Hybrid Full-Arch Rehabilitation Using Conventional And Zygomatic Implants: A Short-Term Retrospective Analysis

Keywords

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Authors

Tommaso Grandi * *(DDS)*

Paolo Toti ‡ *(BSc, DDS)*

Ugo Covani ‡ *(MD, DDS)*

Cesare Paoleschi ^ *(MD, DDS)*

Luisa Paoleschi ^ *(DDS)*

Giovanni B. Menchini Fabris † § *(DDS)*

Address for Correspondence

Giovanni B. Menchini Fabris † §

Email: editorial.activities@istitutostomatologicotoscano.it

* *Private practice, via Contrada 323, 41126, Modena, Italy*

‡ *Tuscan Stomatological Institute, Versilia Hospital, Via Aurelia 335, 55041, Lucca, Italy*

^ *Private practice, via A Gramsci 12, 50121, Florence, Italy*

† *Department of Healthcare, Pegaso University, Italy*

§ *San Rossore Dental Unit, Viale delle Cascine, 152, 56122, Pisa, Italy*

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ABSTRACT

Objectives: To report one-year outcomes of prosthetic rehabilitation of the atrophic maxillae, supported by angled abutments on zygomatic implants and conventional implants. Methods: In the present retrospective analysis, edentulous maxillary areas treated with fixed-hybrid prostheses supported by angled abutments of 45, 52.5, and 60 degrees screwed to zygomatic implants inserted using an extrasinus surgical approach were included. Prosthesis, implant, and abutment success/survival rates, complications, Mucosal Seal Efficacy Evaluation (MSEE), modified PLaque Index (mPLI), modified Bleeding Index (mBI), and Zygomatic Implants Classification Level (ZICL) were assessed. Results: Ninety-eight straight implants and 81 zygomatic implants (21 abutments of 45 degrees, 23 of 52.5 degrees, and 37 of 60 degrees) were inserted into 35 patients. Biological complications: postoperative sinus opacity was observed in seven patients, two of whom experienced a unilateral perforation of the sinus membrane. ZICLO-1 was recorded in 95% of zygomatic sites; the cumulative success rates were 100% and 94.3% when using the implant and prosthesis as units of analysis, respectively. Conclusion: Survival rate for the implants attested to the highest percentage (100%), whereas survival rate of the prostheses was 94.3%. No differences were registered among the clinical indices related to different inclinations of the abutments.

INTRODUCTION

Since it may be very difficult to rehabilitate atrophic maxillae by means of implant placement without augmentation procedures, clinicians recognize that zygomatic implant placement is a demanding yet fast and reliable surgical method for treatment of the severe maxillary atrophy.[1] Taking into account the local anatomy of the maxilla and the dimensions of the sinus cavity, many strategies have been suggested for rehabilitating maxillary edentulous patients, i.e., using "quad" zygomatic implant-supported prostheses (two per quadrant), full-arch prostheses supported by both axial and tilted implants, or hybrid prostheses supported by a combination of conventional implants and zygomatic fixtures (one per quadrant) in single or bilateral configuration.[2,3]

When compared to conventional dental implants, zygomatic implants seem to have a higher incidence of biological complications, such as gingival hyperplasia and hypertrophy, and bleeding on probing during patient recall

visits, together with higher probing pocket depths. These issues are likely due to the more demanding surgical procedure and significantly different macro design of implant placed on zygoma bone.[4-6] Reducing the number of zygomatic implants per patient (one or two instead of four) could improve the quality of the treatment procedure even if it does not seem to affect the survival of prostheses supported by quadrilateral, bilateral, or monolateral zygomatic implants. However, neither a meta-analysis nor a randomized clinical trial comparing the possible configuration options (quad versus hybrid) has yet been reported in the literature. In fact, few studies describe immediately loaded zygomatic implants together with conventional implants (recently referred to as the hybrid zygoma concept),[7,8] and even fewer studies describe the outcomes of patients treated with full-arch fixed prostheses supported by single unilateral zygomatic implants. Authors usually reported only a single clinical case or an unusual situation involving the treatment of partially edentulous patients.[9,10]

Originally suggested as an optional therapeutic approach for patients with partial or total edentulism, zygomatic implants have become viable substitutes for bone defect treatments allowing for the rehabilitation of severely atrophic jaws through both intrasinus and extrasinus approaches;[11] following that, it is suggested that a zygomatic implant treatment leads to a surgical-prosthetic approach well supported by the emerging literature and that it can also be combined with an immediate loading protocol, that is, now focusing on shortening treatment times and improving patient comfort. Additionally, treated subjects may experience significant and immediate perceived improvements in their speaking, chewing, and esthetics.[12]

When compared to bone augmentation procedures, which generally involve higher surgical morbidity, lower predictability, and increased treatment costs zygomatic implant placement typically results in less severe symptoms or morbidity.[13] Complications, however, occur with any surgical procedure; in fact, sinusitis, soft tissue infections, paresthesia, and oroantral fistula are the most frequent biological complications of zygomatic implants that generally require additional interventions to be addressed.[14-17] Moreover, not only patients suffering from bruxism and/or having functional issues may experience mechanical complications as a result of risky prosthetic strategies that clinicians choose during the planning stage (such as anterior, posterior, or buccal cantilever).[18,19] When the placement of tilted and straight implants to the anterior maxilla is not possible, an anteroposterior (AP) spread of the prosthesis can be increased till to the canine area, especially; the increased spread seems to enhance maxillary sinus pneumatization.[20] The ability to fabricate implants without structural problems during immediate loading represents a major advancement in the way clinicians care for patients. In the short and medium terms, zygomatic implant therapy seems to achieve good survival rates, and prostheses that implants can support appear to have high survival rates too.[21,22] Since major drawbacks for using an intrasinus approach during zygomatic implant placement can include a higher risk of sinus infections and a bulky prosthesis due to palatal emergence of the implant,[23] an extrasinus surgical approach can overcome these limitations.[17] Some authors use the term "all-on-X" to describe all-on-four standard and plus solution, that is, subjects who have been edentulous, are restored with full-arch fixed four to eight implants.[24,25] Thus, by providing proper compensation in angulation of the implant (of 45°, 52.5°, and 60°), angled abutments may be beneficial to these types of rehabilitation strategies.

The aim of the present study is to evaluate the short-term clinical outcomes of implant supported quad and fixed-hybrid prostheses (all-on-X) screwed to extrasinus zygomatic implants, either alone or in combination with conventional implants, and utilizing three different angled abutments.

METHODS

STUDY DESIGN AND SAMPLE DESCRIPTION

From 2018 to 2020, in a single private clinic, each patient received treatment for bilateral edentulism in the maxilla. The upper jaws were rehabilitated with full-arch prostheses through the all-on-X concept with four to seven implants as part of the rehabilitation program. From 2019 to 2022, patients were called back for delayed reexaminations performed in two affiliated clinics operating within the National Health Service (the San Rossore Dental and the Tuscan Stomatological Institute); all data were retrospectively collected. Clinically relevant parameters were gathered, entered into a database, and prepared for statistical analysis.

By using the following inclusion and exclusion criteria, 35 patients were included.

Subjects were included if:

- at least eighteen-year-old patients approved and signed the form for permission to analyze the data;
- subjects receiving immediate full-arch rehabilitation in the upper jaw supported by at least one zygomatic implant;
- patients with a full set of data related to surgical procedures and prosthetic treatments;
- subjects who were monitored for at least 1 year following the delivery of the final prosthetic restoration.

Patients were excluded from the analysis if they:

- underwent an augmentation procedure;
- there was a history of systemic diseases that might be a contraindication for oral surgery;
- took bisphosphonate drugs;
- underwent bone resection or radiation therapy.

Prosthetic specialists and skilled oral surgeons carried out all the surgeries and interventions. The study was conducted according to the principles embodied in the Helsinki Declaration of 1975, revised in 2000, for biomedical research involving human

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subjects. The authors analyzed preexisting and non-identifiable data from patients, who were all informed about the nature of the data analysis, and all patients signed a written informed consent form for the retrospective data analysis. The present retrospective analysis was approved by the Regional Ethical Review Board of Saint Camillus International University of Health and Medical Sciences (under reference number ID: E00930-2023).

