

# Navigating the Challenges of the Severely Atrophic Maxilla: A Review of Zygomatic Solutions

**Dr. Vaishnavi Deshpande<sup>1</sup>, Dr. Rajesh Kumar<sup>2</sup>, Dr. Sunil Kumar MV<sup>3</sup>,  
Dr. Rhythm Saxena<sup>4</sup>, Dr. Krishan Kumar<sup>5</sup>, Dr. Diksha Verma<sup>6</sup>**

<sup>1</sup>PG Student, Department of Prosthodontics, Crown and Bridge, Jaipur Dental College and Hospital, Maharaj Vinayak Global University.

<sup>2</sup>Head of Department, Professor, Department of Prosthodontics, Crown and Bridge, Jaipur Dental College and Hospital, Maharaj Vinayak Global University.

<sup>3</sup>Professor, Department of Prosthodontics, Crown and Bridge, Jaipur Dental College and Hospital, Maharaj Vinayak Global University.

<sup>4</sup>Reader, Department of Prosthodontics, Crown and Bridge, Jaipur Dental College and Hospital,

<sup>5,6</sup>Senior Lecturer, Department of Prosthodontics, Crown and Bridge, Jaipur Dental College and Hospital, Maharaj Vinayak Global University.

## Abstract

Managing severe maxillary atrophy or extensive midface defects presents a profound clinical challenge, often demanding substantial bone augmentation when utilizing conventional implant therapies. Zygomatic implants have emerged as a highly predictable, graftless alternative that utilizes the dense cortical anchorage of the zygomatic bone to support immediate functional prostheses.

This review synthesizes the clinical evolution of zygomatic implantology, tracing the paradigm shift from traditional intrasinus protocols to modern, anatomically guided strategies such as the Zygoma Anatomy-Guided Approach (ZAGA).

A systematic evaluation of patient selection criteria is presented, delineating absolute and relative contraindications alongside rigorous pre-surgical three-dimensional (3D) diagnostic imaging protocols. Furthermore, key biomechanical principles—including the maxillary fulcrum effect and cross-arch stabilization—are analyzed in the context of safe, immediate functional loading. Modern technological adjuncts, such as piezoelectric osteotomy instruments and dynamic computer-aided navigation systems for flapless placement, are also examined.

While meticulous management of potential complications (e.g., chronic sinusitis, orbital penetration) remains vital, these risks do not statistically compromise long-term implant survival rates. Ultimately, continuous refinements in digital workflows and soft-tissue preservation techniques position zygomatic implants as a dependable, patient-specific standard of care in complex maxillofacial reconstruction.

**Keywords:** Atrophic Maxilla, Bone Grafting, Conventional Protocols, Current Concepts, Zygomatic Implants.

## 1. Introduction

Complete edentulism remains a debilitating oral health condition that severely compromises masticatory function, phonetic capability, and psychosocial well-being, ultimately diminishing a patient's self-esteem and quality of life. Given the shifting demographics of an aging global population, oral healthcare providers face increasing demands for predictable, accelerated, and minimally invasive rehabilitative modalities.[1]

Although conventional endosseous implants represent the historical gold standard for dental rehabilitation, their efficacy is strictly contingent upon adequate residual alveolar bone volume. [1,2] Patients presenting with extreme ridge resorption, advanced alveolar atrophy, severe facial trauma, or structural defects secondary to ablative oncological surgeries frequently exhibit insufficient bone architecture for standard implant placement. [2,3]

To address these severe anatomical limitations, Professor P-I Brånemark introduced zygomatic implants as an innovative, alternative therapeutic strategy. These specialized, elongated titanium fixtures bypass the deficient maxillary alveolar ridge to achieve rigid fixation within the dense, highly stable cortical matrix of the zygomatic bone. The classic Brånemark protocol originally dictated the placement of a single zygomatic implant bilaterally, traversing the maxillary sinus cavity, supplemented by two to four conventional anterior implants to stabilize the future prosthesis. [1]

By eliminating the necessity for invasive ancillary procedures—such as autologous bone harvesting, sinus floor elevations, or extensive ridge augmentations—this graftless approach substantially compresses treatment timelines, minimizes donor-site morbidity, and mitigates patient discomfort. Consequently, it facilitates immediate functional loading, accelerating postoperative recovery and optimizing clinical outcomes. [3,4]

## 2. Indication, Contraindications and Pre-surgical Evaluations

### Indications:

The selection of zygomatic implant protocols is primarily governed by the spatial distribution and severity of residual maxillary bone resorption. Clinical indications are broadly categorized into two primary anatomical scenarios: [5,6]

**Segmental Posterior Maxillary Atrophy:** Indicated when the residual vertical bone height in the posterior maxilla is less than 4 mm, while the anterior maxillary bone volume remains sufficient to support standard implants. This clinical scenario favors a hybrid treatment design, combining posterior zygomatic anchorage with conventional anterior endosseous implants to establish a stable, multi-unit prosthetic foundation. [5]

