Original Article - Prospective Study

# Evaluation of Surgical Outcomes of Zygomatic Implant-Supported Rehabilitation of Atrophic Maxillary Arches - A Prospective Study

**Vaishali Venkatachalam, Rajesh Pandiarajan, Alagappan Meyappan, Harushi Anbukkarasu[1]**

Department of Oral and Maxillofacial Surgery, Chettinad Dental College and Research Institute, Chennai, [1]Department of Oral and Maxillofacial Surgery, A.S Dentistry, Salem, Tamil Nadu, India

## Abstract

**Introduction:** Prosthetic rehabilitation with implants in the atrophic edentulous maxilla often requires a bone augmentation procedure to enable implant placement and integration. However, rigid anchorage can also be achieved using long zygomatic implants. The aim of this study was to evaluate the surgical outcomes of rehabilitation of atrophic posterior maxillary ridges with zygomatic implants using the zygomatic success code (ZSC) and derive the success grade for the procedure based on the observed results. **Materials and Methods:** A total of eight implants were placed in an extrasinus technique based on the zygomatic anatomy-guided approach. The following were evaluated postoperatively – primary stability, maxillary sinus pathology, soft-tissue healing and prosthetic offset. The ZSC score was calculated, and success grading was given with ZSC based on Aparacio *et al*.,'s guidelines. **Results:** One implant had Grade 1 mobility and partial maxillary sinus opacification, 25% ($n$ = 2) revealed a mild recession exposing the implant head and 12.5% ($n$ = 1) showed significant recession up to 7 mm. The prosthetic offset of zygomatic implants was scored −1 for all eight implants. Five implants were given a success code of 1/1/1/1 and a success grade of Grade I, two implants were given code 1/1/2/1 with Grade II and one implant 2/2/3/1 and grade III. The results imply that zygomatic implants can be a successful option in maxillary rehabilitation. **Discussion:** The zygomatic implants, as a graft less and promising solution to the rehabilitation of atrophied maxillary arches, have excellent surgical outcomes with varied advantages.

**Keywords:** Atrophic ridge, quad zygoma, zygomatic anatomy guided approach, zygomatic implants

## Introduction

Patients with moderate-to-severe atrophic ridges often necessitate alternative ways to use existing bone or resort to augmentation with autogenous or alloplastic bone materials.[1] The continuous, cumulative and irreversible bone loss following a loss of teeth, especially in the maxilla[2-4] involves factors such as centripetal pattern of alveolar resorption,[2] maxillary sinus pneumatisation,[5] presence of nasal fossae and nasopalatal duct, poor bone quality complicating implant placement.[3] Rehabilitation in such cases involves bone augmentation or modifying the implant design, either concurrently or in staged procedure.[1] Initially, bone augmentation procedures included autografts secured from intraoral sites or extraoral grafts but posed risks of complications of the graft procedure itself, donor site surgical morbidity, additional operating time and extra costs.[6-8] Direct and indirect sinus lift procedures effaced simultaneous bone augmentation along with placement of implants reducing the complications with autogenous grafts.[9,10] However, post-operative complications observed were breaching of the sinus, acute sinusitis, infection and nonosseointegration.[7] Nongrafting options for atrophied maxilla included short and wide implants, pterygoid implants[11] and tilted implants.[5-8] Branemark in 1997 introduced zygomaticus fixture to provide fixed solutions when the conditions for implant insertion were

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**Address for correspondence:** Dr. Vaishali Venkatachalam, Department of Oral and Maxillofacial Surgery, Chettinad Dental College and Research Institute, Kelambakkam, Chennai - 603 103, Tamil Nadu, India.
E-mail: vaish712.venkat@gmail.com

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poor in the posterior maxilla.[12] Since this description, many authors have varied the technique including Aparicio *et al*.[13] The objective of this study was to evaluate the surgical outcome of rehabilitation of atrophic posterior maxillary ridges with zygomatic implants using the zygomatic success code (ZSC) originally given by Aparicio *et al*.[13]

## Materials and Methods

A descriptive analysis of the surgical outcomes of zygomatic implant-supported rehabilitation of atrophic maxillary arches was done. Patients with partially or completely edentulous arches reporting to the Outpatient Clinic of the Department of Oral and Maxillofacial Surgery of Chettinad Dental College and Research Institute, Kanchipuram, seeking implant-supported rehabilitation between September 2019 and February 2022 were included in the study. All procedures in the study were conducted following the ethical standards given in the 1964 Declaration of Helsinki, as revised in 2013 and after obtaining the approval of the institutional ethical committee (535/IHEC/3-19) and the review board. Patients' consent for utilising their records for any research purposes was obtained before the surgical procedures. At the preliminary visit, information regarding the type of study and any alternative possible treatment was explained to the patients.

