Retrospective Analysis of Zygomatic Implants for Maxillary Prosthetic Rehabilitation

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Purpose: The aim of this study was to evaluate 141 zygomatic implants for the reconstruction of severely atrophic maxillae. Materials and Methods: In this retrospective case series study, zygomatic implants were placed under general anesthesia. Inclusion criteria were as follows: ASA I or ASA II, age older than 18 years, inadequate bone for restoration with conventional implants, alternative augmentation procedures considered either inappropriate or contraindicated, absence of a medical condition related to implant failure, and providing written consent. Zygomatic implants used in the study consisted of three different brands: NobelZygoma, Southern Implants System, and Implantswiss. Results: The study included 45 patients, in whom 141 zygomatic implants were placed. The mean age of the patients was 51.76 (range: 23 to 72) years. Three patients were rehabilitated with removable prostheses, 19 patients with fixed prostheses, and 23 patients with hybrid prostheses. The overall complication rate was 5.67% (two zygomatic implants developed infection [1.4%], one zygomatic implant developed peri-implantitis [0.7%], three zygomatic implants developed sinusitis [2.1%], and two zygomatic implants showed unsuccessful prosthetic rehabilitation [1.4%]). The follow-up period ranged from 6 to 36 months. Conclusion: Clinical complications of zygomatic implants are acceptable, and their survival rates are similar to those of endosteal implants. Zygomatic implants can contribute to prosthetic rehabilitation. Int J Oral Maxillofac Implants 2020;35:750–756. doi: 10.11607/jomi.8196

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Maxillary prosthetic rehabilitation is occasionally a dilemma because of an atrophic or defective maxilla, although some patients prefer using a removable prosthesis, contrary to other patients preferring a fixed prosthesis. In maxillary bone deficiency cases, conventional dental implants are not sufficient to ensure a fixed prosthesis and sufficient anchorage. Techniques or procedures to solve maxillary bone deficiency problems include maxillary sinus augmentation, intraoral and extraoral autogenous bone graft, alloplastic bone graft, onlay bone graft, and Lefort 1 osteotomy coupled with interpositional bone grafting. However, these procedures entail multiple surgical interventions, prolongation of the prosthetic process, failure of the graft, perforation of the sinus membrane, and infection.

Zygomatic implants were first used by Brånemark in 1998 to reconstruct the atrophic maxilla, which is not treated with only conventional dental implants. Zygomatic implants are inserted through the crest of the alveolar bone and engage the zygomatic bone to ensure anchorage. Zygomatic implants are used to rehabilitate severely atrophic maxillae caused by trauma, total or partial maxillectomy, tumor resection, congenital deformities, or enhanced pneumatization. Absolute and relative contraindications include acute sinus infection, maxillary and/or zygomatic bone pathology, underlying uncontrolled or malignant systemic disorders, chronic maxillary sinusitis, and smoking more than 20 cigarettes a day.

There are surgical insertion zygomatic implant techniques to increase survival success and anchorage. The original first technique used by Brånemark, the intrasinus technique, consists of a small window on the lateral wall of the maxillary sinus and placement of the zygomatic implant through the maxillary sinus to anchor apically zygomatic bone. Stella and Warner described the “sinus slot technique,” which located the exterior maxillary sinus and minimized the presence of zygomatic implants through the sinus by circumvention. A high bone-to-implant contact is provided, and the apex of the zygomatic implant is inserted at the junction of the lateral orbital rim and zygomatic arch. High bone-to-implant contact increases prosthetic
anchorage and enables immediate prosthetic loading.  
However, bone-to-implant contact in the zygoma varies from patient to patient. The extrasinus approach is mostly indicated in distinctive maxillary buccal concavity, and the coronal part of the zygomatic implant is closer to the maxillary alveolar crest.

Zygomatic implants might have several biomechanical and biologic complications. Biomechanical complications include fracture/loosening of prosthetic components and stress distribution problems. Biologic problems include sinusitis, infection of the soft tissue, chronic pain, oroantral fistula, sensory deficit (infraorbital nerve damage), motor nerve injury (zygomatic branch of the facial nerve), periorbital/facial hematoma, and bruising.

