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CLINICAL RESEARCH

Pterygoid and tuberosity implants in the atrophic posterior maxilla: A retrospective cohort study

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ABSTRACT

Statement of problem. Rehabilitation of the partially or completely edentulous posterior maxilla using dental implants is a clinical challenge because of the presence of the maxillary sinus, as well as the low quality and quantity of bone in that region. In addition to bone augmentation procedures, posterior maxillary rehabilitation using implants includes their anchoring in bones such as the zygoma, pterygoid, and maxillary tuberosity, as well as in short implants. However, the performance of pterygoid and tuberosity implants in the atrophic posterior maxilla is unclear.

Purpose. The purpose of this retrospective cohort study was to evaluate the survival of tuberosity and pterygoid implants in patients with posterior maxillary atrophy.

Material and methods. A nonprobability convenient sample of patients who had received fixed prostheses on implants placed in the maxillary tuberosity or pterygoid regions was analyzed retrospectively. Demographic variables included sex (male, female) and age. Implant-related variables included surface characteristics, site of placement, implant design, length, diameter, and anteroposterior insertion angle. Prosthetic-related variables included the type of reconstruction for rehabilitation and loading protocols. Implant survival, complications, crestal bone loss, and follow-up intervals were also documented. Collected data were analyzed at both patient and implant levels. The demographics and implant characteristics of patients receiving pterygoid or tuberosity implants were analyzed with a statistical software program (α=.05). Survival analysis was estimated by using the nonparametric Kaplan-Meier curve.

Results. A total of 119 patients had 183 pterygoid or tuberosity implants inserted. Most implants in the pterygoid region (71.5%) were Ø4.1 mm (87.4%) and 15 mm in length (60.1%). The most common prostheses were complete maxillary reconstructions (49.2%) with late loading (74.3%). The average implant anteroposterior insertion angle was 60.8 degrees. The cumulative survival rate was 97.3% (n=178) during the mean follow-up period of 57 months (range 1 to 168 months). Among all implants placed, 2.7% failed (n=5) within 2 months of their placement. The statistically significant differences noted between tuberosity and pterygoid implants were related to design, surface characteristics, and loading. The average crestal bone loss was 1.5 mm.

Conclusions. The survival of the implants placed in the maxillary tuberosity and pterygoid regions was high in patients with posterior maxillary atrophy. (J Prosthet Dent xxxx;xxx:xxx-xxx)

Rehabilitation of the atrophic edentulous posterior maxilla using dental implants is challenging, in part, because of the presence of the maxillary sinus, which is often pneumatized, the low quality and quantity of the bone compared with the anterior maxilla,[1–3] and associated prosthetic rehabilitation challenges.[4,5] Various implant surgical modalities have been developed to restore function and esthetics in the posterior maxilla, including transcrestal[6] and external maxillary sinus augmentation,[7,8] the use of tilted,[9] short,[10] zygomatic,[11,12] tuberosity or pterygoid implants, ridge expansion, and bone condensation. These surgical procedures could be performed with or without bone grafting.[13–22] Complete maxillary prosthetic rehabilitation combining implants in the anterior maxilla with those in

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Clinical Implications The results of this study suggest that tuberosity and pterygoid implants represent a suitable option for implant-supported prostheses for patients with atrophic posterior maxilla, avoiding augmentation procedures. However, a good knowledge of anatomy, preoperative planning, and proper surgical skills are imperative for a favorable outcome.

the tuberosity and pterygoid regions has been advocated as a suitable option.[23–38] Placement of zygomatic implants[39,40] with surgical drill guides helps ensure accurate placement.[41] Because of the presence of vital structures in the posterior maxillary pterygoid region, anatomic studies have focused on identifying landmarks and angulations critical to implant placement.[42–48] Few studies have assessed the long-term survival of implants in the pterygomaxillary region,[49,50] although 18-mm-long implants have been recommended.[51]

The main aim of this study was to assess the survival of pterygoid and tuberosity implants, with the secondary objective of identifying predictors of failure. The null hypothesis was that the survival of tuberosity and pterygoid implants would be similar to that of endosseous implants.

MATERIAL AND METHODS

A retrospective cohort study was designed according to the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) statement and met the criteria for medical research involving human participants according to the ethical principles described in the Declaration of Helsinki. A nonprobability, convenient sample of 119 consecutive American Society of Anesthesiologists (ASA) Class I and II patients with controlled systemic disease, presenting with partially or completely edentulous atrophic posterior maxillae and who had received pterygoid and/or tuberosity implant-supported fixed prostheses, were included in this study. Patients with systemic disease or with more than 6 mm of vertical residual bone height in the posterior maxilla or who had received bone augmentation procedures in the posterior maxilla were excluded.