A patient was considered eligible if 18 years of age or above, with Cawood and Howell-class V, VI or VII completely edentulous maxillary arch or partially edentulous maxillary arches with ridge <4 mm in width and height in the posterior maxilla distal to the canine pillar. Those with a loss of posterior maxillary dentoalveolar segment due to trauma or any pathology were also included in the study. Patients with the presence of active infection or inflammation of the planned site of placement of implants, the pre-existing maxillary sinus or osteomeatal complex pathology, heavy smoking habits, systemic illness contraindicating surgical placement of implants or general anaesthesia and irradiation to the head and neck within six months from surgery were excluded from the study. Four patients were included in the study.

After obtaining demographic details, clinical evaluation was carried out by a single independent examiner trained and calibrated using study models of various ridge patterns and ridge characteristics were recorded. Radiographic evaluation was done with an orthopantomogram and cone-beam computed tomography (CBCT) and computer-assisted planning of the proposed surgery was done [Figure 1]. The data from the CBCT and the ridge dimensions from models were used to prepare a surgical stent to locate the pilot drill and precise angulation of the implant placement [Figure 2]. The zygomatic implants (Noris Medical Pvt. Ltd.,) were anchored in the body of the zygomatic bone through the 12.5 mm apical conical part achieving an extremely high torque. The implants were placed by the primary investigator following the extramaxillary approach, modification of Branemark's intrasinus approach to bypass any iatrogenic sinus damage. An angled multiunit abutment from 17° to 60° was used to correct the emergence profile.

Under general anaesthesia, crestal and releasing incisions were made raising mucoperiosteal flap to expose the alveolar crest, the lateral maxilla, the maxillary antral wall, the infra-orbital nerve, the zygomaticomaxillary complex and the lateral surface of the zygomatic bone. The surgical stent guided the extrasinus path [Figure 3]. A coarse, medium and fine grit drill was used to penetrate through the maxillary alveolus followed by 2 mm, 2.8 mm and 3 mm twist drills that penetrated both the cortices of the zygomatic bone till its desired length. The implant was then placed without damaging the sinus membrane. The implant body

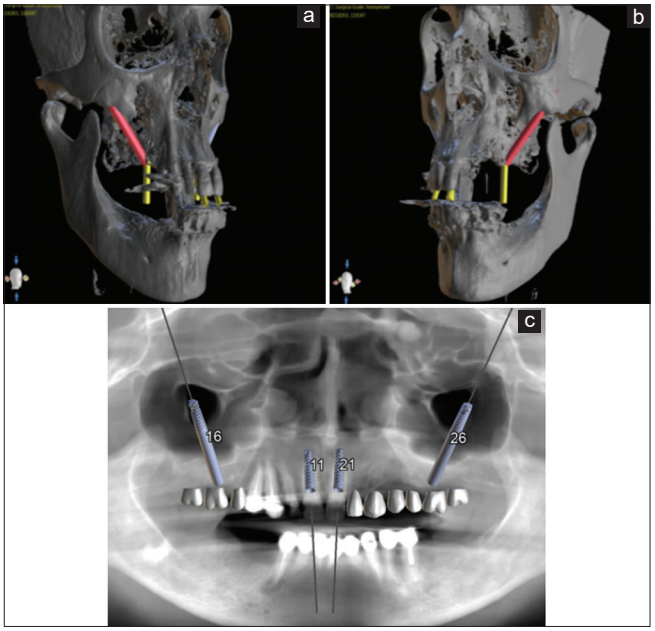


**Figure 1:** (a) Virtual planning on the right side (b) Virtual planning on the left side (c) Virtual planning and positioning in OPG