**MATERIALS AND METHODS**

**Study Design**

This retrospective study was approved by the local institutional research ethics committee (no: 1295). Patients with severely atrophic maxillae who underwent placement of zygomatic implants between January 2015 and December 2018 were included in the present multicenter trial. All of the zygomatic implants were performed by experienced maxillofacial surgeons under general anesthesia. The inclusion criteria for the zygomatic implant surgery were as follows: age > 18 years, severely atrophic maxilla, excessive bone loss after maxillofacial trauma, congenital defects, failure in sinus elevation techniques and conventional implants, patients without maxillary sinus pathology, and absence of acute or chronic infection in the oral cavity. Patients who had the following conditions were excluded from the present study:

- ASA III, IV, V, or VI (according to the American Society of Anesthesiology [ASA] classification system)
- Immunosuppressed
- Addiction (illegal drugs, alcoholism)
- Undergoing chemotherapy and/or radiotherapy
- MRONJ (Medication-Related Osteonecrosis of the Jaws)
- Systemic disease that may cause healing problems
- Epilepsy or Parkinson’s disease
- Pregnant

The data collected consisted of age, sex, implant brand, complications, type of prosthesis (fixed, hybrid, or removable), and number of placed implants. Three different zygomatic implant brands were applied to the patients: NobelZygoma (Nobel Biocare), Southern Implants System (Southern Implants), and Implantswiss (Novodent). All these implants were used according to the anatomy of the maxillary sinus and zygomatic bone and/or quantity and quality of the bone. The macrodesign of the implants was preferred according to the anchorage place (only zygomatic bone or both zygomatic and alveolar bone). Two different designs were used in this study: (1) zygoma implant and (2) atrophic maxillary zygoma implant (Fig 1). The presence of a smooth surface in the middle third of the zygomatic implant body is to prevent the accumulation of possible microorganisms on the surface of the implant (especially in the intrasinus technique). Atrophic maxillary zygomatic implants were used when the anchorage was localized only to the zygomatic bone, so that the threads of the implant body were localized to the apical part of the implant. In cases where atrophic maxillary zygoma implants were placed, there was not sufficient bone for anchorage in the alveolar bone. Oncologic zygomatic implants were not used in this study. Thus, three different zygomatic implant brands were preferred for optimum anchorage and placement in each patient. In this study, the effect of the prosthesis on the survival rate of the zygomatic implants was not evaluated, although types of prosthesis were recorded. Location, number of zygomatic implants, and combination with endosseal implants were determinant factors for the type of prosthesis.

While assessment of the success was carried out, the following criteria were admitted as a complication or failure:

- Mobility of the zygomatic implant
- Continuous radiolucency around the zygomatic implant
- Peri-implantitis with/without suppuration resulting in zygomatic implant failure
- Fracture of the zygomatic implant and/or prosthetic components
- Pain
- Dysesthesia
- Foreign body sensation
- Persistent edema (periorbital region)
• Persistent maxillary sinus infection resulting in zygomatic implant failure
• Postoperative hematoma, infection, and suppuration

Peri-implantitis is defined as “an inflammatory process that affects the tissues surrounding the implants and results in the loss of the bone.”9 Alteration in probing depth, presence of bleeding on probing, and suppuration and peri-implant bone loss confirmed the peri-implantitis diagnosis.10 In the present study, the diagnostic criteria for peri-implantitis was probing depth of 4 to 6 mm, bleeding on probing at one or more sites, and radiographic bone loss of 0.5 to 2 mm.11

Surgical Technique
All patients were evaluated clinically and radiologically with cone beam computed tomography (CBCT) with a three-dimensional (3D) solid model before surgical intervention. After the evaluation process, the surgical technique and implant design that would be used was determined. The two-stage protocol was planned for all patients with 6 months of healing time. The healing cap was implemented, and the prosthetic superstructure was completed in the second stage, which was performed 6 months later. According to the CBCT examination, one of three surgical techniques was applied under general anesthesia with local infiltration anesthesia (2% lidocaine with 1:100,000 adrenaline). These surgical techniques were intrasinus, extramaxillary sinus, and sinus slot approaches (Fig 2). The flap was designed with two vertical incisions on the canine and maxillary tuberosity region and a horizontal incision on the alveolar crest. The flap was reflected and the palatal mucosa was detached to determine the insertion point of the drill. After reflecting the flap, the body of the zygomatic bone, infraorbital rim, the exterior surface of the maxillary sinus, and the palatal side of the alveolar crest were exposed. For all three techniques, insertion points were determined by a round bur on the palatal side of the residual alveolar crest. Likewise, a round bur was used to perform an insertion point on the body of the zygomatic bone. Helicoidal drills were used to form a hole to insert the zygomatic implants. The length of the zygomatic implant and control of the hole were evaluated by depth gauze. Zygomatic implants were applied using a wrench recommended by the brand kit. Dual, triple, or quad zygomatic implants were placed under general anesthesia based on prosthetic planning. No graft material (except autogenous bone graft) or membrane was applied in the surgery. After surgical intervention, an orthopantomogram (OPG) or other radiographic techniques were performed to evaluate and verify the location of the zygomatic implants.

