we have a bone in all its routes. In these cases, the length of the implant depends on the bone density
- PARP 2. The patient presents with a sinus invasion but still has >10 mm of the remaining bone. In case of having good bone density, it would be more appropriate to place a conventionally conceptualized retromolar implant
- PARP 3. This is a case of medium-high difficulty, with sinus invasion leaving a bone surface between 5 mm and 9 mm of remaining bone. In these cases, due to the scarce remnant of alveolar bone and the air of the sinus invasion, the pterygoid anchor will always be used in the apophasis of the same name, with a suitable density.
- PARP 4. In the majority of cases of a large sinus invasion, leaving only a remaining bone smaller than 5 mm, the possibility of using long pterygoid implants or opting for other surgical approaches will be evaluated.

New Classification

The pterygomaxillary implants were divided into three different types based on the anatomical structures the implants passed through. As distinguishing the pyramidal process of the palatine bone is challenging using cone-beam CT (CBCT) data, this anatomical structure was not considered while guiding the classification. To prevent cracking of the tuberosity, the distal part of the implant neck should be designed at least 5 mm mesial to the distal margin of the maxillary tuberosity. To sustain ideal implant strength, all pterygomaxillary implants should exhibit a diameter of at least 4 mm. Moreover, at least 2 mm of bone thickness should remain on each side of the implant after placement. All the implants (mentioned below) follow these rules:[15]

- Type I: Tuberosity implants: The entire body of the implant is embedded in the maxillary tuberosity. To

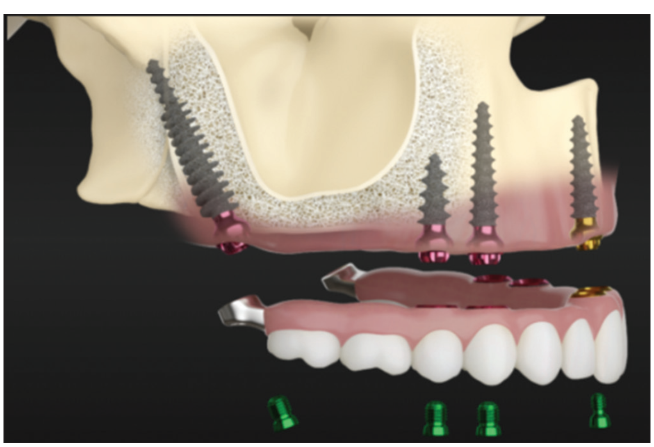

Figure 1: Pterygoid implant

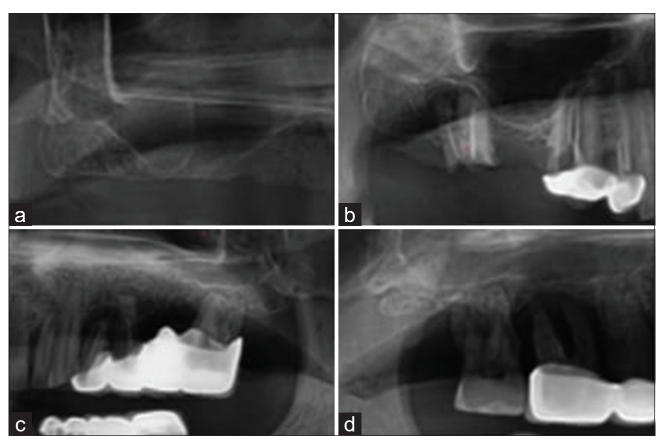

Figure 2: Pterygoid anatomic radiographic prediction (PARP) classification. (a) PARP I, (b) PARP II, (c) PARP III and (d) PARP IV

ensure the ideal primary stability of the implant, the minimal implant length should be 10 mm, and the bone density around the implant should be ideal
- Type II: Pterygoid implants: The implant is placed through the maxillary tuberosity and into the pterygoid plate without maxillary sinus invasion
- Type IIa: Pterygoid implants with adequate bone mass and low bone density of the tuberosity: The position of the implant neck and inclination of the implant are unrestricted
- Type IIb: Pterygoid implants with a limited bone mass of the tuberosity: The three-dimensional position of the implant is restricted due to the morphology of the maxillary tuberosity to ensure sinus integrity
- Type III: Pterygoid implants with maxillary sinus engagement: The implant is placed through the maxillary tuberosity and maxillary sinus, subsequently reaching the pterygoid plate (Figure 3).

Treatment options for posterior maxillary rehabilitation
1. Maxillary sinus floor elevation
2. Zygomatic implants
3. Short implants
4. Tilted implants.