**Generalized Total Maxillary Atrophy:** Indicated when advanced alveolar resorption leaves less than 4 mm of vertical bone height across the entire maxillary arch (both anterior and posterior regions). Because the residual ridge cannot safely accommodate standard fixtures, a "Quad Zygoma" protocol is indicated. This approach utilizes four zygomatic implants simultaneously—two positioned symmetrically within each zygomatic bone—to engineer a robust framework for cross-arch stabilization and fixed prosthetic restoration. [5,6]

### Secondary Indications and Pathological Applications

Beyond idiopathic or age-related alveolar resorption, zygomatic implants are highly indicated under the following clinical and medical circumstances:

**Avoidance of Complex Grafting Procedures:** Indicated for patients who are medically compromised,

present systemic contraindications to extensive bone grafting (such as iliac crest or sinus lifts), or explicitly decline invasive secondary donor-site surgeries. [5,6] **Salvage Therapy:** Serves as a highly reliable secondary intervention to rescue failed conventional implant cases or collapsed bone-grafting sites. **On-cological Maxillofacial Reconstruction:** Acts as a vital retentive framework for obturators or fixed prostheses in patients requiring subtotal or total maxillectomies due to benign or malignant neoplastic diseases. [7,8] **Trauma Rehabilitation:** Utilized to restore stomatognathic function and facial symmetry following complex midface fractures or avulsion injuries resulting in severe loss of maxillary bone. **Congenital Craniofacial Anomalies:** Indicated for the functional rehabilitation of severe structural deficiencies associated with congenital deformities, including cleft lip and palate sequelae.[7,8]

### Contraindications

Patient screening must rigorously isolate conditions that jeopardize osseointegration, wound healing, or surgical safety. These parameters are categorized into absolute and relative contraindications.[5]

#### Absolute Contraindications

**Active Maxillary Sinus Pathology:** Acute or uncontrolled chronic sinus infections, severe mucosal diseases, or untreated fungal pathologies within the maxillary sinus cavity. **Local Osseous Pathologies:** Active benign or malignant tumors, or extensive fibro-osseous lesions localized to the maxillary or zygomatic structures. **Uncontrolled Systemic Diseases:** Severe, uncompensated metabolic or systemic conditions (e.g., uncontrolled diabetes mellitus, advanced immunosuppression) that profoundly impair osseous healing. **Therapeutic Head and Neck Irradiation:** History of high-dose radiation therapy targeting the maxillofacial complex, which induces osteoradionecrosis risks and impairs bone vascularity. **Severely Restricted Trismus:** Inadequate mouth opening that physically prevents the introduction, visualization, or safe manipulation of specialized, elongated surgical instrumentation.[5]

#### Relative Contraindications

**Chronic Managed Sinusitis:** Long-standing sinus inflammation that requires pre-operative otolaryngological clearance, medical management, or functional endoscopic sinus surgery (FESS) prior to implant placement. **Heavy Tobacco Use:** Nicotine dependency exceeding 20 cigarettes per day, which severely compromises peripheral vascularity and soft-tissue healing. **Antiresorptive Medication Use:** Ongoing or historical therapy with high-potency bisphosphonates or other bone-modifying agents associated with medication-related osteonecrosis of the jaw (MRONJ). **General Surgical Incompatibility:** Patients whose systemic health status restricts the safe administration of deep intravenous sedation or general anaesthesia.[5]

#### Pre-surgical Evaluation and Prosthetic Guidelines:

Insertion of implants through the maxillary sinus and the zygoma is a considerable challenge.[9] The level of maxilla, sinus and zygoma will be clinically and radiologically evaluated.[10] The spiral or helical computed tomography (CT) scan is preferred to an assessment, because it can provide two- and three-dimensional images and can produce inaccurate information in OPG.[11,12] In addition, The CT scan checks on the health of the maxilla and sinuses.[10,11] Sinusitis, polyps and other sinus disease can be excluded. The zygoma can be evaluated in terms of density, length and volume, and unique templates can be created on stereolithographic models to facilitate the handling of the zygomatic implants in the surgical area, ensuring the correct angulation and position during the technique.[12] The following are guidelines for pre-surgical evaluation:

**1.Clinical Examination Systemic Health:** Assess the patient's medical history such as smoking, diabetes, history of radiation, and bisphosphonate use. Examining the upper gumline, gum condition of any