SURGERY

Appropriate prophylactic antibiotic therapy was administered one hour before surgery (2 g of amoxicillin or 0.6 g of clindamycin in the event of a penicillin allergy) and continued for one week postoperatively (1 g of amoxicillin or 300 mg of clindamycin twice a day). Before surgery, all patients rinsed with 0.2% chlorhexidine mouthwash for one minute (and twice a day for the next four weeks).

All patients underwent surgery while receiving intravenous sedation (0.02-0.05 mg/kg of chlordesmethyldiazepam) in addition to a local anesthetic infiltration (articaine with or without epinephrine), with an anesthesiologist monitoring their vital signs. When necessary for the procedure, infraorbital and palatine nerves were bilaterally blocked after applying the anesthetic at the buccal area between the central incisor and the third molar. The first step in flap surgery involved a mid-crestal incision between the two maxillary tuberosities. Subsequently, a hybrid all-on-X rehabilitation approach was carried out. This included, a full-arch prosthesis supported by axial and angled abutments, that is a combination of zygomatic implants, pterygoid implants, nasal implants, and standard dental implants, with no augmentation techniques applied.

When clinicians planned the pterygoid implant surgery, the following surgical technique was developed: the surgical procedure began with a crestal incision and full-thickness flap elevation. The implant was placed in the pterygoid process (JDPterygo, JDentalCare, Modena, Italy). Following an underpreparation protocol to achieve an insertion torque of at least 45 Ncm. Using Graves' technique, all implants were placed in the pterygomaxillary region at approximately a 25–40 degree angle relative to the maxillary plane.[26]

Following the manufacturer's instructions, patients were treated with conventional implants with an internal connection (JDEvolution S, JDEvolution Plus, JDIcon, and JDIcon Plus, JDentalCare, Modena, Italy) used in conjunction with tilted implants inserted with their apex anchored in the tight contact between the nasal cortical and the anterior sinus wall, that is, procedures considered transnasal or transsinus (JDNasal, JDentalCare, Modena, Italy).[27,28] The insertion torque for axial and tilted implants ranged from 30 to 80 N-cm.

Regarding the zygomatic implant placement procedure, if necessary, vertical release incisions were made close to the zygomatic pillar. The lateral maxillary wall, the underside of the zygomatic prominence, and the alveolar bone were all made visible to the surgeon through the elevation of a full-thickness flap. The bone between the zygomatic and alveolar processes (second premolar-first molar region) provided zygomatic implants with sufficient bone housing. Along the external cortex of the lateral sinus wall, a groove was carved to house the implant body. After identifying the drill trajectory and contact point with the zygoma bone, drilling was carried out through the cancellous layer till to a depth established during the planning stage and the decision-making of the proper length of the zygomatic implant. Yet, under other morphological circumstances, that is, when a more medial trajectory was planned, the implant passed through the outer cortex; a pilot/twist drill set was used to prepare a different deep-groove access to the inner bone (from 2.8 mm to 3.6 mm). The Schneiderian membrane, visible through the groove, was carefully pushed inward to preserve its integrity. After that, the implant body was manually inserted into the groove while the apex was firmly anchored to the zygomatic bone with its threaded and tapered apical surface. Zygomatic implants were placed (JDZygoma, JDentalCare, Modena, Italy). They were characterized by a hexagonal internal connection, a smooth body, and a threaded, tapered apex for the anchorage to the bone. Specifically, implant apex and body underwent different treatments (threads area was sandblasted and acid-etched, whereas non-treated area of the body was just machined). For adequate primary stability, zygomatic implants inserted via an extrasinus surgical approach had an insertion torque between 35 and 80 Ncm *(Figure 1)*. In order to modify the tilt angle and/or the position of the zygomatic implants and enable the prosthetic screw access to be placed on the occlusal aspect of the prosthesis, three conical angled abutments of 45°, 52.5°, and 60° and proper titanium temporary sleeves (JDentalCare, Modena, Italy) were connected to the implants. Thus, after surgery, the head of the implant protruded from the top of the alveolar crest. Immediately after surgery, temporary sleeve abutments were positioned on the conical screw-retained abutment for zygomatic implants by using a screwdriver. Nonabsorbable sutures (6/0, 5/0, and 4/0) were used to sew the flaps after the components had been connected. A temporary milled polymethyl methacrylate acrylic resin prosthesis was retained with screws through screw-holes in the occlusal surface of the prosthesis, which were finally filled with composite materials. Three to six months following surgery, new impressions were taken, and screw-retained metal composite restorations were fabricated and delivered. The final prosthesis was rigidly connected to the conical abutments and screwed using a dynamometric key set to 15 Ncm. The access channels of the screws were covered with cotton and sealed with temporary filling composite material.

Post-surgical management included ketoprofen 200 mg for a maximum of three times daily according to individual postoperative pain. Oral hygiene and postoperative homecare included the use of chlorhexidine digluconate 0.12% mouthwash (Curasept, Curaden Healthcare srl, Saronno, Varese, Italy) twice a day for 2 weeks, followed by 2 weeks of soft tooth brushing; then patients were advised to resume their normal brushing and flossing routine. Generally, the clinicians suggested smoking cessation for at least one week and a soft diet for one month.

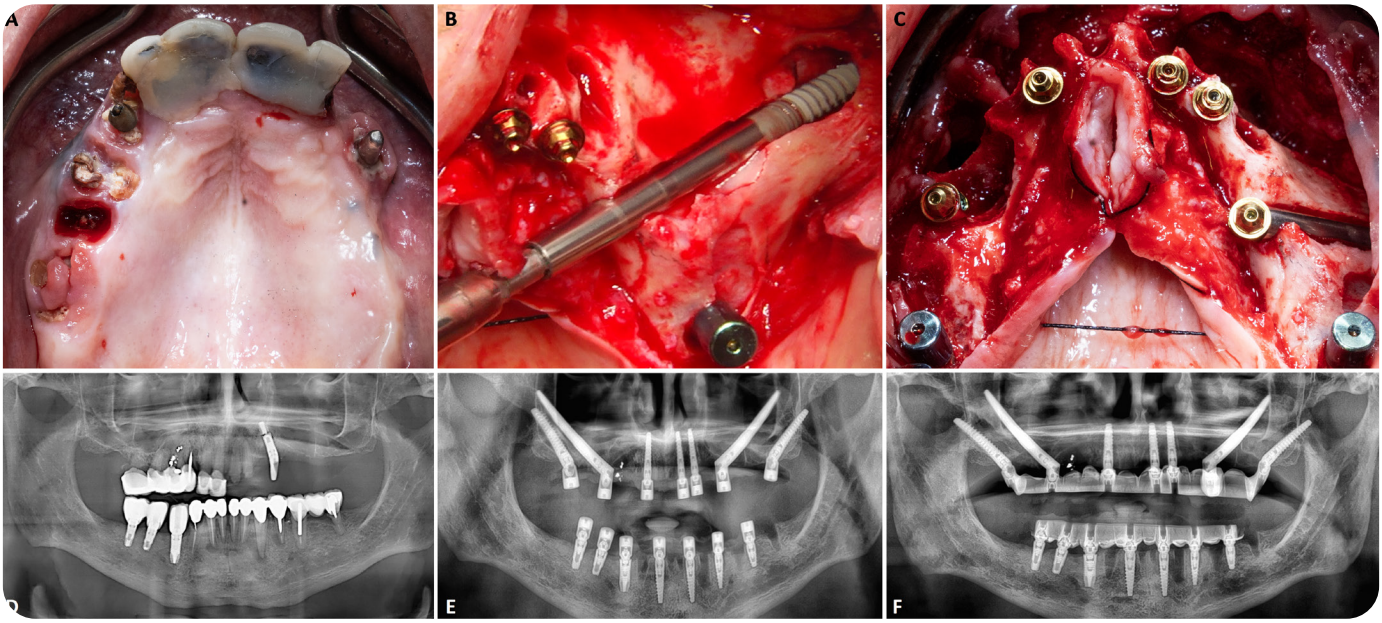

Figure 1: (A) Preoperative and (BC) intraoperative surgical views. (D) Preoperative and (EF) postoperative panoramic radiographs.

