KEY WORDS
Bone atrophy, Pterygoid implants, Maxilla, Follow-up, Immediate loading

Cohort study

IMMEDIATE FIXED REHABILITATION OF THE ATROPHIC MAXILLA WITH PTERYGOID IMPLANTS: 3-YEAR POST-LOADING OUTCOMES OF A PROSPECTIVE COHORT STUDY

TOMMASO GRANDI, DDS
Private practice inn Modena, Italy

RAWAD SAMARANI, DDS, DES, MRes
Senior Lecturer, Department of Periodontology, Saint-Joseph University, Beirut, Lebanon. Private practice, Byblos, Lebanon

FILIPPO CASOTTO, DDS
Private practice in Este, Padova, Italy

LUCA SIGNORINI, DDS
School of Dentistry, Saint Camillus University of Health Science, Rome, Italy

Correspondence to
Tommaso Grandi
Via Contrada 323, 41126 Modena, Italy
t.grandi@grandiclinic.com

PURPOSE. To assess the three-year post-loading outcomes of pterygoid implants supporting immediate full-arch fixed prostheses in patients with atrophic posterior maxilla.

MATERIALS AND METHODS. Fifteen patients, either completely edentulous or with failing dentition, and with severe atrophy of the posterior maxilla requiring a full-arch fixed prosthesis, were enrolled in the study. Fifty-eight conventional implants and twenty-eight pterygoid implants were placed. All participants underwent fixed prosthodontic rehabilitation after implant insertion in both the anterior maxilla and pterygoid regions. Patients were followed-up for a period of three years. Outcomes considered were: implant and prosthesis failures, any complications, and peri-implant bone conditions, as assessed on panoramic radiographs.

RESULTS. Three years after loading no drop-out occurred, no implant or prosthesis loss was reported in any patient. Six minor complications occurred in six patients, and no peri-implant radiolucency was detected on any panoramic radiograph.

CONCLUSIONS. Three years after loading, all immediately loaded prostheses were successful, and no pterygoid implant failed.

CONFLICT OF INTEREST STATEMENT. Tommaso Grandi serves as consultant for JDentalCare, Modena, Italy. This study was completely self-financed and no funding was sought or obtained, not even in the form of free material.

INTRODUCTION

The loss of posterior maxillary teeth alters the occlusion, creating occlusal instability, chewing function deficiencies, and local bone loss[1]. Dental implants are considered the optimal option for the substitution of lost teeth. However, the posterior maxilla remains a challenging area for the insertion of dental implants due to the small quantity and low quality of available bone, and to the presence of the maxillary sinus[2]. Furthermore, high occlusal forces in the molar region during mastication may compromise the survival of implants placed in the posterior maxilla, increasing the risk of fatigue fracture of prostheses and/or screw and/or bone loss[3]. In cases of patients with reduced vertical maxilla height, the placement of implants is especially difficult, particularly when immediate function is required[4]. To overcome these difficulties, surgical techniques such as sinus lift, guided bone regeneration with either autogenous or heterologous materials, tilted implants, and zygomatic implants have been introduced.

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However, these solutions are not always practical, because there are several disadvantages (e.g., higher surgical morbidity, need for bone grafting, experienced surgeon) that preclude their application in some patients[5,6].

Pterygoid implants can be considered an alternative for treatment in patients with atrophic maxilla. The first to describe the use of pterygoid implants was Tulasne in 1989[2]. The anatomic structures offering potential support for the insertion of pterygoid implants in the posterior maxilla are: the maxillary tuberosity, pyramidal process of palatine bone and pterygoid process of the sphenoid bone[7].

The main reasons for using pterygoid implants are the availability of dense cortical bone for engaging the implants[8,9], and the potential to obviate the need for maxillary sinus lift or grafting procedures, with a consequent reduction costs and treatment time, which are further reduced thanks to the possibility of immediate loading[10]. Furthermore, pterygoid implants allow a prosthesis to have sufficient posterior extension, which eliminates the need for distal cantilevers, a potential source of complications such as prosthesis fracture, screw fracture and bone loss. In addition, pterygoid implants may provide better primary stability, which is one of the critical factors influencing the success of dental implants[11].