teeth that are still present and the ability to open the mouth. Evaluate patient expectations and ability to maintain oral hygiene. excluding acute or chronic sinusitis or any maxilla/zygoma pathologies. [5,6]**2. Radiographic Evaluations:** A 3D Cone Beam Computed Tomography (CBCT) scan is a “must” to evaluate the volume and density of the zygomatic bone, health of the maxillary sinuses and anatomical structures. Look for any sinusitis, polyps or thickening of the membranes. Evaluate alveolar ridge remnant and zygoma for implants. Locate the infraorbital nerve, nasal fossa and maxillary sinus cavity. [10,11]**3. ZAGA (Zygoma Anatomy-Guided Approach) Evaluation:** The maxilla and zygoma relationship is classified using ZAGA classification (0-4) to decide to employ either intrasinus or extrasinus pathway. [9,11] Establish the ZICZ (Zygomatic Implant Critical Zone) to evaluate the relationship between the alveolar bone and the soft tissue for the purpose of minimizing soft tissue recession with the placement of the implant.[10] **4. Prosthetic Planning:** Make casts for evaluation of the prosthetic space and to determine the proposed position of the tooth. [12] Diagnostic Wax-up/Set-up: Make a wax up or set-up to decide on the best position of the prostheses. Surgical Guide: Create a surgical guide with digital planning to assure correct angulation of the implant. [11,12] **5. Final Preparation:** Obtain thorough informed consent for procedure, risks, and postoperative.[5] Pre-operative Cleaning Professional oral cleaning. Follow surgical protocol for prescribing antibiotics. Primary stability 35-45 Ncm, don't exceed 45 Ncm (otherwise necrosis will occur). The distance of 3 mm of bone thickness above the implant at the zygoma level is the minimal distance that must be ensured. Patient: Patient management includes treating existing sinus pathologies prior to implant placement.

### 3. Fixture design and Biomechanics

The regular dental implant is normally 8-13 mm long and only supported by the jaw bone. In the case of its serious resorption, the zygomatic implants will have to span a large gap in the bone. These elongated titanium fixtures range from 30 to 52.5 mm in length, engaging directly into the dense predictable structure of the cheekbone (zygoma) without bothering about any missing bone. [13,14]

#### Key Structural Features:

A zygomatic implant is not only a longer implant but also the shape of the implant has been modified from the top to the bottom in order to deal with the various tissue environments.[15]

- **The Angled Head 45 - 55°:** Cheekbone is positioned at an outward angle in relation to where teeth should be. To correct this significant alignment problem, the top (head) of the implant has a built-in tilt of 45° to 55°. [14,15] This important curve brings the mechanical platform back down into the mouth where the final bridge can emerge straight through the gums for normal easy to service screw-retained teeth. [13,15]
- **Dual Surface Treatment:** The surface treatment of the implant is divided into two zones, since the implant passes through bone and open spaces (the sinus) and sensitive gum tissue.
- **Apical Tip (Rough Surface):** is the top tip that fits into the cheekbone, which is treated with a special micro-roughness. This texture forms a scaffolding that makes the implant fast and aggressive to bond with the bone (osseointegration).[16]
- **The Middle Body and Neck (Smooth/Machined Surface):** All of the middle portion that passes through or skims the maxillary sinus is smoothed out perfectly. This machined finish helps to eliminate the possibility of bacteria adhering to the metal, greatly reducing the chances of chronic sinusitis and soft tissue irritation. [13,16]

### Specialized Design Variations: The ZAGA Influence

Modern implant geometry is a variety of specially shaped implants to ensure that the implant isn't a round peg in a square hole, but fits the wide range of human facial contours. [16]

- **ZAGA Flat:** This variant has a flattened side on its cylindrical body. Designed to conform completely to the outside of the maxillary sinus, it ensures a good bone contact and avoids over-drilling or shaping of the bone.[9,16]
- **ZAGA Round:** This is the traditional full round shape and is used most often when there is a straight, secure, bone pathway that can fully contain the implant (round).[11,16]
- **One-Piece / Fixed Design:** Frequently used in immediate loading situations, this design features no additional moving parts, resulting in the highest level of primary stability to facilitate the attachment of temporary teeth. [13,16]

Most of the time the implant enters the mouth on the upper second premolar area on the palate (roof of mouth). It then ascends, enters or passes through the maxillary sinus and firmly anchors its thread-shaped tip in the hard cortical bone of the cheekbone. This particular track teaches the weight of chewing to the sturdy mid-face pillars and offloads it from the weak and vulnerable jaw. [13,14,15]

### Biomechanical principles of zygomatic implants

Zygomatic implant protocols necessitate a significant departure from the standard biomechanical fundamentals governing conventional endosseous implants. In addition, because of their length and positioning at extremely divergent angles, the implants are under a different number of physiological stresses. Pioneers such as Dr. Edmond Bedrossian have relied on cutting-edge biomechanical modeling to impart the answer. [14,15]

The biomechanical configurations of zygomatic implants initially present complex leverage challenges that appear counter-intuitive to conventional implant physics. The basics of the physics, however, are based on these three fundamental concepts:

This is the superior part of the cheekbone anchor. This is the top part of the cheekbone anchor. When the upper jaw is very atrophic, the surviving bone is often thin, soft and porous (Type IV bone). Zygomatic bone consists of high quality and dense cortical bone (Type II) giving it a high initial dental lock in place that allows it to be used immediately. [13,14]

**The Lever Arm Effect:** A zygomatic implant makes up a classic mechanical lever since it connects the mouth to the cheek. The more the teeth are from the anchor bone (cheek bone) the more bending stress is on the hardware (bending moment) This relationship is governed by the mathematical formula for bending moments:

$$M = F \times d$$

where M represents the bending moment, F denotes the occlusal force, and d is the perpendicular distance from the application of force to the osseous anchorage point. [15]