VARIABLES AND OUTCOMES

The following variables were used to accurately define the preoperative clinical features of patients and the success, survival, or failure of both the prostheses and the zygomatic implants. In order to provide comprehensive failure rate analysis and fully characterize all possible adverse events, the variables listed below were gathered.

Pre-Implant Assessment Of Patient Health

All symptoms and comorbidities of the patients were accurately documented in the medical case history, as shown in Table 1. Every patient on the list had long-term maxillary edentulism, which resulted in alveolar ridge bone defects in posterior areas, which very often prevented the use of conventional dental implants. Computerized tomography (TC) imaging analysis was carried out as a routine investigation as a part of pre-assessment for surgery; classification of jaw atrophy were ranked as V and VI classes in accordance with Sbordone and colleagues.[29]

Before implant surgery, all patients exhibited either a depressed ridge form with basal bone loss or a flat ridge form that was not sufficient in height and width for the successful insertion of conventional dental implants. Clinical data currently available did not disclose adverse preoperative events related to infection, bleeding, or inflammation of the surgical sites, nor did it mention the presence of oral parafunctional behaviors like bruxism (neither grinding nor clenching of teeth).

Post-Implant Assessment Of Patient Health

Useful clinical information contained in the patient's medical history was gathered and elaborated. Generally, clinical evaluations were performed on all patients every one to two weeks during the first month after surgery, then at three to six months and collected at the final prosthesis delivery, and then, as part of the standard surveillance protocol, clinicians might decide to visit the patient once a year or more frequently if necessary. A full clinical screening was conducted during the last survey.

At the last follow-up, all the prostheses were removed, all implants were evaluated singularly, and some clinical parameters were acquired, particularly for each zygomatic implant, clinical data about mucosal seal efficacy, plaque index, bleeding index, and clinical level were recorded. Information about success and survival rates were also registered.

Primary Predictors

All zygomatic implants were ranked into three groups based on the angles of the conical abutments: 45° in group A, 52.5° in group B, and 60° in group C.

Primary Outcome

The results here reported included implant and prosthetic success as well as every potential complication of the rehabilitation process.

ZYGOMATIC IMPLANT SURVIVAL/SUCCESS

A zygomatic implant was considered successful, surviving, or failure according to the criteria listed below.

It was a success if it actively supported a prosthesis and: (1) when stability was evaluated after prosthesis removal, it was judged to be fully stable.[30] (2) There was no evidence of infection or dehiscence. (3) The rehabilitation outcomes yielded both favorable functional and aesthetic results. (4) There were both proper implant loading and good comfort and hygiene after prosthetic delivery.[21]

Table 1. Study population: implant type, position of emergence, and loading regimen. M: male; F: female. T: total edentulism; P: partial edentulism. Types of implants: Z: Zygomatic implant; S: Standard implant; D: Pterygoid implant; L:Transinusal implant. Dimension: diameter × length (mm). Angulated abutment: 45 degrees, 52.5 degrees, and 60 degrees.

				Location of Implant Emergence													
				Right (1st Quadrant)								Left (2nd Quadrant)					
Patient List	**Age (Years)**	**Gender (M/F)**	**Edentulism (T/P)**	**17**	**16**	**15**	**14**	**13**	**12**	**11**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
1	77	M	P	Z60 37.5×3.9					S 10×3.2	S 10×3.2	S 10×3.2	S 10×3.2					Z60 37.5×3.9
2	53	F	P			Z60 35×3.9			S 10×3.7			S 10×3.7	S 10×3.2		Z60 35×3.9		
3	65	M	P		Z52.5 40×3.9		Z60 55×3.9							Z60 57.5×3.9		Z52.5 37.5×3.9	
4	70	F	P			Z52.5 40×3.9		S 10×3.2	S 10×3.2			S 10×3.2	S 10×3.2		Z52.5 40×3.9		
5	59	F	T		Z52.5 55×3.9		Z52.5 42.5×3.9					S 11.5×3.2		S 11.5×3.7		Z45 42.5×3.9	
6	58	M	P			Z45 50×3.9		S 13×3.2	S 13×3.2			S 15×3.2	S 13×3.2		Z52.5 50×3.9		
7	51	M	T			Z52.5 45×3.9			Z52.5 57.5×3.9			Z52.5 55×3.9		Z52.5 45×3.9			
8	69	F	P			Z52.5 45×3.9			S 13×3.7	S 13×3.7	S 13×3.7				S 18×3.7		
9	61	M	P			Z52.5 42.5×3.9		S 13×3.2	S 13×3.2			S 13×3.2			Z45 42.5×3.9		
10	75	F	T			Z52.5 57.5×3.9	Z52.5 50×3.9							Z45 50×3.9	Z60 57.5×3.9		
11	62	F	P			Z60 45×3.9		S 10×3.2	S 10×3.2			S 10×3.2	S 10×3.2		Z60 40×3.9		
12	52	F	P			Z60 40×3.9		S 10×3.2			S 10×3.2		S 10×3.2		Z60 40×3.9		
13	73	F	T			Z60 40×3.9		Z60 47.5×3.9					Z60 47.5×3.9		Z52.5 40×3.9		
14	52	F	T			Z45 45×3.9		Z52.5 55×3.9					Z60 55×3.9		Z45 45×3.9		
15	62	F	P		Z45 45×3.9		S 11.5×3.2	S 13×3.2					S 10×3.2		S 11.5×3.2	Z52.5 45×3.9	
16	65	F	T			Z60 35×3.9		Z60 40×3.9						Z60 35×3.9		Z60 40×3.9	
17	61	F	P	D 15×4.0		S 13×3.7			S 10×3.2			S 10×3.2			Z45 45×3.9		
18	71	F	T			Z52.5 45×3.9	Z45 37.5×3.9							Z45 35×3.9	Z60 45×3.9		
19	65	F	P	D 18×4.0			S 10×3.7		S 10×3.7			S 10×3.2		S 10×3.2	Z45 40×3.9		
20	55	M	P			L 18×4.3			S 10×3.7	S 11.5×3.2		S 11.5×3.7			Z45 45×3.9		
21	51	M	P			D 15×4.0			S 13×3.7			S 13×3.7	S 15×3.7		Z45 47.5×3.9		
22	59	M	P		Z52.5 50×3.9		S 15×3.2		S 15×3.7			S 15×3.7			S 15×3.7	Z52.5 50×3.9	
23	67	F	T		Z45 37.5×3.9		Z52.5 52.5×3.9							Z60 52.5×3.9		Z45 37.5×3.9	
24	65	F	T		Z45 42.5×3.9				S 13×3.2			S 13×3.7		L 18×4.3			
25	56	F	P	D 15×4.0		Z60 37.5×3.9			S 11.5×3.2		S 10×3.2		S 10×3.2		Z60 37.5×3.9		D 15×4.0
26	55	M	P			Z60 45×3.9		S 10×3.2	S 10×3.2			S 10×3.2	S 11.5×3.2		Z60 45×3.9		
27	72	M	P			Z60 35×3.9	Z60 50×3.9							Z60 55×3.9		Z60 35×3.9	
28	55	M	P			Z60 42.5×3.9		S 8×3.2	S 8×3.2			S 8×3.2	S 8×3.2		Z60 42.5×3.9		
29	60	M	P			Z60 42.5×3.9	S 10×3.7		S 8×3.7			S 8×3.7		S 10×3.7	Z60 42.5×3.9		
30	71	M	P	D 20×4.0		Z60 42.5×3.9		S 8×3.7		S 8×3.7	S 10×3.7				Z60 40×3.9		D 15×4.0
31	57	M	P			Z45 45×3.9			S 15×3.7	S 15×3.2		S 15×3.7		S 15×3.7	Z45 47.5×3.9		
32	77	M	P			Z60 50×3.9			S 13×3.2	S 13×3.2	S 13×3.2				Z60 47.5×3.9		
33	63	F	T			Z45 42.5×3.9			S 13×3.2			S 13×3.2			S 15×3.7		D 20×4.0
34	57	M	T			Z45 42.5×3.9				S 11.5×3.2	S 11.5×3.2		S 15×3.2				D 15×4.0
35	51	M	T			Z45 55×3.9		S 13×3.2					S 13×3.2		Z52.5 52.5×3.9		
Zygomatic (Z)		81		1	6	24	6	3	1			1	2	7	22	7	1
Standard (S)		87				1	4	10	20	7	7	18	12	4	4		
Pterygoid (D)		9		4		1											4
Transinus (L)		2				1								1			

Otherwise, a zygomatic implant was considered a surviving implant if it actively supported a prosthesis and: (1) showed little movement without pain. Since the extreme length of the zygomatic implants they allowed for some degree of mobility, and this shouldn't be taken as a sign of failure in and of itself. (2) There were signs of acute infection or dehiscence around the implant. (3) The rehabilitation outcomes yielded both favorable functional and aesthetic results. (4) There was a proper implant loading but not adequate comfort and/or sufficient hygiene of the prosthesis.