Three different types of 2-piece tapered type IV titanium-alloy (Ti6AI4VELI) conical implants with an internal octagon connection (STO), with an internal cone connection (STC), and with 2 compressive threads and an internal cone connection (TPG) were used (Ihde Dental implant System). The surface of both the STO and STC implants was airborne-particle abraded twice, acid-etched, and coated with an ultrathin layer of concentrated sodium chloride, while the TPG implant had a microstructured machined surface. Implant insertion protocols were followed as per the manufacturer's guidelines.

The patients received a clinical examination, a panoramic radiograph and/or cone beam computed tomography (Scanora 3D; Soredex) scan before implant placement. Informed written consents were signed by patients and the Institutional Ethical Board at the School of Dental Medicine, University of Belgrade determined that ethical approval was not required. Preoperatively, patients were prescribed 1 g amoxicillin with clavulanic acid (Amoksiklav; Sandoz). If allergic to penicillin, 600 mg of clindamycin (Clindamycin-MIP; MIP Pharma) was prescribed instead. Implant surgeries were performed by the same 2 surgeons (V.S.K., D.J.), and an independent surgeon (F.I.) evaluated the patients and their radiographs postoperatively. Posterior superior alveolar nerve blocks and palatal infiltrations using articaine hydrochloride 4% containing adrenaline 1:100 000 (Ubistesin; 3M) were performed before implant placement. Full-thickness mucoperiosteal flaps were elevated to insert 148 implants, whereas 20 implants were placed transgingivally and 15 immediately in extraction sockets of the maxillary third molars. Most implants (174) were inserted free-handed, and 9 were placed using acrylic resin computer-aided design and computer-aided manufactured surgical guides with metal sleeves (Form 3+ 3D printer; Formlabs) (Fig. 1). The implants were inserted obliquely starting in the maxillary second or third molar region distal to the zygomaticoalveolar crest and directed medially, superiorly, and posteriorly toward the pyramidal process of the palatine bone and pterygoid plates of the sphenoid bone. For pterygoid implants**,** palpation of the palatal side of the pterygoid plates helped guide placement. Postoperatively, written and verbal instructions were provided, including maintaining a soft diet for 12 weeks. Postoperatively, the patients were examined on Days 1, 2, and 5 when sutures were removed.

To verify implant position, postoperative panoramic radiographs were made immediately, at 3 months, and annually thereafter. Before the prosthetic rehabilitation, the patients had been examined monthly and annually. Implant survival was defined as the presence of a functional implant.

Anteroposterior implant angulations relative to the Frankfort plane were measured postoperatively on

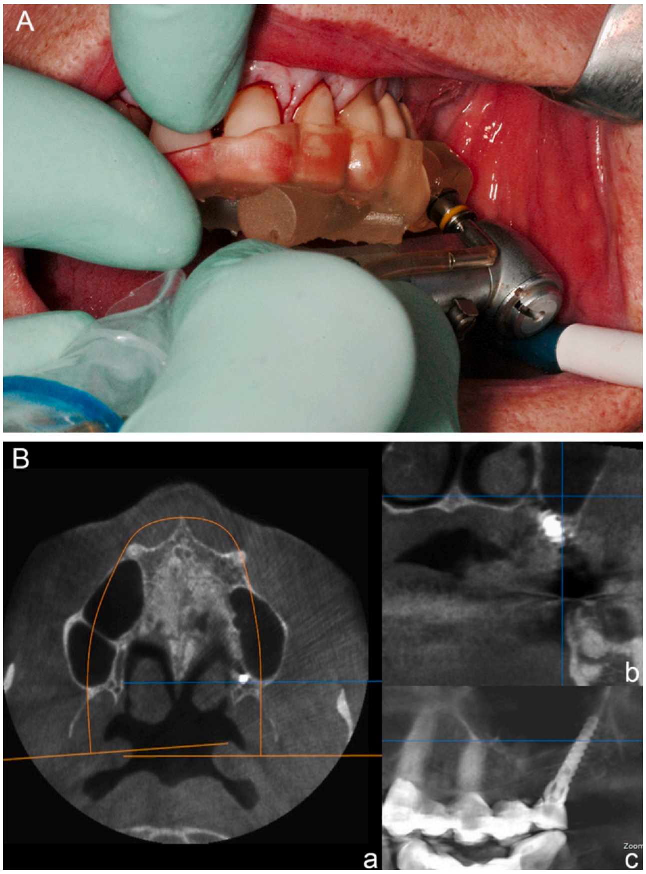

Figure 1. A, Preparation of pterygoid implant bed in left posterior maxilla using acrylic resin CAD-CAM surgical guide with metal sleeve for improved implant placement precision. B, Postoperative CBCT image composed of axial (a), coronal (b), and sagittal sections (c). Sections show 3D position of tubero pterygoid implant. CAD-CAM, computer-aided design and computer-aided manufacturing; CBCT, cone beam computed tomography.

panoramic radiographs (Fig. 2). Digital image files were exported in Digital Imaging and Communications in Medicine formats and imported into a computer software program (Ondemand3dApp; Cybermed). Single time point, crestal bone level, standardized measurements were performed on the most recent panoramic radiographs. Mesial and distal crestal bone loss was calculated based on real implant lengths and magnification errors.

