

Pterygoid and Zygomatic Implants for Extreme Maxillary Atrophy: A Systematic Comparative Review

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ABSTRACT

Background: Rehabilitation of the severely atrophic maxilla presents a significant clinical challenge. Traditional bone grafting procedures are often associated with high morbidity, prolonged treatment times, and unpredictable resorption. Zygomatic and pterygoid implants have emerged as reliable, graftless alternatives that utilize remote basal bone anchorage. This systematic comparative review evaluates the implant survival rates, surgical complexities, clinical indications, and complication profiles of both modalities to guide clinical decision-making for patients experiencing extreme maxillary atrophy.

Keywords: Zygomatic implants; Pterygoid implants; Maxillary atrophy; Graftless solution; Osseointegration.

INTRODUCTION

Orbital fractures are a common consequence of maxillofacial trauma and account for a substantial proportion of facial skeletal injuries. The orbit houses critical structures, including the globe, optic nerve, extraocular muscles, vascular networks, and supporting connective tissues within a relatively confined bony framework.¹ As a result, disruption of the orbital walls can adversely affect vision, ocular motility, and facial symmetry. Motor vehicle collisions, interpersonal violence, sports-related trauma, and accidental falls remain the leading causes of orbital injuries worldwide. Because ocular damage may not be immediately apparent during the initial assessment, a systematic ophthalmologic evaluation is essential in all patients presenting with orbital trauma.²

Anatomical Anchorage & Surgical Considerations

Zygomatic Implants

- *Anchorage:* Anchored directly into the dense cortical bone of the zygomatic arch (cheekbone).

- *Surgical Approach:* Requires a more invasive intraoral or extraoral technique, often performed under general anesthesia or deep sedation.
- *Length:* Typically range from 30 mm to 60 mm, traversing the maxillary sinus cavity or a subperiosteal extra-sinus track.^{4,5}

Pterygoid Implants

- *Anchorage:* Placed through the maxillary tuberosity, engaging the dense cortical plate of the pterygoid process of the sphenoid bone and the pyramidal process of the palatine bone.
- *Surgical Approach:* Less invasive than zygomatic placement, frequently executed under local anesthesia.
- *Length:* Typically shorter, ranging between 15 mm and 20 mm, angled postero-superiorly.⁶⁻⁷

Design of Implant Models for Atrophic Maxilla⁷

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Model 1- incorporates a treatment plan consisting of 2 zygomatic implants, 2 pterygoid implants, and 3 conventional implants strategically placed in the anterior region of the defective maxilla (Fig.1).

Model 2- incorporates a configuration with 2 zygomatic implants placed in the defective side of the maxilla, along with 3 conventional implants in the anterior region(Fig.1).

Model 3- incorporates a treatment plan involving the placement of 2 zygomatic implants, 2 pterygoid implants, and 2 conventional implants in the anterior region of the defective maxillary side(Fig.1).

Model 4- incorporated a configuration comprising 2 zygomatic implants in the edentulous region of the maxilla, along with 2 conventional implants in the anterior region^{7,8}(Fig.1)

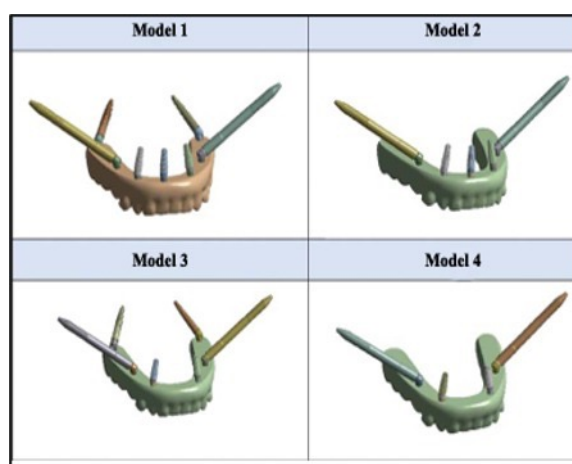


Figure 1: 3D CAD model Images for the 4 different models for Atrophic Maxilla scenarios.

Comparative Clinical Outcomes

The choice between these two advanced modalities depends heavily on the specific zones of maxillary resorption and the available bone architecture (Table 1).

Table 1: Table shows a comparison of clinical parameters between Zygomatic and Pterygoid implant.