A zygomatic implant was considered a failure if either it did not actively support the prosthesis or it was removed because of: (1) any fracture; (2) mobility for failure in osseointegration or sign of rotation either spontaneous or caused by applying external forces; (3) apical pain/discomfort either spontaneous or induced; and (4) irreversible maxillary chronic sinusitis unresponsive to any medical treatment.

PROSTHESIS SURVIVAL/SUCCESS

A modified classification of the survival and success rates was used to dichotomously classify the effects (positive or yes, versus negative or no) pertaining to biological, technical, and mechanical complications that occurred during the maintenance activity:[31]

- biological: an implant failure could be one reason for prosthetic failure. Data were scheduled when patients experienced pain or showed any symptoms related to infection.
- mechanical: any fractures, whether repairable or irreparable, that affect the prosthesis' ability to function (usually involving parts, frameworks, and structures) led to a surviving or failing prosthetic restoration;
- technical: a prosthesis satisfying the aesthetic and psychological needs of the patients without assisting them in functioning (that is, persistent discomfort for unbalanced occlusal contacts or prolonged use of a soft diet) was considered a nonfunctional prosthesis, and it was a failure.

A prosthesis was considered successful if it was stable, comfortable, painless, and free from biological or mechanical problems. In the event of any unexpected prosthetic or abutment detachments, retention screw loosening, chipping, or fractures of the aesthetic materials that could be repaired, the prosthesis appeared to be "surviving". The need for a newly fabricated prosthesis was classified as a failure.[31]

GENERAL POSTOPERATIVE COMPLICATIONS

The following parameters for complications were collected: fracture or loosening of any component, persistent inflammation of soft tissue, presence of the fistula or the maxillary sinusitis, peri-implant pathology, that is, probing pocket depths >4 mm in addition to peri-implant soft tissue bleeding, presence of phonetic and masticatory function, and hygienic complaints.

Secondary Outcome

The secondary outcomes measured around each zygomatic implant were the mucosal seal efficacy evaluation (MSEE), the modified plaque index (mPLI), and the modified bleeding index (mBI). Moreover, the clinical level of the zygomatic implants (ZICL) was determined by combining the worst values of each parameter above-mentioned.

MODIFIED PLAQUE INDEX (MPLI)

An ordinal scale with a range from 0 to 3 was used to record the data: 0 indicated no plaque visible, 1 indicated plaque visible only after the probe was inserted, 2 indicated plaque visible with the naked eye, and 3 indicated an abundance of soft matter.[32,33]

MODIFIED BLEEDING INDEX (MBI)

Again, an ordinal scale with a range from 0 to 3 was used to record the data: 0 indicated no bleeding visible, 1 indicated isolated bleeding spots visible, 2 indicated bleeding forming a confluent red line on the margin, and 3 indicated heavy or profuse bleeding.[32,33]

MUCOSAL SEAL EFFICACY EVALUATION (MSEE)

A periodontal probe under a light pressure of 0.25 N was used to probe the sulcus around the zygomatic implant till to a maximum depth of 4 mm. If the probe stopped before 4 mm of depth, the measurement was recorded as 0, and if it did not stop before 4 mm of depth, it was recorded as 1.33

ZYGOMATIC IMPLANTS CLINICAL LEVEL (ZICL)

It was computed considering the following algorithm involving MSEE, mPLI, and mBI clinical indexes: ZICL = 0 (when MSEE = 0; mPLI = 0; mBI = 0), ZICL = 1 (when MSEE = 0; mPLI = 1–3; mBI = 1–3), ZICL = 2 (when MSEE = 1; mPLI = 0; mBI = 0), ZICL = 3 (when MSEE = 1; mPLI = 0; mBI = 1–3), and ZICL = 4 (when MSEE = 1; mPLI = 1–3; mBI = 0–3).[34]

STATISTICAL ANALYSIS

All statistics were carried out in matrix laboratory software (Statistics Toolbox, MatLab 7.11; The MathWorks, Natick, MA, USA). Descriptive statistics were applied to the variables of interest (complications, mPLI, mBI, MSEE, and ZICL). The cumulative survival and success rates were calculated as per Romeo and co-workers, and confidence intervals (CIs) of 95% were calculated as per Eckert.[35,36] The cumulative survival and success rates were estimated using life tables when using the implant and prosthesis as the unit of analysis. Comparisons among groups were performed using the c2 test with Yates correction if needed. The sample size of the study based on the Zygomatic Implants Clinical Level after the analysis was calculated. The level of significance was set at 0.01.

RESULTS

Patients (17 males and 18 females with a mean age of 62.1±7.8 years) suffering from long-standing edentulism were treated and followed up for a mean period of 1.4 years (15-19 months). With the patient's consent, the clinician did not perform any bone tissue augmentation. Wherever possible, conventional and long dental implants were placed in appropriate areas. A description of each patient (a numeric list) is provided in Table 1. An hybrid all-on-X rehabilitation approach was chosen to rehabilitate the healthy subjects as well as the 17 patients with age-related co-morbidities as reported in Table 2. The distribution of comorbidities included: heart diseases (n = 3), hypertension (n = 3), anxiety-depression (n = 2), heart diseases (n = 2), thyroid disease (n = 2), chronic liver diseases (n = 1), digestive system diseases (n = 1), and hypertriglyceridemia (n = 1). Clinicians could successfully achieve implant-supported prosthetic rehabilitation by placing zygomatic implants in a range of configurations, from unilateral placement of one implant in a single quadrant, to a quadrilateral concept with two implants for each quadrant *(Figure 2)*.

Fixed full arch hybrid prostheses in the selected 35 patients were supported by different combinations of 81 zygomatic, 87 standard, 9 pterygoid, and 2 trans-sinusal implants. Detailed information on implant distribution, site, position, length, and diameter is given in Table 1. Within the first 24 hours after surgery, zygomatic implants were loaded through 45°, 52.5°, and 60° conical angled abutments and connected to interim prostheses via temporary abutment sleeves.

BIOLOGICAL COMPLICATIONS

While none of the included patients in the days following their procedure reported signs or symptoms of acute rhinosinusitis, two patients who underwent bilateral zygomatic implant placement experienced unilateral sinus membrane perforation. These cases were treated in accordance with recommended medical protocols. An increase in postoperative maxillary sinus opacity was observed in seven patients (of whom two had undergone sinus membrane perforation).

IMPLANT SUCCESS RATE

Patients' histories stated that all the implants placed showed successful osseointegration until the survey's conclusion. None of the implants failed, and neither infection nor peri-implant mucositis were encountered during the clinical follow-up. Consequently, the cumulative success and survival rates were both 100%.

PROSTHETIC SUCCESS RATE

Within three to six months following surgery, 35 definitive hybrid all-on-X full-arch maxillary prostheses were delivered. These prostheses were supported by zygomatic dental implants used in combination with conventional dental implants (standard and/or long). Two of the thirty-five prostheses had technical and mechanical issues, resulting in 2 chippings of the veneer material *(Table 2)*. After prosthesis repair, a success rate of 94.3% (with a CI95%: from 86.6 to 100) was reached. The 100% survival rate meant that there was no prosthetic failure. Regarding the distribution of the angled conical abutments, there were no statistically significant differences among the three study groups (A, B, and C) when success rates were compared.