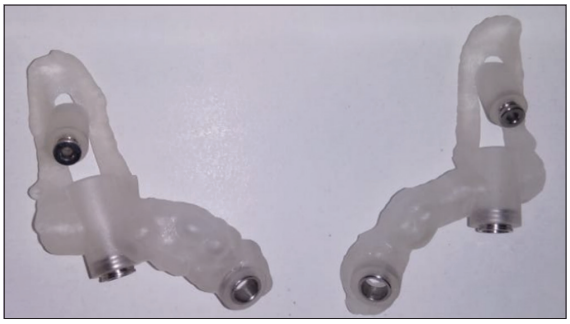

**Figure 2:** Three-dimensional printed custom surgical stent

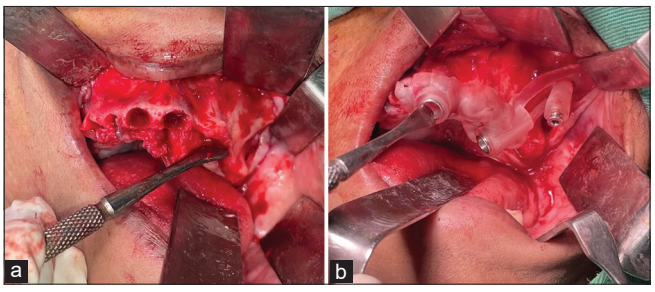


**Figure 3:** (a) Surgical site exposure (b) Surgical stent positioning

engaged the lateral bony wall of the maxillary sinus. Primary stability was assessed immediately after placement. After placing the cover screw, freeze-dried demineralised particulate alloplastic bone graft was placed over the alveolar end and supported by autologous leucocyte-platelet-rich fibrin (L-PRF) membrane [Figure 4]. After the placement of the rest of the zygomatic and endosseous implants, closure was done with 3-0 Vicryl sutures either continuous or in the form of a mattress. Four parameters were evaluated postoperatively – primary stability, incidence of maxillary sinus pathology, peri-implant soft-tissue healing and prosthetic offset. Millers grading was used to test the primary stability of the implant intraoperatively and during the abutment placement after three months. Any rotational mobility was also checked and recorded.

Evaluation of incidence of maxillary sinus pathology was done by the principal investigator in two parts three months after the surgery. Subjective evaluation was done using Task Force Questionnaire by Lanza–Kennedy (translated to the local language), where the presence of two or more major criteria or one major and two or more minor criteria was considered positive for the incidence of rhinosinusitis. Lund-Mackay computed tomography (CT) evaluation was done pre- and postoperatively to assess the maxillary sinus and the osteomeatal complex and scored between 0 and 2 based on the opacification of the sinuses and patency of the osteomeatal complex [Figure 5].

Peri-implant soft-tissue healing was evaluated using Landry Wound Healing Index before the placement of the abutment and was scored based on the recession, exposing the implant. Prosthetic offset was calculated to ascertain the implant head emergence profile and was given a positive value in case of palatal emergence and negative if buccally emergent. The success grading criteria by Aparicio *et al*.,[13] were applied to derive the ZSC based on the mean value of individual scores. The data were entered into Microsoft Excel (Version 2019) and analysed using SPSS (SPSS Inc. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp). Frequency tabulation was computed.

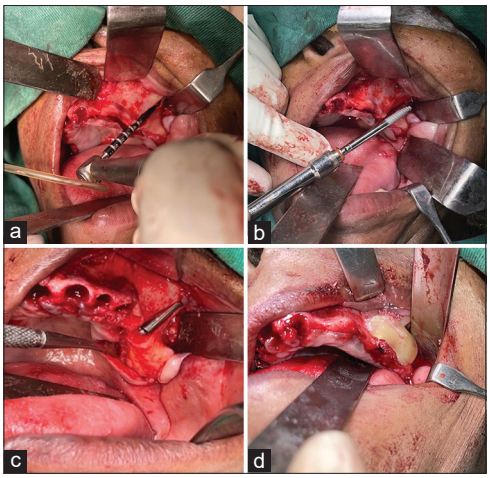


**Figure 4:** (a) Sequential drilling, (b) Implant entry (c) After placement of the implant (d) Placement of PRF

## Results

The mean age of the study population was 59.5 years, and the population was equally distributed. Seventy-five per cent of the population was partially edentulous. All of them were instated with zygomatic implants of varying lengths between 35 and 45 mm and with a diameter of 4.2 mm in the posterior maxilla and endosseous implants in the anterior maxilla. The implant stability was assessed immediately following the placement of the implant to assess primary stability and after three months when the abutment was placed. The mean mobility was 1.125. ZSC 1 was given to all the immobile (87.5%, $n = 7$) implant and code 2 was given to the other (12.5%, $n = 1$).