That being said, pterygoid implants also have some disadvantages. In particular, access to the pterygomaxillary region is not easy for either clinicians or patients, and appropriate knowledge of the anatomy involved is essential, because there are vital structures in the insertion area (e.g., the maxillary artery and the pterygomaxillary fossa) that could be injured during surgery[10,12]. Moreover, the marginal bone loss in the area around these implants is difficult to assess using periapical radiographs because of the implant position[12].

The aim of the present study was to evaluate the 3-year survival and success rates of pterygoid implants supporting full-arch fixed prostheses in patients affected by severe atrophy of the posterior maxilla. This report is the continuation of a previous study published one year after loading, in which not a single implant failed[13].

MATERIALS AND METHODS

This prospective study was conducted at a private practice (Tommaso Grandi Dental Clinic, Modena) in Italy. A total of fifteen participants with either complete maxillary edentulism or terminal dentition who had maxillary sinus pneumatization and bone atrophy on at least one side were enrolled in the study. They received immediately loaded, fixed implant-supported prostheses with implants in both anterior areas and the pterygoid region. All participants received full explanation and signed informed written consent before undergoing treatment.

The inclusion criteria were: complete maxillary edentulism or terminal dentition; need for immediate restoration supported by four to six implants; and insufficient bone posterior to the canines to anchor and stabilize the implants on at least one side, as determined via the following anatomical criteria:

- an anterior sinus wall that did not allow placement of a tilted implant fully inside bone via a standard protocol using 30–45 degree angulation;
- and/or an inferior corner of the anterior sinus wall positioned anterior to first premolar;
- and/or horizontal bone atrophy posterior to the canines precluding the insertion of a standard-diameter implant (≥3.7 mm);
- and/or vertical bone atrophy posterior to the canines precluding the insertion of a standard-length implant (≥10 mm);
- presence of a bone corridor between the posterior wall of the sinus and the end of the tuberosity with a width ≥6 mm, capable of anchoring and stabilizing implants of standard diameter (implant diameter 4 mm) towards the pterygoid process.

Patients were not accepted onto the study if any of the following exclusion criteria applied:

- Bruxism and/or clenching;
- Uncontrolled systemic disease that could represent a general contraindication to implant dentistry;
- Emotional instability;
- Ongoing maxillary radiation therapy;
- Active chemotherapy;
- Bone grafting procedures at planned implant sites;
- Enough bone height bilaterally in posterior maxilla to allow the insertion of implants via a standard protocol.

Before the intervention, patients underwent at least one session of oral hygiene instructions and professionally delivered debridement, as required. Anamnestic and clinical data were collected for all participants, and a cone-beam computed tomography (CBCT) scan and panoramic radiograph were obtained. Antimicrobial prophylaxis was given, specifically 1 g of amoxicillin plus clavulanic acid (or clarithromycin 500 mg if allergic to penicillin) starting the night before the surgery, and then prescribed twice a day for 7 days after the surgery.

On the day of surgery, patients were treated under local anaesthesia (articaine with epinephrine 1:100000, Septanest Septodont articaine 4%, Septodont Corp, Saint-Maur-des-Fossés, France). Tooth extractions, when needed, were performed as atraumatically as possible, with care taken to preserve the buccal alveolar bone. Extraction sockets were carefully cleaned of any granulation tissue. An incision was made along the crest, and a full-thickness flap was raised. Implants were placed in the anterior (JDEvolution S and JDEvolution Plus, JDentalCare, Modena, Italy) and pterygoid regions (JDPterygo, JDentalCare) of the maxilla with a torque of at least 45 Ncm. Patients whose implants were inserted with lower torque were not included in the study.