CLINICAL EVALUATION PARAMETERS

Figure 3 displays the distribution of the plaque and bleeding indexes (MPLI and MBI, respectively) for zygomatic implants, as well as the variable referring to the mucosal seal efficacy (MSSE). The distributions of MPLIs among the three groups were examined, but no significant differences were found ($p = 0.9396$). However, patients in groups B (13%) who practiced perfect oral hygiene appeared to be half of the patients of both groups A and C (23.8% and 24.3, respectively).

Among the three groups, about one-third of patients had no bleeding in the soft tissue surrounding the implant; nevertheless, nearly all patients, except for one who belonged to group C, exhibited either no bleeding or minimal mucosal bleeding *(Figure 3)*. In terms of MSEE, the proportion of sites with class = 1 (sulcus of the zygomatic implant deeper than 4 mm) was 4.8%, 4.3%, and 5.4% in groups A, B, and C, respectively.

Following an investigation into zygomatic implant clinical levels (ZICLs), no statistically significant differences were found among the three groups for either overall non-repeated data (mean ZICLs of 1.0 for group A and 1.1 for both B and C groups) or matched data (mean ZICLs of 1.1, 1.2, and 0.8 for groups A, B, and C, respectively). In Table 4, all distributions are fully displayed and associated with significances and sample sizes of the three groups (A vs. B, A vs. C, and B vs. C). Clinicians estimated that a sample size exceeding 750 subjects would be required to identify statistically significant differences among all three groups.

DISCUSSION

This study evaluated the short-term clinical outcomes of implant supported full-arch quad and fixed-hybrid prostheses (all-on-X) for the rehabilitation of severely atrophic maxillae, screwed to extrasinus zygomatic implants alone or in combination with conventional implants; three different multi unit conical angled abutments (45°, 52.5°, and 60°) were used. Prosthetic survival and success rates are found and used in conjunction with other clinical parameters that specifically measure the survival and success rates of the zygomatic implants, such as the mucosal bleeding, plaque status, depth of peri-implant probing, and the zygomatic implant clinical level. It's critical to emphasize that the clinical status of the zygomatic implants assessed in the present study cannot be described by just one index, such as their survival rate; moreover, clinical data regarding success rates are provided. The term "zygomatic success" raises the possibility of misinterpretation because there are no unique criteria

Table 2. Patients' health condition with biological and technical complications.

Patient	Systemic Conditions	Abutment Type Degrees (Number)	Complication Event	Follow-Up (months)	Position (R/L)	Radiopaque Sinus (Y/N)	Resolution Approach
4	anxiety-depression	52.5 (2)	-	-	-	N	-
5	thyroid disease	45 (1) 52.5 (2)	-	-	R	Y (unilateral)	-
12	anxiety-depression	60 (2)	-	-	-	N	-
13	thyroid disease	52.5 (1) 60 (3)	-	-	-	N	-
14	hypertriglyceridemia	45 (2) 52.5 (1) 60 (1)	-	-	-	N	-
16	thyroid disease	60 (4)	-	-	-	N	-
19	heart diseases / diabetes	45 (1)	-	-	-	N	-
20	heart diseases / hypertension / chronic liver diseases	45 (1)	-	-	-	N	-
22	hypertension	52.5 (2)	-	-	-	N	-
23	thyroid disease / diabetes	45 (2) 52.5 (1) 60 (1)	-	-	-	N	-
27	hypertension	60 (4)	-	-	-	N	-
30	diabetes / hypertension	60 (2)	-	-	R	Y (unilateral)	-
32	diabetes / heart diseases	60 (2)	-	-	-	N	-
33	digestive system diseases	45 (1)	-	-	-	N	-
			Biological Complications				
6	healthy	45 (1) 52.5 (1)	sinus membrane perforation	surgery	R	Y (bilateral)	antibiotics
31	chronic liver diseases	45 (2)	sinus membrane perforation	surgery	L	Y (unilateral)	antibiotics
			Technical/Mechanical Complications				
18	thyroid disease / hypertriglyceridemia	45 (2) 52.5 (1) 60 (1)	prosthesis chipping	8		N	repaired
24	hypertension	45 (1)	prosthesis chipping	10		N	repaired

for determining the success of a zygomatic-supported rehabilitation. In fact, the zygomatic success must take into account the index of bleeding and/or the peri-implant bone loss, both of which are significant indicators for assessing peri-implantitis in addition to the health of the involved maxillary sinus, which may have an impact on the success rate of zygomatic implants too. Different authors evaluate in different ways the success rate of immediately loaded zygomatic implants. Additionally, the overall cumulative success and survival rates may be influenced by the different surgical techniques applied, such as extrasinus or

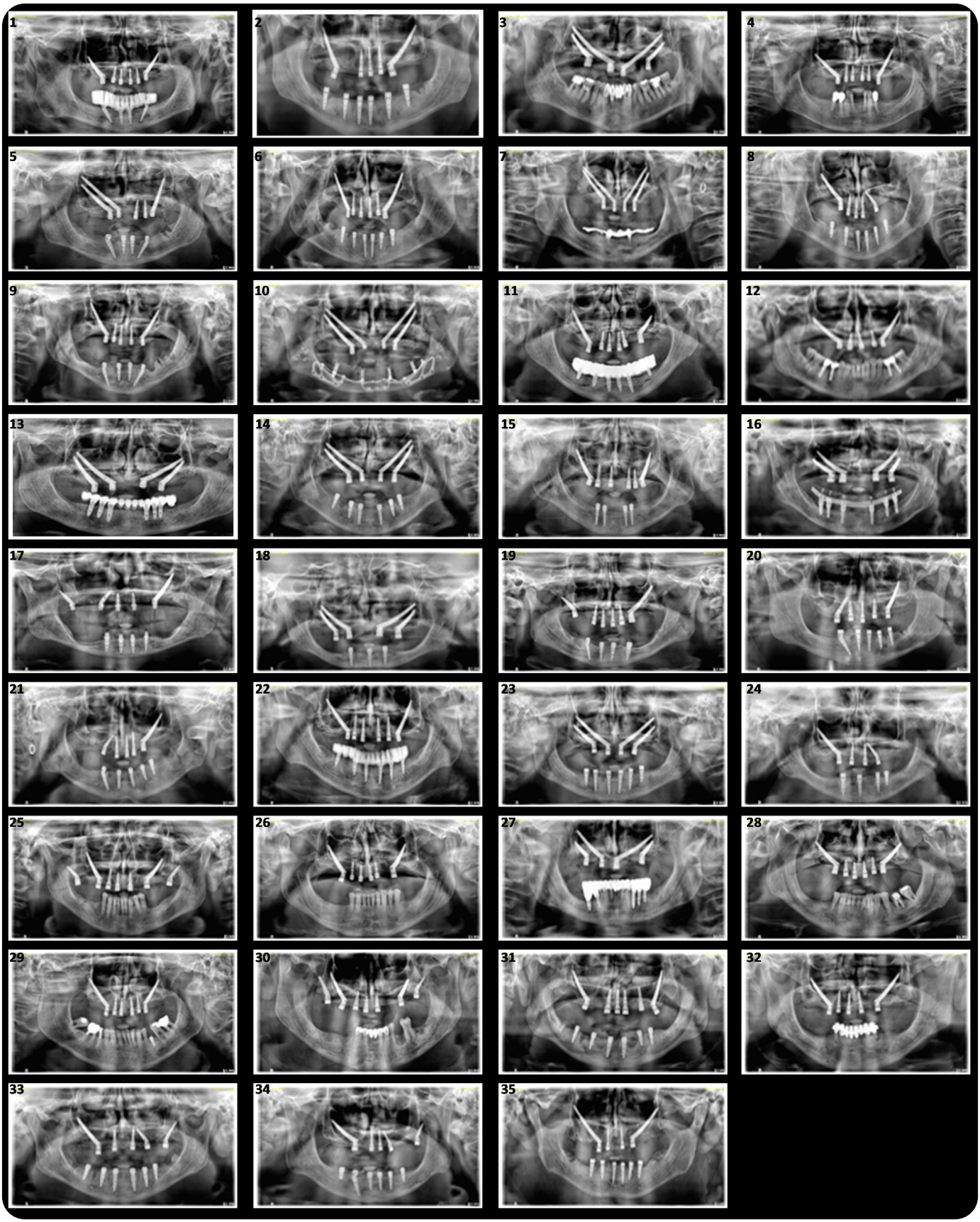

Figure 2: Postoperative panoramic radiographs of all patients.