**The Maxillary Fulcrum:** Where the implant passes through the jawbone ridge, delivers a function as a pivot point. Bedrossian emphasizes that even though they use up-to-date "sinus slot" or "extrasinus" techniques, the implant needs only to be in contact with the bottom of the jaw ridge.[13] When the chin implant is suspended completely in space without contact with the maxilla, the amount of physical pressure that is applied to the structure increases dramatically, with the potential of failure. The mechanical stress ought to be shared evenly around the system as forces are applied on a day-to-day basis to prevent the system from disintegrating under stress (stability under pressure). [14,15]

**The Golden Rule:** Cross Arch Stabilization is proper fit: Zygomatic implants should only be used in the right combination with each other. Use a solid prosthetic bridge, by rigidly locking them together, to evenly distribute the bending forces into the whole jaw. In this cross-arch unity, the neutralization of the lever effect of each of the implants is very effective. [13,15]

The Stress Concentrates – Finite Element Analysis (FEA) computer models determine that there are two specific areas of stress peaks:

**The neck of the implant (the part that pokes through the average gum into the mouth).**

**The very top of the implant (where it is nestled in the cheekbone).[14]**

**The "Quad" Advantage:** If no bony portion of the front of the jaw is available for use, the "Quad" Zygoma (4 implants) is used. This affords a structural set up which is much more stable and forms a box that out hold "next to nothing" tipping, twisting or rotational forces compared to a two-implant set up. [13,14]

**Bedrossian's Clinical Rules:** How to turn Physics into Success

To implement these engineering principles into predictable clinical results, Bedrossian has three rules that are never violated on the restorative team: The end bridge cannot be movable. It needs to be made of another completely-stable metal such as milled titanium, cobalt-chromium or zirconia. This stiffness ensures that they will move as one piece of solid object (tripod, or quadpod). [13,15]

**Optimize Emergence Profile:** The implant should protrude as near as possible to the ridge of the jaw and gums to the top of the jaws. By keeping the ridge close, this shortens this cantilever, which decreases the mechanical bending forces every time it is clenched by the patient. [14,15]

Immediate loading is safe: High initial tightening (insertion torque) is possible with the dense cheek bone and when the implants are rigidly cross-slitted across the arch, they are extremely successful with immediate use of the temporary teeth.[13]

zygotic implants (ZIs) are used to deal with heavy loads of chewing (occlusal forces), especially in the patient with severe bone loss (atrophic maxilla). The authors don't consider the ZIs as ordinary dental implants but rather they consider these implants to be biomechanically modeled, giving their explanation on why the implants are not moving when subjected to heavy loading and very large angles relative to the buccal plane.

Not only does it depend on the bone's ability to heal around the implant, it's a matter of the physics of the lever. ZIs can resist forces, which may cause failure in standard implants, due to the rigid cross-arch stabilization and the dense bone of the zygoma.

#### **4. The Zygoma Anatomy-Guided Approach (ZAGA): A Zaga Concept**

The earlier zygomatic implants made their appearance, the surgery was a bit standard; implants were all placed through a more or less standard trajectory, regardless of the patient's unique facial area. That was all upended thanks to Dr. Carlos Aparicio's Zygoma Anatomy-Guided Approach (ZAGA).[11]

Rather than directing the patient's anatomy to fit an "averaged" implant pathway, ZAGA will optimize the surgical trajectory to fit the patient's anatomy and native bone structure. It is a patient specific, prosthodontically directed plan which aims to optimize the stability of the implant and to minimize typical long-term complications such as sinusitis and tissue recession in an aggressive manner. [9,10]

**Anatological Adaptation (The ZAGA 0–4 Framework):** Anatomy is hugely different among individuals. The specific morpho-concavity of the outer wall of the maxilla is classified into 5 specific profiles

(ZAGA, 0 to 4). It is a roadmap that is specific for each patient and helps the surgeon choose the implant route that best compliments the patient's bone contouring, thereby maximizing the effects of augmentation. This classification is a personalized roadmap for the surgeon to opt for an implant approach that complements the patient's unique bone contour and ensures optimum outcomes from surgery. [9,10]

Lateral window that shows the drill is a traditional approach that creates a large opening or "slots" into the lateral wall of the maxillary sinus; however, this approach includes minimalist surgical footprint.[11] Instead, ZAGA will intentionally break with this aggressive window method, allowing only a small amount of sinus entry. There is no one "right" zone for a ZAGA implant. The path of the trajectory will depend on what the bone wants it to do—and so it may travel along the entire sinus or entirely outside of it (extrasinus) or reside somewhere in the middle. [9,10]

ZAGA is proactive rather than reactive when it comes to complications: They do not only work for a successful surgery today; they work for a successful surgery for years to come. The entire idea is designed to avoid late complications, namely to avoid the appearance of chronic rhinosinusitis and degradation of soft tissues. When it involves gums, it is about defense line, while when the teeth are involved, it is concerning the anchorage, provided my Bone. [9,10]. The ZAGA concept utilizes very exact incision and flap design protocols, which help to maintain thick (keratinized) mucosa around the implant head, and maintain a healthy, long-lasting biological seal.