Specially designed, tapered implants with internal connection, airborne particle-abraded and acid-etched surface and a 4-mm anodized collar were used in the pterygoid area (**FIG. 1**). They were inserted in the pterygomaxillary region with an angle of 30–50 degrees relative to the maxillary plane, as described by Graves[9]. Final insertion torque was measured using a calibrated torque wrench (JDTorque, JDentalCare), able to perform torque measurements within a range of 15-80 Ncm with 5% precision. After closing and suturing the flap with 4/0 nonabsorbable sutures, the abutments were connected with a torque of 30 Ncm, and a provisional restoration, made out of metal-reinforced acrylic resin or milled from polymethyl methacrylate (PMMA), was fitted. Prosthesis screws were tightened at a torque of 15 Ncm. Definitive screw-retained titanium-composite prostheses (JD Lab, JDentalCare) were fitted 6 months after surgery (**FIGS. 2, 3**). All participants had scheduled hygiene recalls every 4 months for the entire duration of the study.

Primary outcome measures were the following.

- Prosthesis failure: a prosthesis was considered a failure if it needed to be replaced by an alternative prosthesis.
- Implant failure was defined as implant mobility, or removal of stable implants dictated by progressive marginal bone loss, infection and/or fracture. Implant stability assessment was performed at fitting of definitive prostheses (6 months after implant placement) by tightening implant–abutment screws with 30 Ncm torque. After insertion of the definitive restorations, prostheses were not removed to assess clinical mobility of individual implants.

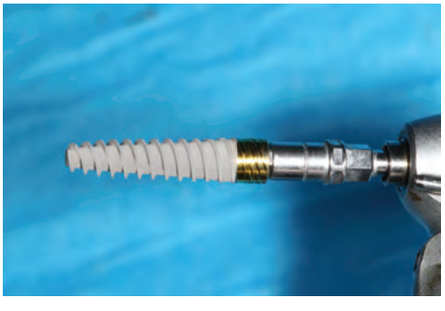
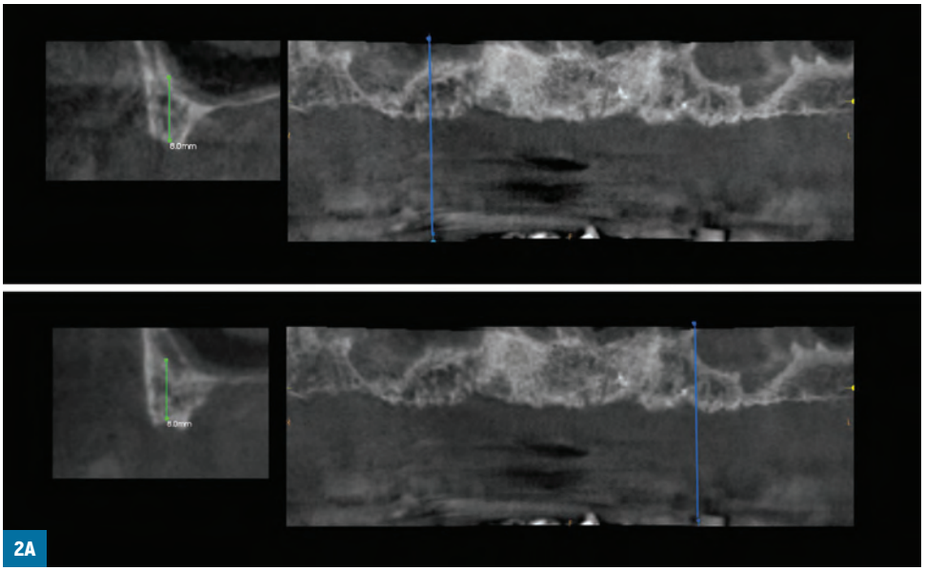
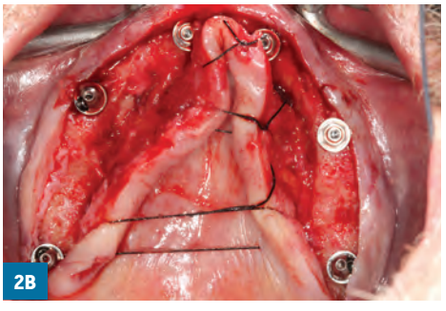
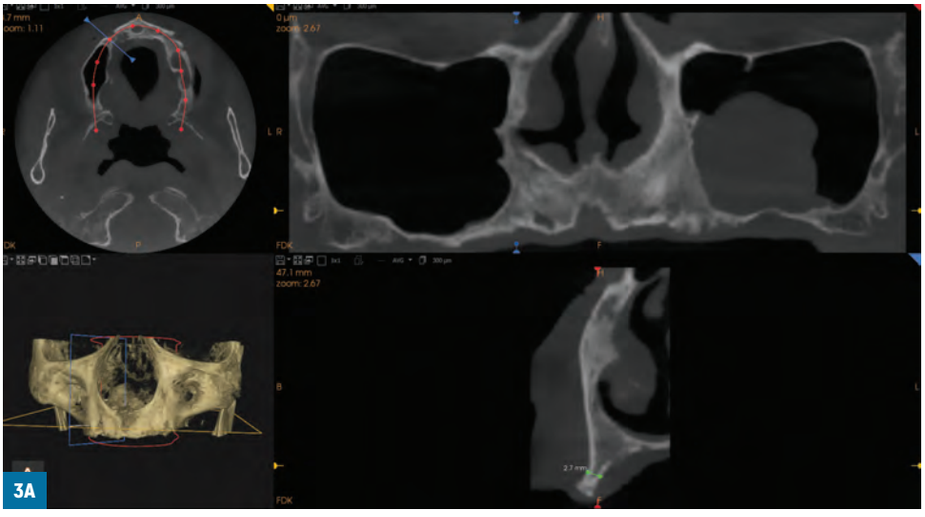