intrasinus approaches. When comparing the extrasinus and the classical techniques, one of the most recent success criteria to systematically describe the outcome of zygomatic implant rehabilitation (that is, the ORIS criteria, an acronym of Offset, Rinosinusitis, Infection, and Stability) is related to the position of the zygomatic implant head/prosthetic abutment. Some authors suggest that an extrasinus approach allows zygomatic implants to emerge slightly buccal to the residual ridge, resulting in a thinner prosthetic base that better facilitates the patient's ability to take care of themselves.[37]

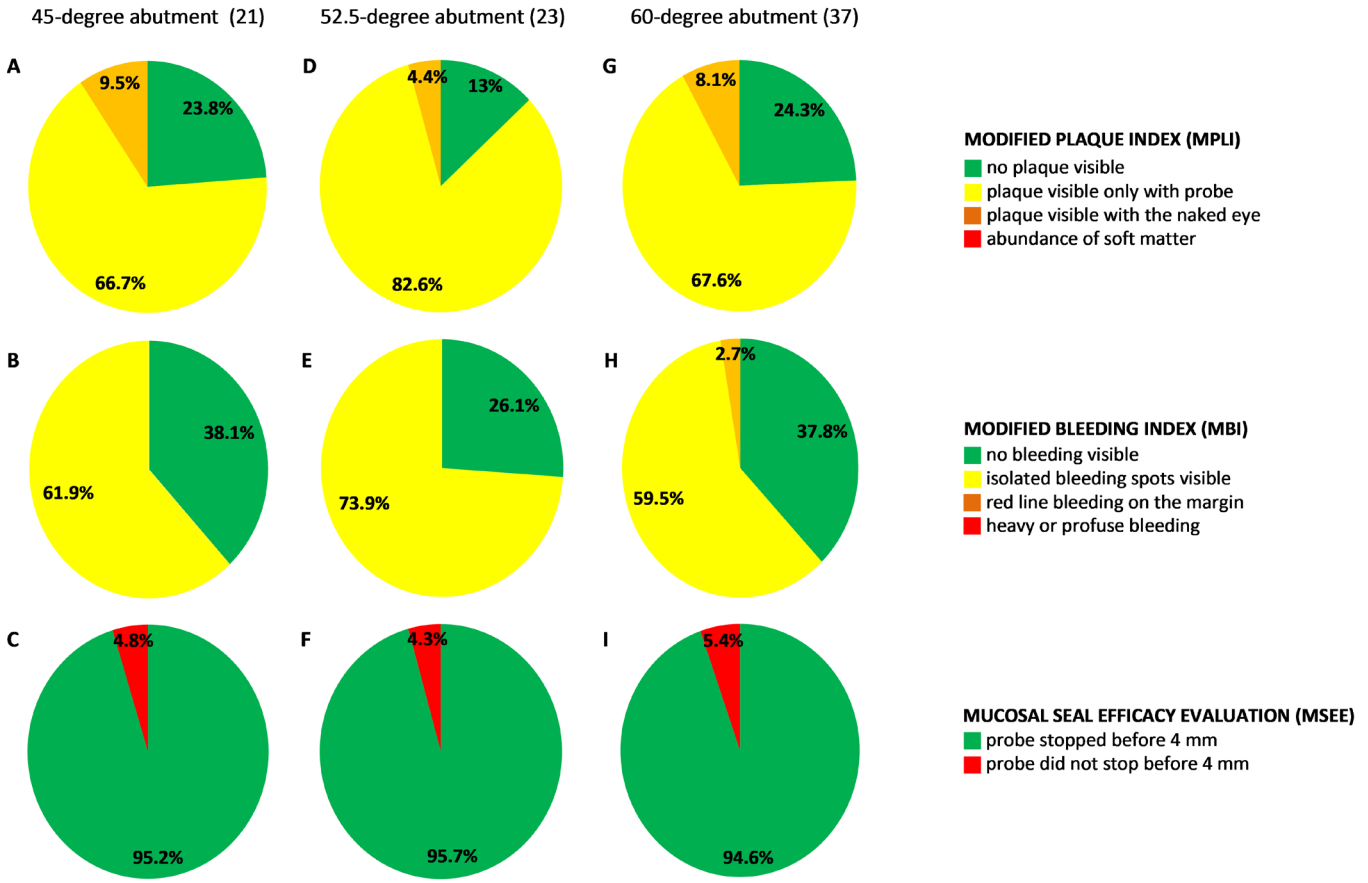

Figure 3: Modified plaque index levels, MPLI, modified bleeding index, MBI, and mucosal seal efficacy evaluation (MSEE), respectively, for 45° (ABC), 52.5° (DEF), and 60° abutments (GHI). MPLI comparison: Yates chi-square = 0.791, df = 4, p = 0.9396; MBI comparison: Yates chi-square = 0.477, df = 2, p = 0.7878; MSEE comparison: Yates chi-square = 0.402, df = 2, p = 0.8179.

In the present study, minor biological complications, such as sinus membrane perforation, occur in 5.7% of patients; however, no severe biological complications are observed during the study follow-up. These results seem to be consistent with data provided by extrasinus zygomatic implants previously reported by other authors (below 12.8%), despite the fact that sinusitis, with an incidence ranging from 0.28% to 6.12%, is the most frequently reported factor associated with implant infection.[38,39]

The 100% implant survival rate of the present study is consistent with previous findings in the literature regarding the outcomes of zygomatic implants inserted using an extrasinus surgical approach. When using the implant as the unit of analysis, some authors find a survival rate of 98.7% at two years, while others report cumulative implant survival rates at two years ranging from 98.5% to 100%.[21,33,34]

According to different approaches in the placement of zygomatic implants, that is, either the original surgical technique (OST) or the anatomy-guided approach (AGA), and to the individual anatomy of each patient, implant location and trajectory can be extremely variable. So, obtaining parallelism during implant placement is quite impossible due to the high inclination of the implants; this issue must be addresed.[40] During the placement of zygomatic implants supporting a full-arch fixed prosthesis, favorable aesthetic and prosthetic outcomes cannot be fully achieved without the use of angled superstructures (conical abutments). They compensate for the buccal inclination of the zygomatic implants so that the screw access holes are projected in the direction of the artificial teeth. Subsequently, second superstructures (titanium temporary sleeves) connect the prosthesis to the conical abutments for achieving the perfect passive fit.[41] So, it is reasonable to assume that a zygomatic implant supporting two conical abutments with different inclinations can be subjected to different forces and mechanical stresses; thus, they could show different survival rates. At the last clinical examination, all the implant components are in place and are so successful. This may preserve the aesthetic of the patients. Some authors describe that the first generation of angled abutments performs well aesthetically as well as functionally, but, given the anatomical bone limitations, it has been previously reported that the designing of the prosthetic restoration can be a laboratory challenge.[42] Among mechanical complications of angled abutments, no significant differences are found among the three groups. Given that the abutments with different inclinations should behave (theoretically) in different ways, it can be presumed that these differences are diminished or eliminated once other factors are taken into account, such as the conical and hexagonal internal very tight connection between the implant and the abutment, immediate implant loading, and passive prosthetic fit.

Table 4. Zygomatic Implants Clinical Level (ZICL) for each zygomatic implant from 0 to 4. In the same patient, among the ranked values of ZICL, the highest value per angulated abutment group (45°, 52.5°, and 60°) was selected. $\chi 2$ test with Yates correction and related p-value comparing the three abutment groups among conditions: ZICL 0, ZICL 1, and ZICL 2-3-4. ND: non-detectable.