When the bone structure is there, the "Tunnel" Strategy is used in the protocol. This then allows for maximum primary stability of the implant when immediately loaded by native bone hugging and supporting the body of the implant. [9,11]

The ZAGA (Zygoma Anatomy Guided Approach) idea refers to three main anatomical areas positioned along the zygomatic implant trajectory that led to an implant pathway according to the patient's needs and allow for a prosthetically driven approach, thus avoiding adversely affected soft tissue and sinus complications that could develop. These zones are called the **Zygomatic Implant Critical Zone (ZICZ), Antrostomy Zone, and Anchor Zone.** [9,10]

1. **Zygomatic Implant Critical Zone (ZICZ):** The coronal level, where the implant first comes into contact with the alveolar bone (residual alveolar bone) and soft tissue. This is the most important area to control and to avoid the chances of oral sinus/oral nasal fistulae and soft tissue dehiscence. This level is very coronal; they are concerned with preserving or enhancing soft tissue and bone characteristics so as to provide long-term stability and seal. [10,11]
2. The zone of surgical drilling of the maxillary sinus cavity is called **Zygomatic Antrostomy Zone (ZAZ):** Marks the point of entry in the sinus where the implant will enter. That area is adjusted based on the anatomy of the maxilla (ZAGA 0-4 classification), in order to minimize damage to the sinus membrane. The extra-sinus trajectory option is feasible for implants in cases where the concavity is high. [9,10]
3. **Zygomatic Anchor Zone:** The top (apical) part of the implant that is firm in the zygomatic bone. Lessens primary stability of zygomatic implant. In this zone, the ZAGA concept ensures proper positioning for optimal engagement with the zygomatic bone while considering the patient's individual bone structure. [10,11]

## 5. Specialized Armamentarium and Surgical Steps

The specialized armamentarium includes the following:

Zygomatic implants are available in **8 lengths and 2 angulations (0 and 45)**. A 0 implant allows for the

choice of multiple abutment angles and can achieve a more buccal position. Length in 2.5-mm increments available from 30 to 52.5 mm. Multi Abutment options available from 0 to 60 degrees. [19,20]

The armamentarium consists of Zygoma retractors, Zygoma implant-specific drill, Zygoma depth gauge Angled surgical or contra-angle dental implant handpiece [19,20]

Surgical guide, if planned

It is recommended to have at least 2 implants in each length available.

A zygomatic implant protocol is a very well-choreographed surgical balancing act. It demands the shift from complex levels of anatomy into exact restorative positioning. [19,20]

### **1. Incision and Exposure: Getting Secure Access**

It is very important that a surgeon's field remains clean, clearly indicated and that valuable facial nerves are preserved before drilling starts.[19]

**Anaesthesia:** The process is carried out while under anaesthetic (general anaesthetic) or deep IV sedation. Requires patient to have sufficient maximum jaw opening and fit for office based deep sedation.[20]

**The Incision:** Make a crestal incision along the ridge, but be sure to make it slightly toward the palate. Make bilateral vertical releasing incisions extending into the posterior area, if needed, to replace this for a broad clean flap availability.[19]

**Anatomical Landmarks:** Be careful not to damage or irritate the infraorbital nerve when reflecting the tissue. Exposure should continue to clear the lower and outer eye sockets (orbital rims). [17,19]

### **Choosing the Approach:**

**Intrasinus Technique** – Make a small 5 - 10 mm window/slot directly into the wall of the sinus. Apply gentle pressure on sinus membrane (Schneiderian membrane) inward in order to prevent the membrane from coming into contact with the drill. [17,19]

**Extra-sinus Technique (Effective):** Maintain the trajectory completely out of the sinus cavity. Start the osteotomy where the body of the cheek bone is, leaving a small opening on the palatal side that will allow the last molars to come through. [18,19]

### **2. Osteotomy: route of the Extrasinus Trajectory.**

The extrasinus approach is very popular since it does not compromise the integrity of the sinus. Drilling sequence should be done with precision and direction to ensure that an anatomic space is not jeopardized.[18]

Always prepare from the Back – usually between the upper second premolars or lower first molars on the palatal slope.[18]

Making the Guide; Use round bur at max speed of 2000 rpm to open site. To prevent the subsequent drills slipping in the outer sinus wall, form a smooth trough in the wall.