Rhinosinusitis was observed in one patient with four major criteria of the task force questionnaire. Two patients presented with one minor criterion and one did not have any symptom throughout, thus being negative for the rhinosinusitis. Thus, Lanza–Kennedy test was scored negative for seven implants and one scored positive. Partial opacification was observed in 12.5%, and no opacification was evident in the rest 87.5%. The osteomeatal complex was patent without any obstruction in all eight implants. Thus, Lund–Mackay score was given zero to seven implants, and one was given to one implant. When both Lanza and Kennedy test and L-M score were evaluated together, the associated sinus pathology for criteria B was scored one in seven patients and two in one patient with a mean of 1.125.

There was excellent healing of the peri-implant soft tissue in 62.5%, whereas 25% revealed a mild recession exposing the head of the implant and 12.5% ($n = 1$) exhibited recession up to

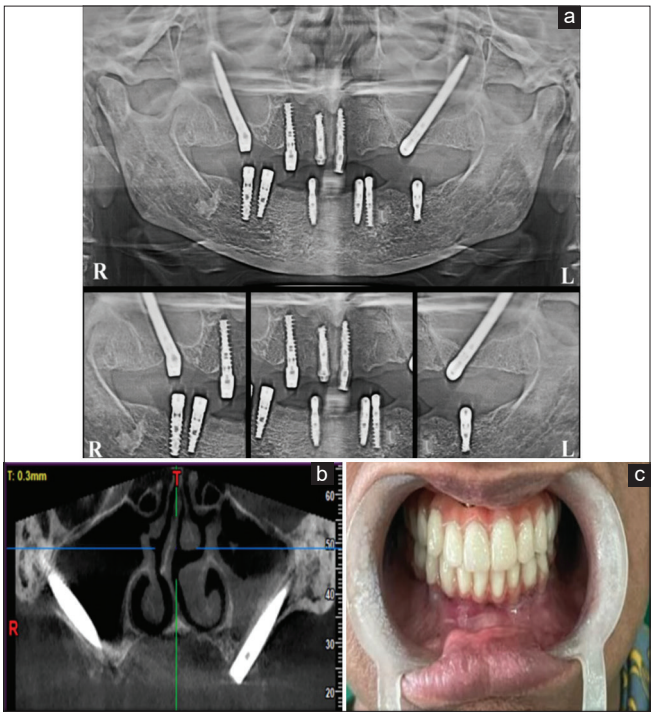


**Figure 5:** (a) Postoperative OPG (b) Coronal CT showing partial sinus opacification on the left (c) Post denture placement

7 mm. Thus, a score of one was given to five implants, two to two implants and three to one implants with a mean score of 2.66. The prosthetic offset of zygomatic implants was negative in all the cases indicating that the implants were buccally placed, and thus a score of 1 was given for all the eight implants [Figure 6]. A ZSC scored by a code, includes four digits, representing one criterion of success for each implant. Success grade was determined by the highest number (representing the worst condition) amongst the four criteria [Table 1]. Thus, five implants were given a success code of 1/1/1/1 with Grade I, two given a code of 1/1/2/1 with Grade II and one implant given a success code of 2/2/3/1 with Grade III. Overall, ZSC was 1/1/1/1 and an overall success of 100% of the implants.

## Discussion

Continuous, cumulative and irreversible bone loss follows the loss of teeth, especially in the maxilla.[1-4] Successful implant-supported rehabilitation with a success rate of 84%–92%[1] hinges on adequate bone volume. However, atrophy in maxillary arch complicates conventional implant placement.[14-16] Initially designed to address extensive maxillary defects post-resection by Branemark, the use of zygomatic bone for long oral implants expanded to severely atrophic ridges by Aparicio *et al*.[17-19] The merits of anchoring implants in the zygomatic bone were reported due to its cortical nature providing superior anchorage.[20,21] This was highlighted by Kato *et al*.,[22] and Nkenke *et al*.,[23] as the zygomatic bone was resistant to resorption due to external factors and 98% cortical density provides an excellent support to the implants and channelise the forces being transferred upon them. Conversely, others have suggested that minimal cancellous content does not provide enough osteoblast/osteoclast coupling for the remodelling during osseointegration.[24] Later studies revealed zygomatic implants primarily rely upon mechanical retention than osseointegration necessitating engagement of four cortical borders (palatal or alveolar cortex, cortical wall of the maxillary sinus and zygomatic bone cortices at the apex) by the implants.[25]