At least 3 months postoperatively, second-stage surgical procedures were performed when required, removing cover screws and replacing them with healing abutments. The prosthetic phase started approximately 1 week later. Complete or segmental maxillary fixed prostheses were distributed among 4 indications: a complete maxillary reconstruction on implants (CMRI) (Fig. 3) or on implants and teeth (CMRIT) (Fig. 4); a unilateral segmental reconstruction on implants (USRI) (Fig. 5A) or on implants and teeth (USRIT) (Fig. 5B). A 12-month follow-up was considered the minimum acceptable timeframe for a meaningful outcome after the cementation of the prostheses. Implant loading protocols were either immediate, early, or delayed. Definitive fixed prostheses were retained with custom abutments (Ihde Dental) on pterygoid and tuberosity implants and cemented to other implants and/or teeth. Occlusal adjustments were performed after the delivery of the prostheses.

The demographic parameters age, sex, and anchorage site, as well as the implant parameters design, length, diameter, surface, follow-up period, and survival, were noted. Prosthetic parameters, including the rehabilitation type and loading protocol, were also documented. Intraoperative and postoperative surgical complications such as trismus, pain, neurosensory disturbances, bleeding, edema, suppuration, and plaque and calculus accumulation around the implants were recorded.

Statistical analyses were performed with a statistical software program (IBM SPSS Statistics, v22.0; IBM Corp). Descriptive data were expressed as mean ±standard deviation for continuous measures or as a percentage for discrete measures. Data were analyzed using bivariate analyses at the implant and patient levels. Implant survival analysis was estimated using the Kaplan-Meier method (α=.05).

RESULTS

The demographic characteristics of 119 patients with a total of 183 pterygoid and tuberosity implants are shown in Table 1. The age distribution ranged from 27 to 84 years (mean ±standard deviation 53.9 ±9.9). Most implants were inserted in the pterygoid region (71.5%, n=129), with the others in the maxillary tuberosity (29.5%, n=54). Implant characteristics (type, design, length, diameter, surface), side of implant placement, indication, angle of implant insertion, type of loading, complications, crestal bone loss, survival, failure, and follow-up period are shown in Table 2.

Of all implants placed (n=183), 2.7% failed (n=5); 4 were pterygoid implants and 1 was a tuberosity implant. The follow-up period ranged from 1 month to 168 months, with an average of 57.2 months.

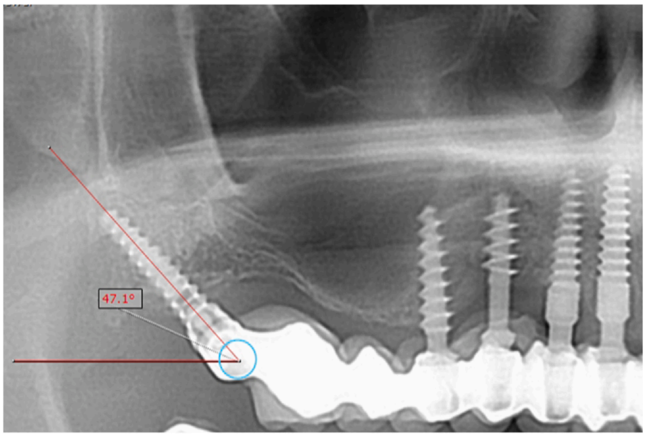

Figure 2. Implant angulation of insertion relative to Frankfort plane of anteroposterior axis on panoramic radiograph measured postoperatively.

Figure 3. Panoramic radiograph showing maxillary and mandibular fixed prostheses. Maxillary prosthesis supported by 8 implants, 2 pterygoid implants placed in right and left posterior maxillary areas, referred to as complete maxillary reconstruction on implants.