Maxillary sinus floor elevation

The reduced vertical bone height in the posterior maxillary region is often a major obstacle to the placement of dental implants. Elevation of the maxillary sinus floor with or without grafting is the only solution for this problem. Various surgical techniques such as endoscopically controlled technique,[16] hydraulic pressure technique,[17] and antral membrane balloon elevation technique[18] have been presented to access the sinus cavity and elevate the sinus membrane.[19,20]

Zygomatic implants

The technique-sensitive zygoma implants are indicated for severely resorbed maxilla this engages zygomatic bone for anchorage.[21] These implants are screw shaped in commercially pure titanium of variable lengths of 30–52.5 mm.[22] The concept can be expanded when required by inserting two zygomatic implants in a more anterior position (quad zygoma).

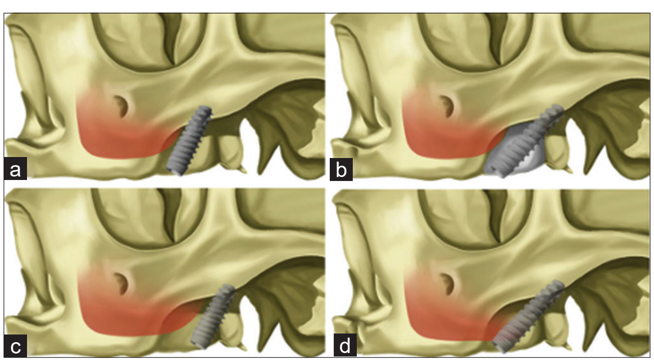

Figure 3: New classification of pterygomaxillary implants. (a) Type I: Tuberosity implants. (b) Type IIa: Pterygoid implants with adequate bone mass and low bone density of the tuberosity. (c) Type IIb: Pterygoid implants with limited bone mass of the tuberosity. (d) Type III: Pterygoid implants with sinus engagement

Short implants

The short implant is considered as an alternative in a situation which is characterized by limited vertical bone height. It is used to avoid bone augmentation procedures in maxillary and mandibular posterior regions. Standard implants have a length of approximately >8 mm, while short implants are usually referred designed with intrabony lengths of ≤8 mm.[21]

Tilted implants

Since the 19th century, a tilted concept in the posterior region of the maxilla was demonstrated as one of the alternatives to bone grafting. Using tilted implants, the 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.[23,24] Tilting of the implants reduces the cantilever length by increasing the inter-implant distance and decreasing compressive stress. Multiple studies have suggested the use of tilted implants for maxillary rehabilitation using immediate loading.[23,24]

Protocol for Pterygoid Implant Placement

Diagnostic level preclinical record

- Clinical assessment summary/relevant medical history
- Pretreatment Photographs: Extraoral: Frontal, lateral, oblique intraoral: Frontal, right, left, upper, and lower occlusal view
- Radiographs: Orthopantomogram, CBCT, and radiovisiography.

Surgical level

Presurgical stereolithography model pterygoid implants are suited to all age groups and systemic conditions unless there is a frank surgical contraindication. Patients with diabetes Type 2 (HbA1c <7%) are suitable for pterygoid implants. To take clinical advantage of pterygoid implants surgical guides and stereolith models are necessary, fabrication of which is done by conversion of patients' CT scan images (Dicom) to stereolithography format. Virtual planning of implant placement and clinical angle measurement should be done. The surgical metal template is fabricated with markings of the point of entry and drilling angulation as per the planned sites. The use of a surgical guide avoids perforations into adjacent anatomical sites (palatal or buccal). Models help to identify the patient-specific anatomy, point of entry, exit and mesiodistal, and buccopalatal angulations.

Surgical phase

The pterygoid implant is placed using a tilted concept, i.e., Tall and tilted pinhole immediately loaded (TTPHIL) technique, surgical metal guide fabricated using the stereolith model. The implant is placed for the second to third molar edentulous space toward the junction formed by the posteroinferior projection of the sphenoid, palatine process, and the maxillary surface with distal angulation of 25–45° depending on the maxillary floor and height of tuberosity. The implant site is prepared using a pilot drill and a final tapered drill (Single drill concept) in a superior, posterior, distal, and palatal direction. The entry point and angulations of drills are guided by the metal template. The implant used is 18–25 mm long and 3.75 mm or 4.2 mm in diameter. To check for the stability of the implant torque values of >40N cm are to be obtained if immediate loading is desired. Multiunit abutments with varying lengths (3–5 mm) and angulations (30°, 40°, and 50°) are placed.