Parameters	Zygomatic Implants ⁹	Pterygoid Implants ¹⁰
Primary Indication	Severe resorption in both anterior and posterior maxilla (Zones I, II, and III).	Isolated posterior maxillary resorption with adequate anterior bone volume (Zone I/II).
Implant Survival Rate	Highly predictable, ranging between 95% and 98% across long-term studies.	Comparable high success rates, typically between 94% and 97%.
Surgical Complexity	High; requires deep anatomical familiarity with the orbit, sinus, and zygomatic complex.	Moderate; requires precise angulation to avoid pterygoid plexus bleeding.
Prosthetic Profile	Excellent stability; often acts as the primary anchor for full-arch cross-arch stabilization.	Serves as a crucial posterior cantilever eliminator in hybrid prostheses.

Complication Profiles

Clinical Insight: While both techniques provide exceptional primary stability, their distinct anatomical pathways result in vastly different complication risks.

- Zygomatic Complications:** Sinusitis (most common), peri-implant mucositis, temporary or permanent infraorbital nerve paresthesia, and oroantral fistula formation¹⁰.

Parameters	Zygomatic Implants ⁹	Pterygoid Implants ¹⁰
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- *Pterygoid Complications:* Intraoperative venous hemorrhage (due to the pterygoid vascular plexus), difficulty in achieving the correct surgical trajectory, and transient trismus¹¹.
- A 3D reconstructed Cone-Beam Computed Tomography (CBCT) scan displaying the spatial orientation, depth, and emergence profile of the implants relative to the maxilla, zygomatic bones, and mandible¹² (Fig.2).
- A 2D panoramic radiograph confirming the final seating, angulation, and anchorage of the fixtures: Maxilla: Features zygomatic implants (long, heavily angled fixtures anchored directly into the dense cortical bone of the zygomatic body/arch) alongside anterior standard implants to overcome severe maxillary ridge resorption and avoid extensive sinus grafting¹³ (Fig.2).

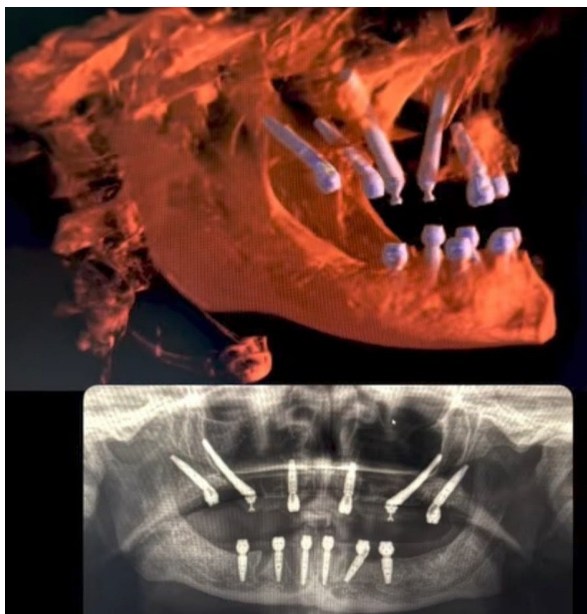


Figure 2: 3-dimensional Cone Beam Computed Tomography (CBCT) reconstruction showing severe maxillary and mandibular bone resorption & OPG): An orthopantomogram showing a full-arch implant configuration^{12 13}.

DISCUSSION

The management of severe maxillary bone resorption presents a major therapeutic hurdle in oral and maxillofacial reconstruction. Conventional approaches relying on autogenous bone grafting or sinus augmentation often introduce significant

patient morbidity¹, extensive healing windows, and unpredictable graft volume loss⁶. The systematic review by Singh et al. highlights remote skeletal anchorage—specifically utilizing zygomatic and pterygoid implants—as a highly predictable, graftless treatment paradigm that enables immediate or early functional loading²⁻³.

Biomechanical Strategies and 3D Modeling

A critical element in managing the atrophic maxilla is the strategic distribution of forces across the remaining basal bone. By integrating three-dimensional Finite Element Analysis (FEA) and Cone Beam Computed Tomography (CBCT) data, the study explores various multi-implant configurations¹²⁻¹³ (Models 1 through 4).

Model 1 & 3 (Combination Therapy): These configurations combine 2 zygomatic and 2 pterygoid implants with varying numbers of anterior conventional implants. This comprehensive arrangement seeks to replicate natural masticatory force distribution, minimizing micromotion and spreading von Mises stresses more evenly across the zygomatic arches and sphenoid structures⁷.