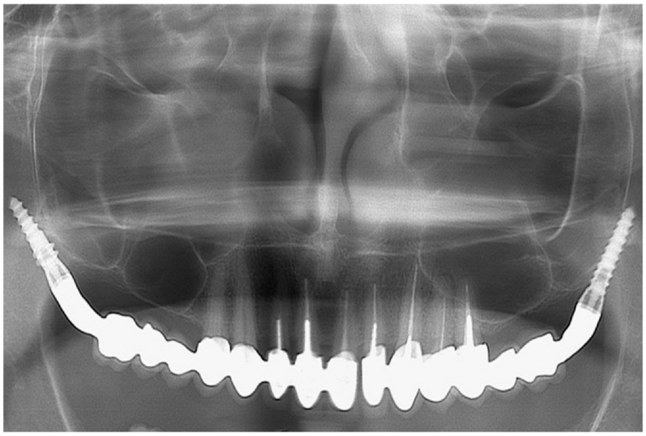

Figure 4. Panoramic radiograph showing maxillary prosthesis using natural dentition and 2 pterygoid implants placed in right and left posterior maxillary area, referred to as complete maxillary reconstruction on implants and teeth.

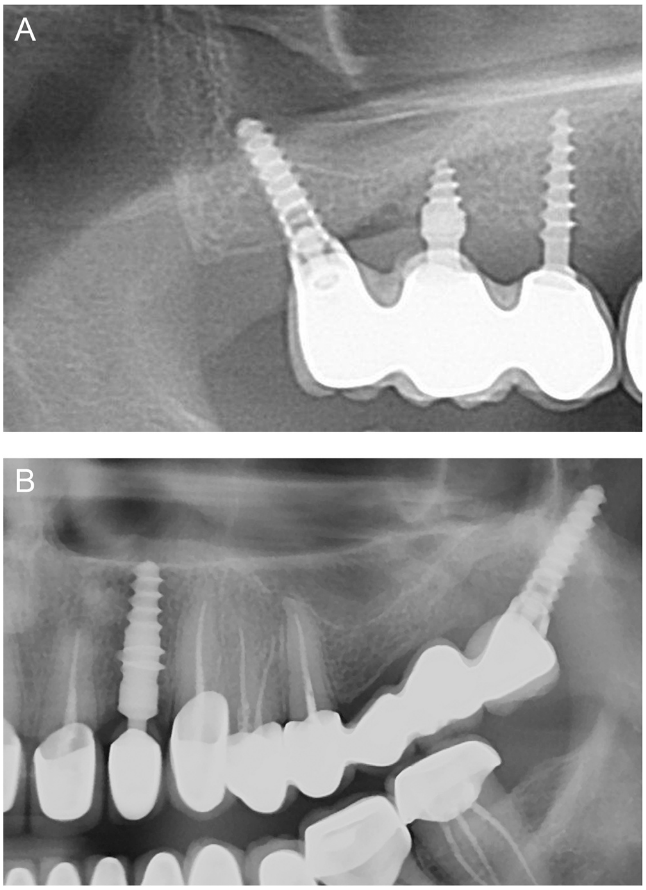

Figure 5. A, Segmental partial prosthesis of right posterior maxilla based on tuberosity implant and 2 1-piece implants, referred to as unilateral segmental reconstruction on implants. B, Segmental partial prosthesis of left maxilla based on pterygoid implant, and 2 crowns on premolars, referred to as unilateral segmental reconstruction on implants and teeth.

Loading of the implants was late, at least 3 months after insertion, in 74.3% of the patients (n=136), while other implants were loaded early, within the first week of insertion (18.6%, n=34) or rarely immediately, within the first 3 days of insertion (7.1%, n=13) (Table 2). No statistically significant differences were found between the failure and survival of implants in both groups as a function of various variables, including the type of implant whether pterygoid or tuberosity, diameter, length, surface, loading time, indication, surface, design, anteroposterior insertion angle, follow-up period, or survival ($P > .05$) (Table 3).

The only statistically significant differences noted between tuberosity and pterygoid implants were related to design, surface characteristics, and loading. STC accounted for 92.6% of tuberosity and 63.6% of pterygoid implants. Most of the tuberosity (98.1%) and pterygoid implants (75.2%) had a rough surface. The late-loading

Table 1. Demographic characteristics of patients receiving pterygoid and tuberosity implants

Patient Level	
All	**n=119 (100%)**
Sex, men	64 (53.8)
Age	53.9 ±9.9
Side of implant	
Only Right	29 (24.4)
Only Left	26 (21.8)
Both	64 (53.8)
Number of implants	
1	55 (46.2)
2	64 (53.8)

protocol was used for 87% of the tuberosity and 69% of the pterygoid implants (Table 4).

The survival of all the implants was 97%, with all failures occurring during the first 2 months after implant insertion in Ø4.1×15-mm implants, with USRI and CMRI prosthetic indications, and with STC implants. Failures related to TPG implants and CMRI occurred only in the second month after implant insertion. Pterygoid implants failed during the first and second months after implantation, whereas failures of tuberosity implants only occurred in the first month (Table 5).