	Zygomatic Implants Clinical Level (highest value)								
Group	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
Abutment Type (Angle In Degrees)	**45**	**52.5**	**60**	**45**	**52.5**	**60**	**45**	**52.5**	**60**
Patient List	**Overall Non-Repeated Data**			**Independent Data**			**Matched Data**		
1			1			1			
2			3			3			
3		4	1					4	1
4		1			1				
5	1	1					1	1	
6	0	1					0	1	
7		1			1				
8		0			0				
9	1	1					1	1	
10	1	1	1				1	1	1
11			1			1			
12			1			1			
13		1	1					1	1
14	1	1	1				1	1	1
15	1	1					1	1	
16			1			1			
17	0			0					
18	1	1	0				1	1	0
19	1			1					
20	1			1					
21	1			1					
22		1			1				
23	4	0	1				4	0	1
24	1			1					
25			1			1			
26			1			1			
27			2			2			
28			1			1			
29			1			1			
30			1			1			
31	1			1					
32			1			1			
33	1			1					
34	1			1					
35	0	1					0	1	
ZICL 0	3	2	1	1	1	0	2	1	1
ZICL 1	13	12	15	7	3	10	6	9	5
ZICL 2-3-4	1	1	2	0	0	2	1	1	0
$\chi 2$ test	Yates $\chi 2 = 0.47$, df = 4, p = 0.9763			ND			Yates $\chi 2 = 0.453$, df = 4, p = 0.9779		
postop sample size				groups	N.	groups	N.	groups	N.
ZICL 0 (%)	17.7	13.3	5.6	A vs B	746	A vs C	71	B vs C	153
ZICL 1-2-3-4 (%)	82.3	86.7	94.4						

The majority of patients in the present study show just local accumulation of bacterial plaque, with a percentage of plaque scarcely perceptible or totally absent ranging from 90.5% to 95.6% and with a complete absence of plaque in a percentage ranging from 13% to 24.3%; these findings fall within the very wide range of measures (from 3% to 65%) that are reported by some clinicians about zygomatic implants.[33,34] According to the same research mentioned above, mBIs range from 17% to 80%, and the indices registered in the three groups of the present study and related to NOT a bleeding event around zygomatic implants range from 26% to 38%.[33,34] The amount of negative events reported in the present study appears to be extremely low, and no significant differences are found among the different abutment groups. Again, in the present paper, the mucosal seal reveals that only 4 of the 81 zygomatic implants have sites with pocket depth greater than 4 mm. The SSEE rates, which are roughly 5%, are consistent with those previously published by other researchers (around 10% at two years).[33,34]

Finally, the majority of sites in the three abutment groups are ranked as either ZICL 0 or ZICL 1, with no group differences. However, as previously reported in other studies, the worst clinical levels of the zygomatic implants (from ZICL 2 to ZICL 4) are very uncommon occurrences.[33,34]

Concerning the experimental issues existing in this manuscript, the main drawback is the retrospective design of the study. The current study only includes a small number of treated patients, so it is important to exercise caution when extrapolating the findings to the general population. Moreover, there are some confounding factors that cannot be controlled by clinicians, such as smoking habits, general health conditions, and postoperative home oral care; some of them probably affect the outcomes even if there are not necessarily absolute contraindications for ambulatory surgery. Due to the retrospective nature of the study, no randomization procedure can be applied, as seen that an untold number of patients can be hesitant to accept the treatment because of low motivation, financial reasons, or, simply because they do not want to sign the consent form or to confirm their agreement to the processing of their personal data; otherwise, other confounding factors could be controlled directly by the surgeon, such as exclusion from surgery, number and type, position, and inclination of placed implants.

To determine the long-term outcomes of rehabilitations supported by zygomatic implants, longer and prospective studies must be conducted. Special attention could be given to variables describing the peri-implant soft tissue conditions.

CONCLUSIONS

All the parameters describing the health status of zygomatic implants, inserted by using an extrasinus surgical approach, and their conical angled abutments used in the present study seemed to confirm a maximum success rate for the implant and a success rate of 94.3% for the prostheses. However, no differences were registered among the conical abutments with different inclinations (45°, 52.5°, and 60°) when clinical indices related to the peri-implant mucosa were compared.

The classification of the clinical outcomes based on the presence of a mucosal seal (higher than 4 mm) around zygomatic implants and on the absence of a health severity score related to plaque and bleeding indices seems to attest that the health of the zygomatic implants should not be affected by the inclination of the conical abutments.

REFERENCES

1. Esposito, M. and Worthington, H.V. Interventions for replacing missing teeth: dental implants in zygomatic bone for the rehabilitation of the severely deficient edentulous maxilla. *Cochrane Database Syst. Rev.* 2013; **2013**:CD004151.
2. Almeida, P.H.T., Cacciacane, S.H. and Arcazas Junior, A. Extra-long transnasal implants as alternative for Quad Zygoma: Case report. *Ann Med Surg. (Lond.)* 2021; **68**:102635.
3. Polido, W.D., Machado-Fernandez, A., Lin, W.S. and Aghaloo, T. Indications for zygomatic implants: a systematic review. *Int J Implant Dent.* 2023; **9**:17.
4. Becktor, J.P., Isaksson, S., Abrahamsson, P. and Sennerby, L. Evaluation of 31 zygomatic implants and 74 regular dental implants used in 16 patients for prosthetic reconstruction of the atrophic maxilla with cross-arch fixed bridges. *Clin Implant Dent Relat Res.* 2005; **7**:159-165.
5. Maló, P., Nobre, Md., Lopes, A., Francischone, C. and Rigolizzo, M. Three-year outcome of a retrospective cohort study on the rehabilitation of completely edentulous atrophic maxillae with immediately loaded extra-maxillary zygomatic implants. *Eur J Oral Implantol.* 2012; **5**:37-46.
6. Maló, P., de Araújo Nobre, M., Lopes, A., Ferro, A. and Moss, S. Extramaxillary surgical technique: clinical outcome of 352 patients rehabilitated with 747 zygomatic implants with a follow-up between 6 months and 7 years. *Clin Implant Dent Relat Res.* 2015; **17**:e153-e162
7. Pesce, P. Menini, M. Bagnasco, F. Gamalero, M. Pera, F. Tealdo, T. Outcomes of zygomatic implants combined with anterior regular implants: a retrospective analysis with a mean follow-up time of 36 months. *Int J Oral Maxillofac Implants.* 2023; **38**:251-258.
8. Migliorança, R.M., Coppedê, A., Dias Rezende, R.C. and de Mayo, T. Restoration of the edentulous maxilla using extrasinus zygomatic implants combined with anterior conventional implants: a retrospective study. *Int J Oral Maxillofac Implants.* 2011; **26**:665-672.
9. Gunaseelan, R., Saravanakumar, M. and Hariharan, R. Restoration of failing maxillary implant-supported fixed prosthesis with cross arch splinted unilateral zygomatic implant: a clinical report. *J Oral Implantol.* 2012; **38**:751-755.
10. Petrungaro, P.S., Gonzales, S., Villegas, C., Yousef, J. and Arango, A. A retrospective study of a multi-center case series of 452 zygomatic implants placed over 5 years for treatment of severe maxillary atrophy. *Compend Contin Educ Dent.* 2020; **41**:232-241.
11. Chana, H., Smith, G., Bansal, H. and Zahra, D.A. A retrospective cohort study of the survival rate of 88 zygomatic implants placed over an 18-year period. *Int J Oral Maxillofac Implant.*, 2019; **34**:461-470.
12. Davó, R., Malevez, C., Rojas, J., Rodríguez, J. and Regolf, J. Clinical outcome of 42 patients treated with 81 immediately loaded zygomatic implants: a 12- to 42-month retrospective study. *Eur J Oral Implantol.* 2008; **9**:141-150.