Next, use the round bur to make an exact shot into the body of the cheekbone, the Zygoma Entry. [17,19]

Golden Safety Rule: Always avoid the zygomatic notch (incisura). This is necessary to ensure that the drill bits do not accidentally penetrate the eye socket (orbit).[19]

Protect the adjacent cheeks and lips to the outside using drill guards and a zygoma retractor: Drilling Sequence. Make a 2.9 mm hole using a drill that extends on both sides of the dense cheekbone (bicortical engagement), then add an additional 0.6 mm with a 3.5 mm drill.[19]

¼ of the channel should be filled with a specialized zygoma depth gauge, and the implant position is determined by the measurement to ensure implant length. [17,18]

Moving to the Front: Prepare the Front implant site close to the canine area. This site should be angled in a backward direction from the back implant, up to the head – the implant length usually will need to be increased.[18]

### 3. Implant Placement:

The key to the secure fitting of the titanium implant is a perfect mechanical balance, which is achieved when it is installed without being set too tightly or fixed in any way that would harm the bone.[19]

**Abutment Preparation:** Prior to insertion, give a "loosen and retighten turn" to the transfer abutment to ensure that there shouldn't be any binding that can take place later.[20]

**Insertion Spot:** Gently guide the implant using a manual driver until its tip sits, or is snugly placed, in the cheek bone. Torque should be between 35 Ncm and 45 Ncm. If you're below 35 Ncm, you are unable to withstand stability while wearing immediate dentures and above 45 Ncm you are putting unnecessary pressure on the bone and the implant parts.[19]

**Restorative Check:** Check the top of the implant before it is removed from the transfer tool, to make sure it is resting correctly against the gums. Then the exit angle must be exactly suited to the dentist to place the final bridge. After it is confirmed, attach a cover screw or a multi-unit abutment (MUA).[20]

After the surgery, the road to function is paved with postoperative care.

After surgery, the surgeon's job is to make sure that the implant is in place and that the entire jaw is stabilized. [19,20]

**Imaging:** Take a panoramic X-ray immediately after surgery or CBCT to ensure proper positioning of the implants and complete clearance of the orbit.

#### A. Immediate and B. Delayed Loading

- If the insertion torque you achieved is rock solid, refer to the patient's restorative dentist either on the day or the next morning to have a provisional fixed bridge in place.[21]

**Delayed Restoration:** If a bone has been soft, you may be suggested to bury under the gums and let them get on with their lives for 4–6 months.[20]

**The Final Step:** After 6 months healing (osseointegration) the final, permanent tooth is made.

**The Stabilization Rule:** The definitive prosthesis must utilize a screw-retained architecture to ensure rigid cross-arch splinting. This results in a tough cross arch splint which performs the function of distributing the load of biting forces evenly across all the implants and prevents individual failures. [21,23]

### 6. Prosthetic Phase

Guide toward rock-solid, permanent restorative care from temporary care and a correct diagnosis, along with precisely handled management! The prosthetic work flow for zygomatic implants is explained in a today's environment-focused and efficient manner.

The first step is to assess **the Provisional and Prepping the Tissue**. Appropriate tissue condition is the basis for long term success. [21,23]

**Timeline:** When the patient is in the initial stages of healing, fabrications typically start between two to six months after surgery and will depend on further healing and implant integration.

**Qualify the existing provisional prosthesis before proceeding forward:** Temporary Check-up. Test for structural soundness, mobility (looseness) and unusual wear facets. This is also when fine tuning facial harmony, aesthetics, speech phonetics and overall patient comfort is possible.

**Tissue Conditioning:** If sutures are left, condition the gums with a triple antibiotic paste prior to the use of a soft liner to promote good healing. This temporary soft reline should be exchanged for permanent

tissue conditioners after tissue healing for around 6 weeks.

**No Alcohol:** For the first 4 weeks after the liner's installation, alcohol (such as alcohol-based mouth washes) must be completely avoided by the patient. Alcohol deteriorates the material making it harden too early, and rubs tissues raw.

**Baseline Radiographs:** Implant Health Check to assess bone levels and sinus health. Clinically, it is a requirement that each and every implant move absolutely no more than this. Since the zygomatic implants cross long distances of anatomy, even a minor mistake in taking an impression can jeopardize the fit. [21,23]

The **Go-To Technique:** Use an open tray (pickup) technique. Its great accuracy is the reason it still is the gold standard for full arch rehabilitations. For multi-unit abutment (MUA) impression copings, they need to be rigidly connected. Use Pattern Resin, it has much more dimensional stability with a negligible post shrinkage during setting. [22,23]

**Passivity Today:** A passive fit is all that matters. Look for structural lifting or micro-gaps with a fine explorer. If the mismatches are  $> 60\mu$ , the framework is under tension and will require correction.

**Clinical Verification:** Perform the Sheffield test, (tighten one screw at one end, and then check if the other side moves; if it does, it means it is not perfectly passive and needs to be adjusted) and take careful periapical X-rays, so that a perfect passive fit is confirmed visually.[22]

**Smoothly and conveniently use the PVS Impression:** One-step system made with Polyvinyl Siloxane (PVS). Fill the tray with heavy body putty, and, while the heavy-body putty is loaded into the tray, use a syringing tool loaded with the light body, to apply it completely around the resin splinted jig and around the copings. [23,22]

This includes **the mapping of Bite (Maxillomandibular Records):**

Correct jaw positioning increases comfort for the patient and does not strain the jaw attachment muscles. Understand **the Fox occlusal plane (FOP)** to orient the upper arch in the proper way. The front should just be level with the interpupillary line/pupils of the patient and the sides should be parallel to the Camper line/ala-tragus line.[22]

**Prepare a Vertical Dimension of Occlusion Record (VDR):** Secure a screw-retained maxillary record base to accurately indicate the Vertical Dimension of Occlusion (VDO), proper lip support and the facial midline.[23]

**Use the Verification Jig:** For final verification use a special verification jig which ensures that your master lab model is an exact fit with the patient's mouth. With very rigid, yet unforgiving materials such as zirconia, PEEK or Trinia, this step cannot be ousted.