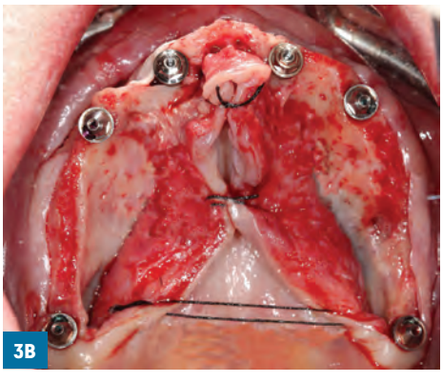
FIG. 1:. *Picture of the pterygoid implant used in the study (JDPterygo, JDentalCare).*





FIGS. 2A-D: *Example of one study participant: pre-operative CBCT of an edentulous patient showing vertical bone atrophy in the premolar area (A); elevation of mucoperiostal flap and insertion of six implants (4 regular and 2 pterygoid) (B); panoramic X-ray upon fitting of the metal-resin provisional restoration (C); panoramic X-ray after 3 years (D).*





FIGS. 3A-D: *Example of another study participant: pre-operative CBCT of an edentulous patient showing horizontal bone atrophy in the premolar area (A); elevation of mucoperiostal flap and insertion of six implants (4 regular and 2 pterygoid) (B); panoramic X-ray immediately after surgery, upon fitting of the PMMA provisional restoration (C); panoramic X-ray after 3 years (D).*

Secondary outcome measures were the following.

- Complications: any biological or prosthetic complication occurring during the entire follow-up period was recorded and reported. Examples of biological complications were: peri-implant mucositis (heavily inflamed soft tissue without or with minimal bone loss) and peri-implantitis (presence of periodontal pockets ≥5 mm, bleeding on probing, with simultaneous loss of peri-implant supporting bone of 3 mm or more), assessed with the aid of a manual periodontal probe (Colorvue, Hu-Friedy, Milan, Italy), any fistulas, anaesthesia or paraesthesia (temporary or permanent); or abnormal or prolonged pain after implant insertion.
- Mechanical complications: fracture or loosening of prosthodontic components, as assessed both clinically and radiographically.
- Peri-implant bone conditions: evaluated on digital panoramic images acquired immediately after surgery and after one year and three years.