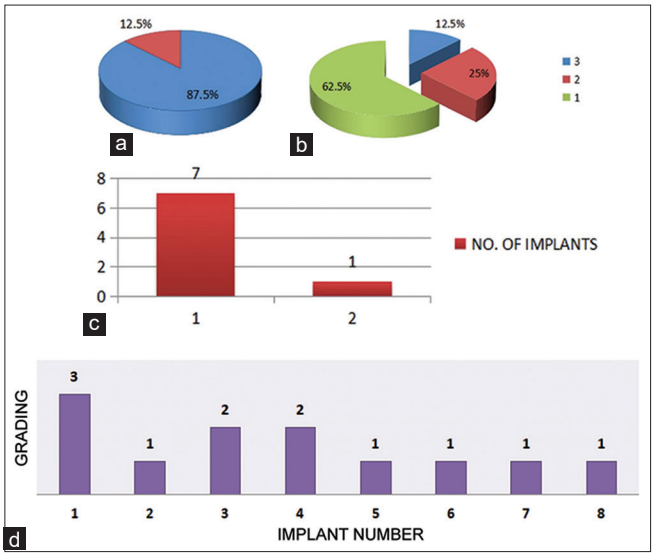


**Figure 6:** (a) Implant stability scores (b) Soft tissue healing scores (c) Rhinosinusitis scores (d) Success grades of implants

This study evaluated the surgical outcomes of atrophic posterior maxillary ridges rehabilitation with zygomatic implants using the ZSC proposed by Aparicio *et al*.[13] Utilising zygomatic implant requires comprehensive knowledge of the zygoma and its related structures to avoid iatrogenic injury to the orbital plate, infraorbital nerve and the zygomatic arch.[20,23,26] Adequate volume of the body at the 'Z point' with a dimension of 14 mm anteroposteriorly and 5 mm mediolaterally has been recommended for safe implant placement.[22,27] Extrasinus path was chosen for our patients based on the zygomatic anatomy-guided approach by Aparicio *et al*.[25] This approach neither 'internal' nor 'external' to the sinus wall but, tailors implant placement to individual anatomy.[25,28] Determination of the coronal and apical entry points, marking the desired emergence profile and implant length, outlining the trajectory for implant insertion in this approach.[13] Branemark's intrasinus implants were threaded throughout their body. Since the cortical anchorage was majorly dependent on the apical threads and the majority of the implant body resided out of the sinus and lateral maxilla, we chose implants with smooth body and threaded apical part that had fewer post-operative infection rates without compromising the outcomes against the traditional ones.

A CBCT with extended emphasis on the zygomatic bone guided the computer-assisted designing of the surgical guide and to evaluate the volumetric dimensions to plan the path of insertion of implants. Custom surgical stents ensured accurate positioning of implants without jeopardising the sinus membrane. Similarly,

**Table 1: Zygomatic implant success code**

| Implant number | Implant stability | Incidence of sinus pathology | Soft tissue healing | Prosthetic offset | Success code | Success grade |
|---|---|---|---|---|---|---|
| 1 | 2 | 2 | 3 | 1 | 2/2/3/1 | III |
| 2 | 1 | 1 | 1 | 1 | 1/1/1/1 | I |
| 3 | 1 | 1 | 2 | 1 | 1/1/2/1 | II |
| 4 | 1 | 1 | 2 | 1 | 1/1/2/1 | II |
| 5 | 1 | 1 | 1 | 1 | 1/1/1/1 | I |
| 6 | 1 | 1 | 1 | 1 | 1/1/1/1 | I |
| 7 | 1 | 1 | 1 | 1 | 1/1/1/1 | I |
| 8 | 1 | 1 | 1 | 1 | 1/1/1/1 | I |
| Mean | 1.125 | 1.125 | 2.66 | 1 | 1/1/1/1 | 1 |

results were reported by Vrielinck *et al*., with a success rate of 92%.[29] However, without a surgical stent, optimal implant angulation ranged between 39° and 62° with additional implant advised between 25° and 47°.[27] This was supplemented with additional dimensional data by Uchida *et al*.,[26] for a safer placement of zygomatic implants. Recently, surgical navigation in achieving high precision is also being advocated by various authors such as Zhou *et al*.,[30] and Nocini *et al*.[31]