Postoperative Care
Broad-spectrum antibiotics, analgesic, and chlorhexidine mouthwash were prescribed postoperatively for all patients. The patients were instructed on maintaining oral hygiene and consuming a soft diet and liquids. The second surgery was performed approximately 6 months later, and healing abutments were placed before prosthetic rehabilitation. The removable prosthesis consisted of acrylic with clips on a bar, and the fixed prosthesis was a full-ceramic or metal-ceramic prosthesis with titanium or zirconia. Follow-up periods were planned as the 1st, 3rd, and 10th day after the operation, and 1 month, 6 months, and once a year after. Clinical and radiologic examinations (CBCT, OPG, and intraoral radiographs) were performed throughout the follow-up period.

RESULTS
One hundred forty-one zygomatic implants were inserted in 45 patients. The patients’ age range was from 23 to 72 years (mean = 51.76 years), and there were 21 women (46.7%) and 24 men (53.3%). Three different zygomatic implant brands were applied to the
patients. Fifty-four NobelZygoma zygomatic implants were applied to 16 patients, 55 Implantswiss zygomatic implants were applied to 19 patients, and 32 Southern zygomatic implants were applied to 10 patients (Table 1). Nineteen patients with fixed, 23 patients with hybrid, and 3 patients with removable prostheses were rehabilitated (Figs 3 to 5). Eight zygomatic implants failed, and the survival rate was 94.33%, with a mean 17.2 months of follow-up. The overall complication rate was 5.67% and included two zygomatic implants with infection (1.4%), one zygomatic implant with peri-implantitis (0.7%), three zygomatic implants with sinusitis (2.1%), and two zygomatic implants with the wrong prosthetic rehabilitation (1.4%) (Tables 2 and 3). Two zygomatic implants with infection occurred within 1 month after the insertion of the zygomatic implants. It was detected that oroantral fistula and infection were surrounding the coronal part of the two zygomatic

| Table 1 Distribution of Patients and Zygomatic Implants (zi) by Brands |
|---------------------------------|-------------|-------------|----------|------|
|                               | NobelZygoma | Implantswiss | Southern | Total |
| Patients (n)                  | 16          | 19           | 10       | 45    |
| ZI (n)                        | 54          | 55           | 32       | 141   |

Fig 3 Radiologic and intraoral views of fixed prosthesis.

Fig 4 Radiologic and intraoral views of hybrid prosthesis.

Fig 5 View of removable prosthesis.
implants. A zygomatic implant that developed peri-implantitis had a probing depth of 5 mm, bleeding following probing at the mesial, distal, and buccal points, and radiographic bone loss of 2 mm. Three zygomatic implants that were placed with the intrasinus technique failed due to recurrent sinusitis. One zygomatic implant was a failure due to the fracture of the implant-abutment screw, and mechanical overloading resulted in one zygomatic implant failure. All the patients were ASA I and II, according to the ASA classification system. No membrane or graft material (except for autogenous graft) was used in any patient (Table 4).