13. Rocha, R.S., Vianna, C.P., Trojan, L.C., Padovan, L.E.M. and Dos Santos, M.C.G.L. Comparison of sinusitis rate after sinus lift procedure and zygomatic implant surgery: a meta-analysis. *Oral Maxillofac Surg*. 2024; **28**:63-77.
14. Chrcanovic, B.R. and Abreu, M.H. Survival and complications of zygomatic implants: A systematic review. *Oral Maxillofac Surg.*, 2013; **17**:81–93.
15. Davó, R., Malevez, C., and Pons, O. Immediately loaded zygomatic implants: A 5-year prospective study. *Eur J Oral Implantol*. 2013; **6**:39-47.
16. Aparicio, C., Manresa, C., Francisco, K., Ouazzani, W., Claros, P., Potau, J.M. and Aparicio, A. The long-term use of zygomatic implants: a 10-year clinical and radiographic report. Clin Implant Dent Relat Res. 2014; **16**:447-459.
17. Maló, P., de Araújo Nobre, M., Lopes, A., Ferro, A. and Moss, S. Extramaxillary surgical technique: clinical outcome of 352 patients rehabilitated with 747 zygomatic implants with a follow-up between 6 months and 7 years. *Clin Implant Dent Relat Res*. 2015; **17**:e153-e162.
18. Jensen, O.T., Adams, M.W., Butura, C. and Galindo, D.F. Maxillary V-4: Four implant treatment for maxillary atrophy with dental implants fixed apically at the vomer-nasal crest, lateral pyriform rim, and zygoma for immediate function. Report on 44 patients followed from 1 to 3 years. *J Prosthet Dent*. 2015; **114**:810-817.
19. Gelpi, F., Alberti, C., De Santis, D., Bevilacqua, M., Mellone, F. and Tealdo, T. A retrospective multicentric study of 52 nasal and trans-nasal implants in 31 severe atrophic patients to reduce anterior cantilever bending in full arch implant-supported fixed rehabilitation. *Int J Oral Maxillofac Implants*. 2024; in press doi: 10.11607/jomi.10921.
20. Krekmanov, L., Kahn, M., Rangert, B. and Lindström, H. Tilting of posterior mandibular and maxillary implants for improved prosthesis support. *Int J Oral Maxillofac Implants*. 2000; **15**:405-414.
21. Maló, P., de Araujo Nobre, M. and Lopes, I. A new approach to rehabilitate the severely atrophic maxilla using extramaxillary anchored implants in immediate function: a pilot study. *J Prosthet Dent*. 2008; **100**:354-366.
22. Agliardi, E., Romeo, D., Panigatti, S., de Araujo Nobre, M. and Malo, P. Immediate full- arch rehabilitation of the severely atrophic maxilla supported by zygomatic implants: a prospective clinical study with minimum follow-up of 6 years. *Int J Oral Maxillofac Surg*. 2017; **46**:1592–1599.
23. Esposito, M. and Worthington, H.V. Interventions for replacing missing teeth: Dental implants in zygomatic bone for the rehabilitation of the severely deficient edentulous maxilla. *Cochrane Database Syst Rev*. 2013, CD004151.
24. Afrashtehfar, K.I., Moawad, R.A., F-Eddin, A.W. and Wang, H.L. Mandibular full-arch fixed prostheses supported by three-dental-implants: A protocol of an overview of reviews. *PLoS One*. 2022; **17**:e0265491.
25. Ponnusamy, S., Gonzalez, J. and Holtzclaw, D. A systematic approach to restoring full arch length with maxillary fixed implant reconstruction: The PATZi protocol. *Int J Oral Maxillofac Implants*. 2023; **38**:996-1004.
26. Graves, S.L. The pterygoid plate implant: a solution for restoring the posterior maxilla. *Int J Periodontics Restorative Dent*. 1994; **14**:512-523.
27. Maló, P., de Araujo Nobre, M. and Lopes, A. Immediate loading of 'All-on-4' maxillary prostheses using trans-sinus tilted implants without sinus bone grafting: a retrospective study reporting the 3-year outcome. *Eur J Oral Implantol*. 2013; **6**:273-283.
28. Gelpi, F., De Santis, D., Bernardello, F., Luciano, U., Iurlaro, A., Marconcini, S., Nocini, P.F. and Finotti, M. Immediate rehabilitation of the posterior maxilla with an axial and a tilted post-extractive implant: a technical report and brief literature review. *J Biol Regul Homeost Agents*. 2019; **33**:67-77.
29. Sbordone, C., Toti, P., Brevi, B., Martuscelli, R., Sbordone, L. and Di Spirito, F. Computed tomography-aided descriptive analysis of maxillary and mandibular atrophies. *J Stomatol Oral Maxillofac Surg*. 2019; **120**:99-105.
30. Maló, P., de Araujo Nobre, M., Petersson, U. and Wigren, S. A pilot study of complete edentulous rehabilitation with immediate function using a new implant design: Case series. *Clin Implant Dent Relat Res*. 2006; **8**:223-232.
31. Anusavice, K.J. Standardizing failure, success, and survival decisions in clinical studies of ceramic and metal-ceramic fixed dental prostheses. *Dent Mater*. 2012; **28**:102-111.
32. Mombelli, A., van Oosten, M.A.C., Schürch, E. and Lang, N.P. The microbiota associated with successful or failing osseointegrated titanium implants. *Oral Microbiol Immunol*. 1987; **2**:145-151.
33. de Araújo Nobre, M., Maló, P. and Gonçalves, I. Evaluation of clinical soft tissue parameters for extramaxillary zygomatic implants and conventional implants in all-on-4 hybrid rehabilitations: short-term outcome and proposal of clinical recommendations for intervention in recall appointments. *Implant Dent*. 2015; **24**:267-274.
34. Lopes, A., de Araújo Nobre, M., Ferro, A., Moura Guedes, C., Almeida, R. and Nunes, M. Zygomatic implants placed in immediate function through extra-maxillary surgical technique and 45 to 60 degrees angulated abutments for full-arch rehabilitation of extremely atrophic maxillae: short-term outcome of a retrospective cohort. *J Clin Med*. 2021; **10**:3600.
35. Romeo, E., Lops, D., Margutti, E., Ghisolfi, M., Chiapasco, M. and Vogel, G. Long-term survival and success of oral implants in the treatment of full and partial arches: a 7-year prospective study with the ITI dental implant system. *Int J Oral Maxillofac Implants*. 2004; **19**:247-259.
36. Eckert, S.E., Choi, Y.G., Sánchez, A.R. and Koka, S. Comparison of dental implant systems: quality of clinical evidence and prediction of 5-year survival. *Int J Oral Maxillofac Implants*. 2005; **20**:406-415.
37. Maló, P., de Araújo Nobre, M., Lopes, A., Ferro, A. and Moss, S. Five-year outcome of a retrospective cohort study on the rehabilitation of completely edentulous atrophic maxillae with immediately loaded zygomatic implants placed extra-maxillary. *Eur J Oral Implantol*. 2014; **7**:267-281.
38. Maló, P., de Araújo Nobre, M., Lopes, A., Francischone, C. and Rigolizzo, M. Three-year outcome of a retrospective cohort study on the rehabilitation of completely edentulous atrophic maxillae with immediately loaded extra-maxillary zygomatic implants. *Eur J Oral Implantol*. 2012; **5**:37-46.
39. Sales, P.H., Gomes, M.V., Oliveira-Neto, O.B., de Lima, F.J. and Leão, J.C. Quality assessment of systematic reviews regarding the effectiveness of zygomatic implants: an overview of systematic reviews. *Med Oral Patol Oral Cir Bucal*. 2020; **25**:e541-e548.
40. Kämmerer, P.W., Fan, S., Aparicio, C., Bedrossian, E., Davó, R., Morton, D., *et al*. Evaluation of surgical techniques in survival rate and complications of zygomatic implants for the rehabilitation of the atrophic edentulous maxilla: a systematic review. *Int J Implant Dent*. 2023; **9**:11.
41. Zaninovich, M. Immediate rehabilitation of the severely atrophic maxilla using trans-sinus nasal protocol and extended length subcrestal angulated implants. Case series with 1-year follow-up. *J Oral Implantol* 2022; **48**:117-124.
42. Ahlgren, F. and Størksen, K.T. A study of 25 zygomatic dental implants with 11 to 49 months' follow-up after loading. *Int J Oral Maxillofac Implant*. 2006; **21**:421-425.