At the patient level, implant survival was 95.8% (n=114) and 97.3% (n=178) at the implant level. The implants were followed for a minimum of 1 month, a maximum of 168 months, and a mean of 57.2 months, during which 4 complications were noted (Table 6). Only 1 surgical complication was noted, in which the implant insertion angle was superficial. The implant was immediately removed and replaced with the direction corrected, without any adverse consequences. Three implants exhibited signs of peri-implant mucositis, including erythema and bleeding on probing after definitive prosthetic rehabilitation, which was resolved using nonsurgical therapy. Peri-implant mucositis was attributed to limited access to oral hygiene. There was no intraoperative or postoperative bleeding, and all the implants demonstrated adequate primary stability when placed. No trismus or neurosensory disturbances were noted.

Three implants failed in men and 2 in women. Failed implants exhibited granulation tissues but no active infection or pus. The description of patients, implant characteristics, and angles of insertion of failed implants are shown in Table 7. Three of the failed implants occurred in USRI and 2 in CMRI within the first 2 months of implant placement during the osseointegration period before loading of the definitive prostheses (Table 7). The cumulative survival rate for all the implants was 97.3%

Table 2. Characteristics of implants placed in atrophic posterior maxilla

Implant Level	
All	**n=183 (100%)**
Type, tuberosity	54 (29.5)
Design	
STO	19 (10.4)
STC	132 (72.1)
TPG	32 (17.5)
Implant length (mm)	
<15	12 (6.6)
15	110 (60.1)
>15	61 (33.3)
Anteroposterior angle (degree)	60.8 ±13.8
Diameter (mm)	
3.3	2 (1.1)
3.7	21 (11.5)
4.1	160 (87.4)
Surface, rough	150 (82.0)
Side of implant, right	93 (50.8)
Complications	4 (2.2)
Loading	
Immediate	13 (7.1)
Early	34 (18.6)
Late	136 (74.3)
Indication	
CMRIT	32 (17.5)
CMRI	90 (49.2)
USRIT	20 (10.9)
USRI	41 (22.4)
Survival	178 (97.3)
Failure	5 (2.7)
Crestal bone loss	
Average	1.5 ±0.7
Mesial	1.5 ±08
Distal	1.5 ±0.8
Follow-up period (months)	57.2 ±38.7

CMRI, complete maxillary reconstruction on implants; CMRIT, complete maxillary reconstruction on implants and teeth; STC, implant with an internal conical connection; STO, implant with an internal octagonal connection; TPG, implant with an internal conical connection and 2 compressive threads; USRI, unilateral segmental reconstruction on implants; USRIT, unilateral segmental reconstruction on implants and teeth.

(Fig. 6, Table 5). Regarding prosthetic indications, USRIT had the lowest survival (93%) compared with the CMRI (98%) (Fig. 7). The cumulative survival rate for STO, STC, and TPG implants showed that STO implants had a higher tendency to survive with no failures (Fig. 8). Pterygoid implants tended to have a lower survival rate than tuberosity implants (Fig. 9).

DISCUSSION

Bone augmentation procedures, such as sinus floor augmentation, or alternatively using short, zygomatic, tuberosity or pterygoid implants, have been used to rehabilitate the posterior atrophic maxilla.[27–29] Tuberosity implants, unlike pterygoid implants, do not anchor the pyramidal process of the palatine or the

Table 3. Bivariate associations between failure and demographic and implant characteristics

	Failure		
	No	Yes	
	(n=178)	(n=5)	*P*
Sex, men	95 (53.4)	3 (60.0)	> .999
Age, years	54.3 ± 9.9	56.6 ± 7.7	.66
Side of implant, right	90 (50.6)	3 (60.0)	> .999
Type, tuberosity	53 (29.8)	1 (20.0)	> .999
Design			
STO	19 (10.7)	0 (0.0)	> .999
STC	128 (71.9)	4 (80.0)	
TPG	31 (17.4)	1 (20.0)	
Implant length (mm)			
< 15	12 (6.7)	0 (0.0)	.22
15	105 (59.9)	5 (100.0)	
> 15	61 (34.3)	0 (0.0)	
Anteroposterior angle (degree)	60.7 ± 13.8	65.1 ± 12.5	.43
Diameter (mm)			
3.3	2 (1.1)	0 (0.0)	> .999
3.7	21 (11.8)	0 (0.0)	
4.1	155 (87.1)	5 (100.0)	
Surface, rough	146 (82.0)	4 (80.0)	> .999
Loading			
Immediate	12 (6.7)	1 (20.0)	
Early	34 (19.1)	0 (0.0)	.24
Late	132 (74.2)	4 (80.0)	
Indication			
CMRIT	32 (18.0)	0 (0.0)	.27
CMRI	88 (49.4)	2 (40.0)	
USRIT	20 (11.2)	0 (0.0)	
USRI	38 (21.3)	3 (60.0)	

CMRI, complete maxillary reconstruction on implants; CMRIT, complete maxillary reconstruction on implants and teeth; STC, implant with an internal conical connection; STO, implant with an internal octagonal connection; TPG, implant with an internal conical connection and 2 compressive threads; USRI, unilateral segmental reconstruction on implants; USRIT, unilateral segmental reconstruction on implants and teeth.