**DISCUSSION**

Zygomatic implants provide favorable outcomes for prosthetic rehabilitation in cases that cannot be treated with only conventional endosteal implants and bone grafting techniques, particularly in those with extremely atrophic maxillae or inadequate maxillary bone and/or defects caused by trauma, congenital abnormalities, and resective surgeries. A variety of treatment options with zygomatic implants exist for ensuring the success of fixed, hybrid, and removable prostheses, among which quad, triple, dual, and single zygomatic implants and a combination of endosteal and zygomatic implants are used to attain an optimum prosthetic superstructure. Quad zygomatic implants can be inserted in juxtaposition bilaterally either alone or in combination with endosteal implants to ensure anchorage for fixed prostheses. In contrast, single or dual zygomatic implants can be preferred particularly for patients with partial posterior edentulism. In a systematic review and meta-analysis, Centenero et al compared dual zygomatic implants with regular implants versus quad zygomatic implants for evaluation of the success rate.¹² No statistically significant difference between the two groups was detected.¹² Likewise, triple zygomatic implants (one side with two zygomatic implants and the other side with one zygomatic implant) can be used in cases where quad zygomatic implants cannot be inserted surgically due to insufficient alveolar and/or zygomatic bone, and these implants can be supported with endosteal implants. In the present study, the number of patients who had dual, triple, and quad zygomatic implants inserted was 19 (42%), 1 (2%), and 25 (55.5%), respectively. Triple zygomatic implants were placed in only one patient, in whom dual zygomatic implants could not be placed in juxtaposition to the right maxilla and only a single zygomatic implant was placed, although quad zygomatic implants were planned. Triple zygomatic implants and one endosteal implant were placed in the same patient under general anesthesia to support a fixed hybrid prosthesis. The survival rate of the endosteal implants that were inserted with zygomatic implants at the same time was not evaluated. Accordingly, it is considered that triple zygomatic implants with endosteal implants ensure sufficient anchorage for fixed prostheses.

Standard zygomatic implants and atrophic maxillary zygomatic implants are commonly used for patients with complete or partial edentulism. A standard zygoma implant is preferred when there is sufficient alveolar bone in order to support a zygomatic implant. If there is not sufficient alveolar bone to support zygomatic implants, an atrophic maxillary zygoma implant is used. Furthermore, the length and diameter of the zygomatic implants influence biomechanical stability, although it
is not possible to evaluate the effect of the length of the zygomatic implants in retrospective studies. However, placement of one brand of zygomatic implant with or without conventional implants and with a standard prosthesis might show reliable data for the survival rate of zygomatic implants in retrospective studies. In addition to this, anchorage only in zygomatic bone or in zygomatic bone and alveolar bone should be taken into consideration when the long-term survival rate of zygomatic implants is analyzed. Within the limitations of the present study, different brands of zygomatic implants and prosthetic superstructures were used, and the bone-to-implant contact at the zygomatic bone and alveolar bone was not evaluated. Balshi et al conducted a study including bone-to-implant contact at the zygomatic bone with zygomatic implants and reported that the bone-to-implant contact value were higher in men than women, but zygomatic bone-to-implant contact did not influence zygomatic implant survival rate. Freedman et al evaluated the effect of alveolar bone support on the stress distribution of zygomatic implants using an extrasinus approach and reported that the alveolar bone support reduced the internal stress that was induced by occlusal and lateral forces compared to implants with no alveolar bone support.

The present retrospective study aimed to evaluate survival rates and related complications of zygomatic implants that were placed surgically according to the two-stage protocol. Davó conducted a 5-year retrospective study including 45 zygomatic and 109 conventional implants and reported that the success rate of prosthetic rehabilitation after 5 years was 95.8%. The survival rates of zygomatic implants and conventional implants after a 5-year follow-up period were 97.4% and 89.9%, respectively. Becktor et al reported that the survival rates of zygomatic implants and additional endosteal implants with a mean 46.4-month follow-up period were 90.3% and 95.7%, respectively. In a retrospective study by Migliorança et al, 150 zygomatic implants using an extrasinus technique in combination with 286 endosteal implants were placed. Two zygomatic implants failed and two endosteal implants failed. No sinusitis in patients or loosened or fractured screws on any implants were detected. Araújo et al performed a retrospective study including 129 consecutive zygomatic implants to treat 37 patients with a two-stage protocol and reported a survival rate of 98.44%; the most common complication was sinusitis (21.62%). Another retrospective study with a long-term follow-up period (mean follow-up: 7.5 years), which was conducted by Chana et al, revealed a survival rate of 94.32%. In a retrospective analysis of 110 zygomatic implants using a one-stage immediate loading protocol by Balshi et al, the cumulative survival rate was 96.37% (four zygomatic implants failed). In the present study, 141 zygomatic implants were placed in 45 patients and included three different zygomatic implant brands (Table 1). For prosthetic superstructures, the numbers of patients with fixed (full ceramic or metal-ceramic), hybrid, and removable prostheses were 19, 23, and 3, respectively (Table 2). The mean age of the female and male patients was 50.76 and 52.62 years, respectively. The number of patients with ASA I and ASA II was 9 and 36, respectively. The number of patients with inserted dual, triple, and quad zygomatic implants was 19, 1, and 25, respectively. The survival rate was 94.33%, with a mean 17.2-month follow-up (Table 4). The survival rate in the present study was high and similar to previous studies, although the follow-up period was limited.