Once the incision was placed and the flap elevated, the surgical guide was placed in position, sequential drilling was done and implants of dimensions planned with the CT data were placed. After ensuring primary stability, cover screws were placed, the exposed alveolar areas were covered with particulate bone graft covered by L-PRF membrane. L-PRF's rationale lies in platelets at the site of healing releasing internal signalling molecules regulating gene expression for collagen production, cellular proliferation, osteogenesis and matrix synthesis.[32] Studies of Boora *et al*.,[33] observed a significant reduction in marginal bone loss and no receding mucosa post-implant placement. He also suggested a reduction in probing depth and bleeding on probing. Pietruszka *et al*., emphasised membrane placement to be optimal when in contact with the flap and bone than the implant surface. The authors reported a significantly reduced post-operative pain using platelet-rich fibrin (PRF).[34,35]

Our study's outcomes align with numerous previous researches showing 100% success at the 3rd-month evaluation. This mirrors the results of Candel-Martí *et al*., with a 96.7%–100% success rate at a similar timeline.[10] Branemark's initial study gave 97% successful outcome post-placement, whereas Borgonovo *et al*.,'s 6-year retrospective study showed no implant failure amongst 65 zygomatic implants in 27 patients.[36] A series of 22 patients was presented by Aparicio *et al.*, in which 44 zygomatic implants had 100% success and 80 pre-maxillary implants had 91% success rate after 34-month follow-up.[19] Aparicio *et al*.,'s assessment of implants in severe maxillary atrophy reported a cumulative survival rate of 99%.[13] Combining 32 studies, Aparicio *et al*., presented a 98.1% survival rate of zygomatic implants from 1031 patients to 2131 zygomatic implants across a 6 months–12-year follow-up.[19] All these studies depicted a successful long-term survival of zygomatic implants with a regular follow-up.

Stability was observed in our study for all implants, though some exhibited slight mobility due to biomechanical differences. The varied mobility without associated symptoms is due to the elastic modulus of the zygomatic bone that deforms with remotely applied force. Any motion other than rotational will disappear when implants are splinted together.[13] The incidence of rhinosinusitis was previously reported to be 6.6% if the procedure is two staged and 2.8% if immediate functional protocols and 5.5% for both done together. Our results are in accordance with the results of Peñarrocha-Diago *et al*., with 100% successful outcome but 5.5% incidence of rhinosinusitis.[37] Similar results were observed by Aparicio et al., and several others.[19,38]

Peri-implant soft-tissue health is crucial for long-term survival of implants. Routine examination has challenges due to variation in the implant position with respect to the bony crest.[39,40] The positional changes of the membrane PRF could affect the efficacy of the platelet concentrates, and thus the results vary. Our study's prosthetic offset parameter indicated a balanced prosthesis without discomfort or speech disturbance. Although the surgical outcome of the implants was 100%, long-term follow-up with a larger sample size would provide better insights [Table 2]. Expanding research on zygomatic implants' long-term success rates, associated complications, biomechanics and material sciences could enhance their reliability and durability, offering improved rehabilitation outcomes.

## Conclusion

Thus, Zygomatic implants could be advocated as the most successful and reliablefixed rehabilitation option in terms of its minimally invasive and painless protocols, along with the shorter duration of the treatment course culminating in desirable aesthetics to the patients of all age group.. Also an anatomy based approach, aided by surgical stent and the use of adjuncts like L-PRF and allografts during the placement of zygomatic implants played a significant role in the outcome and success of the procedure.

### Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

### Financial support and sponsorship

Nil.

**Table 2: Advantages and limitations of zygomatic implants**

| Advantages | Limitations |
|---|---|
| Eliminates the need for bone grafting | Surgical complexity requiring expertise for placement compared to conventional implants |
| Non-invasive and reduced OT time | Risk of complications such as iatrogenic sinus injury, damage to vessels and nerves |
| Possibility of immediate loading enabling quicker restoration | Expensive compared to conventional implants |
| Improved stability and support make it ideal for severe atrophic arches | Anatomical variability of the bone, limited size and angulation options can limit the optimal placement |
| Reduced total treatment duration | Complex prosthesis fabrication requires long-term follow-up and maintenance |

OT: Operation theatre

## Conflicts of interest

There are no conflicts of interest.

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