Parallelism was obtained on the same day of surgery. Postoperative panoramic radiographs confirmed the position of the implants. Tulasne[25] proposed the pterygoid implant technique using a 22 mm long implant, which was anchored to the pterygoid plate through the maxilla and palate with distal angulation between 45° and 55° (Figure 4). The osteotome technique minimizes surgical risk, and preserves bone, with better tactile control, whereas the drills facilitate the formation of the implant bed, especially in the dense cortical bone area.[26-29]

Prosthetic level

For partial or full arch rehabilitation with posterior pterygoid implants and anterior implants, the prosthetic protocol was as follows. A two-step open tray direct impression technique is used with putty and light body material after splinting multiunit impression copings. Multiunit implant analogs are attached to the impression copings; a gingival mask is poured around the implant analog and die stone is poured to form the final cast. Jig trail, Jaw relation, and bite registration are done, recorded, and sent to the lab for computer-aided design (CAD) computer-aided manufacturing (CAM) designing screw-retained fixed prosthesis. Before the final cementation, metal trial and bisque trial are done.

Discussion

The placement of pterygoid implants has emerged as a viable solution to the challenges posed by the posterior maxillary region's limited bone volume and quality. The present review highlights the anatomical considerations, classifications, treatment options, and protocols associated with pterygoid implants, shedding light on their advantages and limitations.

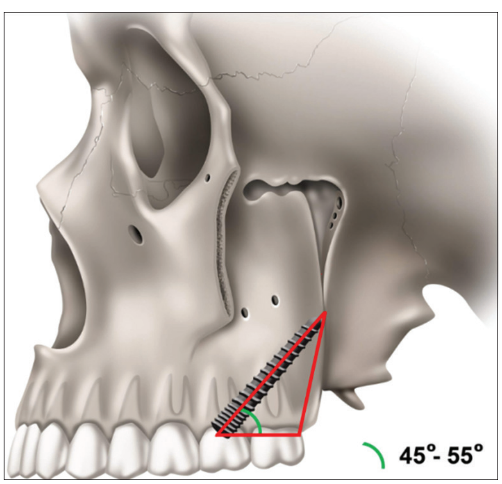

Figure 4: Distal angulation of pterygoid implant

One of the most significant advantages of pterygoid implants is their ability to engage dense cortical bone, providing enhanced primary stability and eliminating the need for maxillary sinus lift procedures. This advantage not only reduces treatment duration but also allows for immediate loading in some cases, making them a promising alternative to conventional implant approaches. Moreover, the strategic placement of pterygoid implants improves prosthetic design by eliminating the need for distal cantilevers, thereby enhancing the longevity and function of the prosthesis.

Despite their benefits, the placement of pterygoid implants remains technique-sensitive, requiring a steep learning curve for clinicians. The proximity to vital anatomical structures such as the maxillary artery, PPF, and the vidian nerve necessitates careful preoperative planning and precise execution. Advanced imaging techniques, including CBCT and the PARP classification system, have been instrumental in assessing the feasibility and complexity of implant placement in the pterygomaxillary region. These diagnostic tools allow for individualized treatment planning based on sinus invasion and residual bone availability, ensuring optimal implant selection and positioning.

The newly proposed classification system for pterygomaxillary implants further refines treatment planning by categorizing implants based on their trajectory and anatomical engagement. This distinction is particularly useful in cases where sinus invasion is unavoidable, as it provides guidelines on implant design and placement strategies to ensure stability and osseointegration.

Comparing pterygoid implants with other treatment modalities for posterior maxillary rehabilitation, including maxillary sinus floor elevation, zygomatic implants, short implants, and tilted implants, reveals distinct advantages and limitations for each approach. While sinus elevation procedures remain a gold standard for addressing vertical bone deficiencies, they involve additional surgical interventions and extended healing times. Zygomatic implants, on the other hand, provide excellent anchorage in cases of severe maxillary resorption but require specialized surgical expertise and carry a risk of sinus-related complications. Short and tilted implants offer less invasive alternatives, but their long-term success is dependent on bone density and implant distribution.

The surgical protocol for pterygoid implant placement, particularly when using the TTPHIL technique and stereolithographic guides, enhances precision and reduces intraoperative risks. By employing customized surgical templates and preoperative virtual planning, clinicians can optimize implant positioning, minimize complications, and improve surgical outcomes. In addition, the osteotome technique, which minimizes bone trauma, provides a valuable alternative to traditional drilling methods, especially in cases with dense cortical bone.

From a prosthetic standpoint, pterygoid implants facilitate full-arch rehabilitation by ensuring adequate posterior support, thereby improving occlusal load distribution. The use of multiunit abutments and CAD/CAM-designed prostheses enhances the accuracy and stability of the final restoration, contributing to overall patient satisfaction and long-term success.

Conclusion

Extremely atrophic maxillae are the most challenging task for restorative dentists. Pterygoid implant provides a reasonable alternative to 3D maxillary reconstruction, sinus lifts, and bone augmentation techniques. Many authors have reported success rates of pterygoid implants ranging from 90% to 100% after a follow-up period ranging from 1 to 12 years with minimal complications. Avoidance of a prosthetic distal cantilever with good stability fit for immediate loading is possible with this technique.

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