The overall complication rate was 5.67% and included two zygomatic implants with infection (1.4%), one zygomatic implant with peri-implantitis (0.7%), three zygomatic implants with sinusitis (2.1%), and two zygomatic implants with the wrong prosthetic rehabilitation (1.4%) (Tables 2 and 3). When the distribution of complications was analyzed, six patients had complications (Table 2). No complication was detected in patients with a removable prosthesis. Two zygomatic implants with infection occurred within 1 month after insertion of the zygomatic implants, and it was detected that oroantral fistula and infection were surrounding the coronal part of the two zygomatic implants. It was supposed that the lack of alveolar bone surrounding the coronal part of the zygomatic implants and/or extended drilling on the residual alveolar bone caused the oroantral fistula and infection. Two zygomatic implant failures were related to fractures of the prosthetic components. A male patient 58 years of age had recurrent sinusitis, and two zygomatic implants failed unilaterally. A female patient 62 years of age who had a fixed hybrid prosthesis with quad zygomatic implants lost one of the zygomatic implants in the left side due to fracture of the zygomatic implant component (fracture of the implant-abutment screw), and another zygomatic implant failed in the right maxilla due to peri-implantitis and buccal abscess (Table 3). Three zygomatic implants that were placed using the intrasinus technique failed due to recurrent sinusitis. Perforation of the sinus membrane during the surgical approach, postsurgical debris, and obstruction of the sinus might be predisposing factors. No complications such as hemorrhage, paresthesia, periorbital edema or hematoma, and extraoral fistula were detected in any patient. It was assumed that these complications mostly are related to the experience of the practitioner and/or surgeon. Every CBCT and 3D solid model should be examined, and surgical and prosthetic treatment planning was determined before surgical intervention by experienced surgeons in order to increase the success rate and
decrease complications. The placement of zygomatic implants by experienced surgeons prevents permanent injury and contributes to survival rates.

In the literature, various surgical techniques have been described for placement of zygomatic implants. Chrcano vic et al19 reviewed surgical techniques for placement of zygomatic implants, which resulted in 41 articles. They revealed five different approaches in their review: (1) Brånemark technique or the classical technique, (2) the sinus slot technique, (3) the exter iorized approach, (4) the minimally invasive approach by the use of custom-made drill guides, and (5) the computer-aided surgical navigation system approach.18 The success rates of these five techniques were 98.1% (1,672 placed, 31 failed), 98.9% (90 placed, 1 failed), 99% (290 placed, 3 failed), 92% (75 placed, 6 failed), and no follow-up (5 placed but no recorded failure and success rates), respectively.18 Davó et al19 applied three techniques (classical, sinus slot, and exteriorized) in their study including 42 patients treated with 81 immediately loaded zygomatic implants and reported that no differences were observed with regard to survival rates of zygomatic implants. The present retrospective study applied three techniques: intrasinus, extramaxillary sinus, and slot techniques. The present study did not mention how many zygomatic implants were placed in each technique. Preference for one technique depends on surgeon choice, the anatomy of the alveolar crest, maxillary sinus, concavity of maxillary sinus lateral wall, and zygomatic bone. All the implants were inserted surgically according to the surgical protocol of the zygomatic implant brands. The present study, unlike other studies, did not compare the success rates of surgical techniques, implant brands, or prosthetic superstructures. Optimal prosthetic rehabilitation and surgical techniques with compatible zygomatic implants were applied in order to obtain long-term success rates, and the success rate was similar to other retrospective studies.5,14,15,18

CONCLUSIONS

Within the limitations of this study, it was revealed that the clinical complications of zygomatic implants are acceptable and their survival rates are similar to those of endosteal implants. It was also found that zygomatic implants, which were used in each patient either in isolation or in combination with endosteal implants, can contribute to prosthetic rehabilitation.

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REFERENCES