Table 4. Bivariate associations between type of implant and demographic, implant characteristics, and outcomes

	Type of Implant		
	Tuberosity	Pterygoid	*P*
	(n=54)	(n=129)	
Sex, men	30 (55.6)	68 (52.7)	.72
Side of implant, right	28 (51.8)	65 (50.4)	.86
Design			
STO	3 (5.6)	16 (12.4)	< .001
STC	50 (92.6)	82 (63.6)	
TPG	1 (1.8)	31 (24.0)	
Implant length (mm)			
< 15	5 (9.3)	7 (5.4)	.55
15	30 (55.6)	80 (62.0)	
> 15	19 (35.2)	42 (32.6)	
Anteroposterior angle (degree)	62.9 ± 16.6	59.9 ± 12.3	.23
Diameter (mm)			
3.3	1 (1.9)	1 (0.8)	.56
3.7	5 (9.3)	16 (12.4)	
4.1	48 (88.9)	112 (86.8)	
Surface, rough	53 (98.1)	97 (75.2)	< .001
Loading			
Immediate	3 (5.6)	10 (7.7)	.03
Early	4 (7.4)	30 (23.3)	
Late	47 (87.0)	89 (69.0)	
Indication			
CMRIT	7 (13.0)	25 (19.4)	.22
CMRI	23 (42.6)	67 (51.9)	
USRIT	8 (14.8)	12 (9.3)	
USRI	16 (29.6)	25 (19.4)	
Survival	53 (98.1)	125 (96.9)	> .999
Failure	1 (1.8)	4 (3.1)	> .999

CMRI, complete maxillary reconstruction on implants; CMRIT, complete maxillary reconstruction on implants and teeth; STC, implant with an internal conical connection; STO, implant with an internal octagonal connection; TPG, implant with an internal conical connection and 2 compressive threads; USRI, unilateral segmental reconstruction on implants; USRIT, unilateral segmental reconstruction on implants and teeth.

pterygoid plates of the sphenoid bone.[25,29] The pterygomaxillary region is challenging for implant placement because of its complex anatomy,[42,43,46,50] poor bone quality, and difficult surgical access.[33,52,53] The dense cortical bone in the pterygoid region is favorable for anchoring the pterygoid implants bicortically.[17,27,39,51]

The results of the present study showed high implant survival (97.3%, n=178), with a mean follow-up period of 4.7 years, the longest being 14 years. In another study with a large sample size that included 1068 implants, the implant survival and follow-up periods were not reported.[51] In a retrospective study that included 356 implants with a similar follow-up period, the survival rate was 88.2%. A possible reason for the lower implant survival could be the use of 8.5-mm implants, shorter than those used in the present study.[54] A recent meta-analysis reported a cumulative survival rate of 94.9%.[33] In contrast, the present study, one of the largest that evaluated tuberosity and pterygoid implants, demonstrated a higher survival rate. Moreover, the low implant failure in the present study was comparable with previous ones that ranged from 2.9% to 10%.[25,27,30,49,51,55] The results of the present retrospective study demonstrated that tuberosity or pterygoid implants had a survival rate comparable with that of endosseous implants placed in other maxillary regions.[26,52,56]

The anteroposterior angle of the tuberosity or pterygoid implants' position ranged from 15 to 90 degrees, with the majority of the studies reporting an angle between 45 and 90 degrees.[27,30,49] In contrast with anatomic studies recommending mean pterygoid implant angulations of 74.2 degrees in the anteroposterior axis and 81.1 degrees in the buccopalatal axis, relative to the

Table 5. Survival of all implants and by implant characteristics

Failure	n	1 Month	2 Months	3-168 Months
Among all	183	0.99	0.97	0.97
By indication				
CMRIT	32	1.00	1.00	1.00
CMRI	90	1.00	0.98	0.98
USRIT	20	1.00	1.00	1.00
USRI	41	0.95	0.93	0.93
By length (mm)				
< 15	12	1.00	1.00	1.00
15	110	0.98	0.95	0.95
> 15	61	1.00	1.00	1.00
By design				
STO	19	1.00	1.00	1.00
STC	132	0.98	0.97	0.97
TPG	32	1.00	0.97	0.97
By type				
Tuberosity	54	1.00	0.98	0.98
Pterygoid	129	0.98	0.97	0.97
By loading				
Immediate	13	0.92	0.92	0.92
Early	34	1.00	1.00	1.00
Late	136	0.99	0.97	0.97