**Direct Passivity Test:** Place the verification jig in place, secure one screw in the most rear implant position and closely examine the other side. Any amount of elevation will cause your model to be off and you will need to re-tape.

The need to choose a framework and do some **clinical try-in**. [22]

It is the framework that is the backbone of restoration. It should be tough, non-allergenic, and it should fit just right.

Modern options are available to bring a lot of flexibility. You can choose between classic milled titanium or cobalt-chromium, high performance polymers like PEEK or Trinia and highly aesthetic zirconia.[21]

**Initial Fitting:** 1st, check framework on the laboratory model to be sure that screws are moving in and out smoothly. Then put it in the mouth to make sure it does not have to be pushed into position.[22]

**Soothing the soft tissue pressure** – Inspect carefully for any blanching or pinching of the gums in pressure areas. Executes slow release of the tight pressure spots with a scalpel or a special carbide/zirconia bur.

If it does not meet the passivity test, attempt no bending or forcing. Must be sectioned diagonally and secured in mouth with Pattern Resin in order to capture the actual position and then carried up in a brand-new impression.[22]

**Showing and designing Pontics:** If they intend to make the underside of their pontics convex or ovate, this will help maintain tissue health. Don't use any concave shapes at all, Concave pontic designs must be avoided, as they create inaccessible food traps that compromise the patient's oral hygiene maintenance. [21,22]

Prior to the day of delivery, a careful mechanical protocol is needed to avoid screw loosening or materials fracture in the future.

**The Screwing Protocol:** Always use clinical screws that are unused and a new set for Final Delivery. Secure them progressively by taking the tension in every side of the arch with a 'X' pattern - this pattern ensures an even spread of tension. [21,22]

**Torque Application:** Apply torque using torque wrench of 20-25Ncm. Wait 15 minutes to allow for the initial rebound of the metals and retorque them a second time to set them in place.[22]

**Sealing the Access Channels:** Plug screw openings with Teflon tape or protective foam and cover the openings with high quality composite resin in a clean manner.

### **The Occlusion:**

Utilize a bilateral balanced approach to traditional hybrid cases.

If so, apply an anterior-assisted group function as the case is heavily supported with 6 or more implants. The Cantilever Rule: (Sideways or Forward Movement of the jaws) never contact any cantilever extension.[24]

A flat, hard, bilaterally balanced nightguard is recommended (mandatory) for the protection of the porcelain/composite when the is bearing on prosthesis throughout the entire paper. natural teeth or other fixed restorations to prevent night grinding damage to the new prosthesis.[24]

**Maintenance and Aftercare of programs:** The long-term therapeutic success of an esthetically optimal prosthesis is strictly dependent upon meticulous oral hygiene and maintenance protocols.. Education for patients is as critical as surgery itself. [21,22] Your diet may change with the new teeth; first treat them carefully. A soft food diet should be followed for the first full month, then, gradually worked up to harder food as the muscles and jaw grow stronger. Home hygiene must be very important. The patients are recommended to use a Waterpik (oral irrigator) and specialized interproximal proxy brushes on a regular basis and ensure that the underside of the framework remains clean.[23] Close Clinical Monitoring Every 15 days for the first month post-insertion This will give you an opportunity to assess the fit of the nightguard, the reaction of the gums to the new material and instruct the patient in the proper cleaning method before their bad habits are formed.[24]

## **7. Complications**

To place an implant in the zygoma is not a trivial task, and positioning the implant in the zygoma gives even more freedom to the patient who has severe maxillary atrophy. It's a really effective procedure, but it requires respect of the complex anatomy involved. But when something does go wrong the range of

problems can vary from minor sinus irritation to rare, highly susceptible orbital problems — and depends completely on a meticulous pre-op planning and a skilled surgical hand.[26]

Part of the problem is that some complications just tend to crop up over time, typically where the implant meets the sinus cavity and oral cavity. [26,27]

**Sinusitis:** This is the most common aggravator. It does not need to be symptomatic immediately, sometimes it slowly creeps up the years, as a chronic sinus infection that needs to be managed continuously.[27]

### General Complications

Like a conventional implant, **peri-implantitis** and **mucositis** are two conditions that can occur around a zygomatic implant when the surrounding soft tissues and bone can be compromised.[26]

Sometimes an unsought and long-lasting opening arises between the mouth and maxillary sinus, allowing bacteria and fluids to pass through called an **Oroantral Fistula**. [25,27] Hard to reach surfaces and angles can cause plaque to build up, potentially resulting in **chronic gingivitis** and persistent **soft tissue problems** at implant components.[25]