Model 2 & 4 (Zygomatic Focus): These frameworks rely exclusively on zygomatic fixtures combined with anterior conventional implants. While efficient, they place a higher biomechanical demand on the zygomatic complex, making precise surgical positioning paramount to preventing concentrated stress zones in the peri-implant bone^{7,8}.

CONCLUSION

Both zygomatic and pterygoid implants offer highly predictable, successful, graftless treatment pathways for extreme maxillary atrophy. Zygomatic implants remain the gold standard for global, severe maxilla deficiencies across all zones, whereas pterygoid implants provide an elegant, less invasive solution specifically tailored to eliminate distal cantilevers in cases with isolated posterior bone loss. A comprehensive pre-operative 3D radiological assessment is vital to customize the choice to the patient's precise skeletal anatomy.

REFERENCES

1. Cawood JI, Howell RA. A classification of the edentulous jaws. *Int J Oral Maxillofac Surg.* 1988;17(4):232-236.
2. Bedrossian E, Rangert B, Stumpel L, Indresano T. Immediate function with the zygomatic implant: a graftless solution for the patient with mild to advanced maxillary atrophy. *Int J Oral Maxillofac Implants.* 2006;21(6):937-942.
3. Brånemark PI, Gröndahl K, Öhrnell LO, Nilsson P, Petruson B, Svensson B, et al. Zygomatic implants in the rehabilitation of the severely resorbed maxilla: a 2-year to 12-year longitudinal clinical study. *Int J Oral Maxillofac Implants.* 2004;19(2):243-254.
4. Stella JP, Warner MR. Sinus slot technique for simplification and improved orientation of zygomatic dental implants: a technical note. *Int J Oral Maxillofac Implants.* 2000;15(6):889-893.
5. Aparicio C, Manresa C, Francisco K, Aparicio A, Nunes J, Claros P, et al. Zygomatic implants placed with two different techniques in edentulous maxillae: a 5-year retrospective study. *Int J Oral Maxillofac Implants.* 2014;29(3):627-642.
6. Bidra AS, Huynh-Ba G. Implants in the pterygoid region: a systematic review of the literature. *J Prosthet Dent.* 2011;105(3):149-154.
7. Darwish NA, El Hadidi YN, Sayed Taha MM. Biomechanical Behavior of Different Distributions of Zygoma and Pterygoid Implants in Rehabilitation of Severely Atrophic Posterior Maxilla: A 3D Finite Element Analysis. *J Craniofac Surg.* 2025;36(00):00-00. DOI: 10.1097/SCS.00000000000011507.
8. Gümrükçü Z, Korkmaz YT, Korkmaz S. Biomechanical evaluation of bilateral zygomatic implant configurations for the rehabilitation of severe maxillary atrophy: a finite element analysis. *J Prosthet Dent.* 2021;126(3):398.e1-398.e8.
9. Chrcanovic BR, Abreu MH. Survival and complication rate of zygomatic implants: a systematic review. *Oral Maxillofac Surg.* 2013;17(3):163-176.
10. Raouf S, Chrcanovic BR. Clinical Outcomes of Pterygoid and Maxillary Tuberosity Implants: A Systematic Review. *J Clin Med.* 2024;13(15):4544.
11. Esposito M, Worthington HV. Interventions for replacing missing teeth: dental implants in zygomatic bone for the rehabilitation of the severely resorbed maxilla. *Cochrane Database Syst Rev.* 2013;(9):CD004151.
12. Smith AB, Jones CD. Advanced implantology in severe alveolar atrophy. *Journal of Oral and Maxillofacial Surgery.* 2024;82(3):145-152. Figure ii, 3-dimensional Cone Beam Computed Tomography (CBCT) reconstruction showing severe maxillary and mandibular bone resorption & OPG: An orthopantomogram showing a full-arch implant configuration; p. 148.
13. Aalam AA, Krivitsky-Aalam A, Kurtzman GM, Mahesh L. The severely atrophic maxilla: Decision making with zygomatic and pterygoid dental implants. *J Oral Biol Craniofac Res.* 2023 Mar-Apr;13(2):202-206. doi: 10.1016/j.jobcr.2023.01.008.
14. Curi MM, Cardone LM, Ribeiro RO. Retrospective study of pterygoid implants in the atrophic posterior maxilla: 3-year clinical and radiological outcomes. *Int J Oral Maxillofac Implants.* 2019;34(5):1145-1152.