CMRI, complete maxillary reconstruction on implants; CMRIT, complete maxillary reconstruction on implants and teeth; STC, implant with an internal conical connection; STO, implant with an internal octagonal connection; TPG, implant with an internal conical connection and 2 compressive threads; USRI, unilateral segmental reconstruction on implants; USRIT, unilateral segmental reconstruction on implants and teeth.

Table 6. Outcomes of complications, survival, and failure at patient and implant levels

Outcomes	
Patient level	n=119
Complications	4 (2.2)
Survival	114 (95.8)
Failure	5 (4.2)
Implant level	n=183
Survival	178 (97.3)
Failure	5 (2.7)
Follow-up (months)	57.2 ± 38.7

Frankfort horizontal plane,[43,49] the anteroposterior implant angulation reported in the present study was 59.9 degrees in the anteroposterior axis. The buccopalatal angle, however, was not measured, as panoramic radiographs had been used rather than 3-dimensional computed tomography images. The variability noted in the anteroposterior angle was similar to that reported previously[57] and could be attributed to the patients' anatomic variations or the free-hand placement of the implants. In a recent randomized clinical trial, dynamic navigation was reported to reduce variability, allowing more precise implant placement.[57]

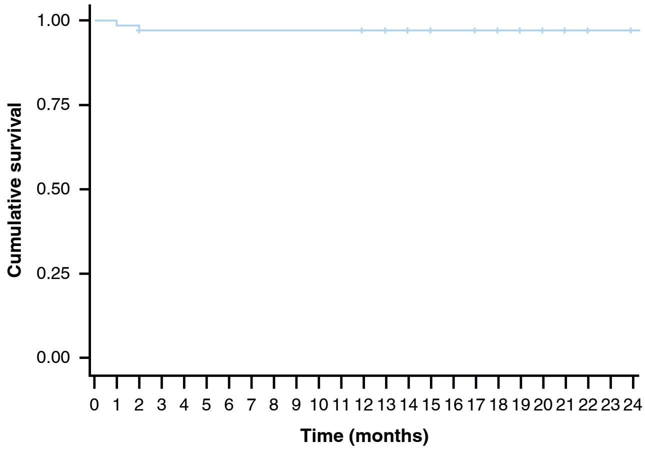

Figure 6. Kaplan-Meier survival curve. Cumulative survival rate for all implants.

Most of the implants in the present study (93%) were at least 15 mm in length, consistent with reported implant lengths ranging from 15 to 18 mm.[50] The majority of the implants had a Ø4.1 mm compared with Ø3.7 mm reported previously.[49] The appropriate length and diameter of pterygomaxillary implants enhances the anteroposterior spread of the mechanical load.[58]

Although complications such as intraoperative bleeding, trismus, pain,[30,49,55] and implant displacement in the pterygotemporal fossa[59] have been reported, none of these complications were noted in the present study. Only 1 issue was encountered with an implant insertion, which was rectified immediately by changing angulation. Clinical signs of inflammation were observed in only 3 implants and were resolved using nonsurgical therapy.

Table 7. Description of patient demographics, implant characteristics, and insertion angle in failed patients

Failures	Sex	Age	Implant Type	Implant Design	Implant Length (mm)	Implant Diameter (mm)	Surface Type	Antero Posterior Angle (degree)	Time to Failure in Months
1	Man	62	Pterygoid	STC	15	4.1	Rough	49.0	1
2	Man	55	Pterygoid	STC	15	4.1	Rough	71.4	2
3	Woman	56	Pterygoid	TPG	15	4.1	Machined	63.3	2
4	Woman	65	Tuberosity	STC	15	4.1	Rough	59.7	2
5	Man	45	Pterygoid	STC	15	4.1	Rough	82.3	1

STC, implant with an internal conical connection; TPG, implant with an internal conical connection and 2 compressive threads.