### Surgical & Technical Complications

The surgical portion is a special anatomic risk because of its close relationship to the eyes, nerves and larger facial bones. [25,26]

**Ocular Complications:** These are rare, but most serious. Orbital penetration may also happen, resulting in diplopia (double vision) and may be accompanied by intense pain, swelling in the eye socket and limited movement of the eye. [25,26]

**Nerve Deficits:** Post-surgical numbness or tingling (paresthesias) along the nerve pathway through the infraorbital nerve is relatively common. [25,26]

Some post-operative "war wounds" will be according to the **presence of hematomas** and/or **edema**. Typical intermediate stages of healing are shiner-like bruising (**periorbital hematoma**), blood spots in the eye (subconjunctival bleeding) and marked swelling of the face.[25]

**Loss of structural integrity due to Implant Malposition or Implant Failure** — Loss of osseointegration to occur if the implant is off course for the ideal trajectory or fails to "take" in the bone will result in loss of structural integrity.[26]

**Zygomatic bone fracture or subcutaneous malar emphysema** due to physical stress of the zygoma (cheekbone) face is very rare. When sinus infections one may occur, specific antibiotic treatment is the first step in resolving the infection. If the infection continues to persist, however, it might need to be removed surgically. These aren't "set-and-forget" restorations: Unlike traditional implant usage, a patient's oral care around Zygomatic implants will be quite rigorous, and will be needed on a regular basis for the patient's lifetime. [25,26]

**Patient Education is Non-Negotiable:** Even before the initial cut is made, patient education is paramount that they will have to be treated impeccably at home. If strict standards are not placed on hygiene, soft tissue lameness around the implant head is almost inevitable.

## 8. Recent Advances

There are two major developments in the field of zygomatic implant surgery:

The use of piezoelectric instrumentation that facilitates minimal access and the incorporation of flapless procedures, coupled with dynamic navigation. This is a procedure involving the use of sure-cutting pieces of surgery technology called the piezoelectric instrument to minimize damage to the skin. [28,29] It is

called the **Minimally Invasive Zygomatic Technique**. The method was introduced by Dr Andrea Tedesco and focuses on preserving the tissue with the help of high precision piezoelectric technology. Developed and taught by Dr. Sevudo, it uses a strictly extrasinus trajectory, piece of bone between the implant and the Schneiderian membrane is kept intact. The optimal placement of the implant is achieved when the body is placed in the osteotomy bed for more than 180 degrees of its circumference.[28]

**Use of special technology:** The technique is based on the ESACROM piezoelectric platform. Its special software and operating inserts enable its superior precision and vibration reduction leading to more patient safety during surgery; and through a unique nebulizing action, it improves visualization during the surgery itself. [28,30]

**The Three-Step Surgical Protocol:** The osteotomy is performed in three steps to ensure that the most precise result is achieved, and the patient is prepared for intra-operative modifications.[28] Maxillary Preparation: An incision is carefully marked on the lateral wall of the maxilla leaving out the region of the sinus. The starting position is determined at the crestal or palatal bone with the aid of special pointed inserts which have depth-control marks. Last, 3 zygomatic preparations perforations are performed in the buccal cortex of zygoma in relation to the path created in the maxillary preparation. [28,30]

**Transplant Capsule and Embryo Capillary Pipet** (new and improved design)

A more non-invasive, yet very precise and accurate alternative to the traditional open surgery techniques is presented in this protocol that uses real-time computer guidance. **Dynamic Navigation:** This is a “GPS for surgery”, as opposed to a “GPS for surgery in a pocket book” (static 3D-printed guide). It offers real time visualization on a screen of the position of the drill and implant. This enables an accurate check of the shoot spot at all times, and makes for quick, accurate adjustments as necessary. [29,30]

The sinus lift protocol is incorporated into Advanced Sinus Management. The sinus integrity can be maintained, without opening the lateral window (antroscopy), and only gently reflected with tracked, navigation guided curettes. The process of switching to a flapless workflow greatly lowers patient morbidity, recovery time and overall total treatment cost. In addition, this technique overcomes the disadvantages of static surgical guides that are prone to tip deflection errors and can cause surgical inaccuracies. Using a calibrated, tracked curette to effect membrane reflection, navigation-monitored drilling then accompanied by real-time electronic tracking ensure a perfect final implant position. [29,30]

## 9. Conclusion

Reconstructive surgery of the defective or atrophic maxilla is one of the most challenging problems in dentistry. Over the years, these traditional methods—bone grafting, guided bone regeneration, and sinus augmentation—have been the standard of treatment, but they often resulted in a higher donor site morbidity, expensive treatment, and longer treatments. As evidenced in this review, this paradigm has been transformed with zygomatic implants where treatment is now a direct approach to structure instead of complex anatomical reconstruction without a graft. Utilizing the high cortical anchorage of the zygomatic bone, clinicians can restore patients who had few viable options the function, aesthetics and social wellbeing they desire.

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