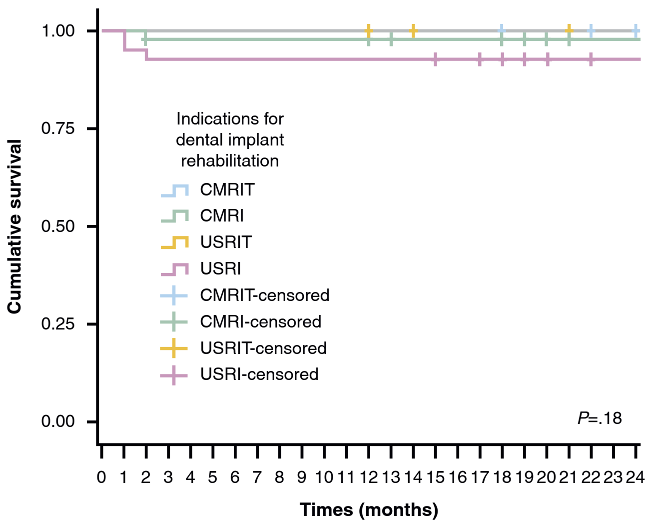

Figure 7. Kaplan-Meier survival curve. Cumulative survival rate for maxillary prosthetic indications for pterygoid and tuberosity implant rehabilitation. CMRI, complete maxillary reconstruction on implants; CMRIT, complete maxillary reconstruction on implants and teeth; USRI, unilateral segmental reconstruction on implants; USRIT, unilateral segmental reconstruction on implants and teeth.

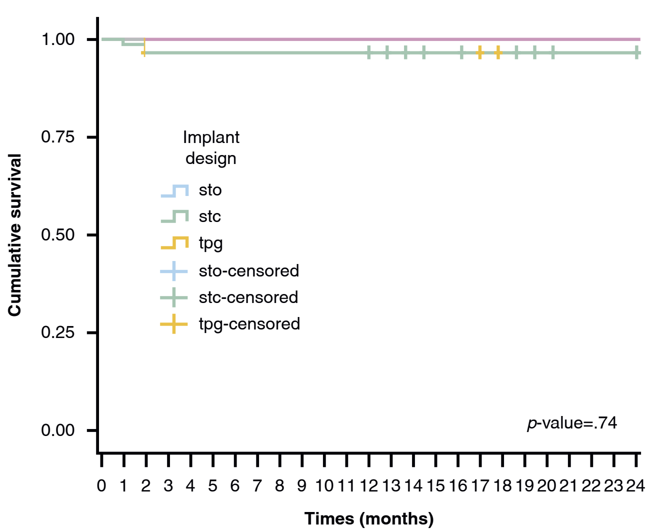

Figure 8. Kaplan-Meier survival curve. Cumulative survival rate for STO, STC, and TPG pterygoid and tuberosity implants. STC, implant with an internal conical connection; STO, implant with an internal octagonal connection; TPG, implant with an internal conical connection and 2 compressive threads.

Limitations of this study included its retrospective nature, which could have induced bias and limited the control of confounding variables. All the patients included were ASA Class I and II without prior surgical augmentation procedures and presented with less than 6 mm of bone height in the posterior maxilla. All of the implant surgeries were performed by the same 2 surgeons, and the patients were independently evaluated postoperatively using panoramic radiographs. Furthermore, because of the small number of implant failures (n=5), meaningful statistical comparisons could not be performed to identify predictors of failure. Although the results indicate high implant survival, consistent with published reports,[33,60] the study did not address implant surgical and prosthetic success over time. The 1.5-mm mean crestal bone loss was acceptable and was consistent with previous reports.[61,62] Future randomized clinical trials are warranted to assess surgical and prosthetic success criteria.

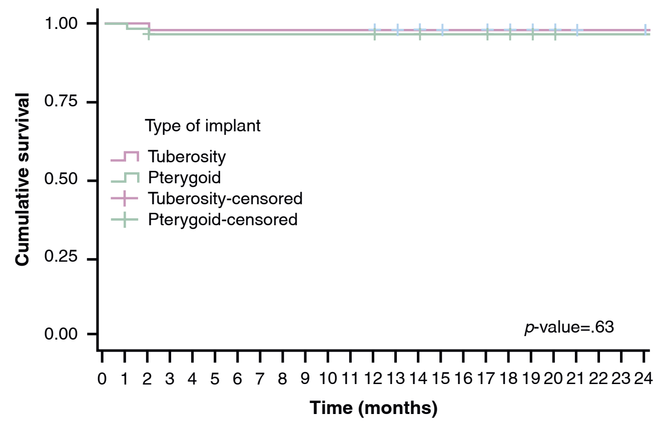

Figure 9. Kaplan-Meier survival curve. Cumulative survival rate for tuberosity and pterygoid implants.

CONCLUSIONS

Based on the findings of this retrospective cohort study, the following conclusions were drawn:

1. Pterygoid and tuberosity implants could be a viable and predictable modality for rehabilitating the atrophic posterior maxilla because of their high rate of survival and their minimal intraoperative and postoperative complications.
2. Knowledge of anatomy, preoperative planning, and proper surgical skills are imperative for a favorable outcome.

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