Statistical analyses were performed using a statistical software package (Prism 5, GraphPad Software; San Diego, USA) by a dentist (LS).

RESULTS

A total of 18 subjects were screened for eligibility, but three subjects were not included for the following reasons: two subjects were hesitant to receive implant treatment, and one patient declined the treatment for financial reasons. A total of 15 subjects were considered eligible, and were consecutively enrolled in the study. The sample was composed of 6 men (mean ±standard deviation age 61.17 ±1.66 years; range: 57–66) and 9 women (mean ±standard deviation age 61.29 ±2.98 years; range: 51–76). Comorbidities were frequently observed, with 3 of the 15 participants having more than 1 comorbid condition. In addition, four of the 15 participants were smokers (less than 10 cigarettes per day). The main characteristics of patients involved in this trial and the number of implants inserted in each are shown in **TABLE 1**. The opposite-arch dentition was: natural dentition (7 patients), implant-supported fixed prostheses (7 patients), or implant-supported overdenture (1 patient).

Patients were recruited and operated on from October 2017 to January 2019. The follow-up for all patients was 3 years post-loading. No dropouts occurred.

Fifty-eight conventional implants and twenty-eight pterygoid implants were placed. All implants were inserted with a torque of 45 Ncm or more. No implant and no prosthesis failed. No radiographic evidence of peri-implant bone loss was observed.

Minor complications were noted in six out of the 15 participants. Specifically, 3 patients developed mucositis within four months of the surgical procedures, and 3 patients experienced complications with their provisional prostheses (2 fractured, 1 chipped).

DISCUSSION

In this study, conducted to investigate the 3-year survival and success rates of pterygoid implants partially supporting full-arch fixed prostheses in subjects with severe atrophy of the posterior maxilla, no implants or prostheses failed in the three years after immediate loading. Pterygoid implants go through the maxillary tuberosity and pyramidal process of the palatine bone, and then engage the pterygoid process of the sphenoid bone. Damage to the palatine artery due to improper placement of the pterygoid implant represents the main risk. Planning the insertion with CBCT and remaining inside the soft bone of the tuberosity until impacting the hard bone of the pyramidal and/or pterygoid process are therefore mandatory to avoid damage to the artery. The internal maxillary artery is located inside the pterygopalatine fossa,

TABLE 1 MAIN CHARACTERISTICS OF PATIENTS

Pt	Age	Smoker	Flap/flapless	Implant number	Implant type	Position	Size	Torque (NCM)
1	57	Y	Flap	6	JDPterygo	UR-second molar	Diameter (D) 4 mm, length (L) 18 mm	45
					JDEvolution	UR-canine	D 3.7 mm, L 15 mm	80
					JDEvolution S	UR-central incisor	D 3.2 mm, L 10 mm	70
					JDEvolution	UL-canine	D 3.7 mm, L 10 mm	80
					JDEvolution	UL-central incisor	D 4.3 mm, L 11.5 mm	60
					JDPterygo	UL-secondo molar	D 4 mm, L 18 mm	45
2	76	/	Flap	6	JDEvolution	UL-canine	D 3.7 mm, L 11.5 mm	60
					JDEvolution	UL-central incisor	D 3.7 mm, L 11.5 mm	60
					JDPterygo	UL-second molar	D 4 mm, L 15 mm	45
					JDPterygo	UR-second molar	D 4 mm, L 15 mm	45
					JDEvolution	UR-central incisor	D 3.7 mm, L 10 mm	60
					JDEvolution S	UR-first premolar	D 3.2 mm, L 11.5 mm	45
3	60	/	Flap	6	JDEvolution	UR-canine	D 3.7 mm, Height (H) 15 mm	80
					JDPterygo	UR-second molar	D 4 mm, H 13 mm	80
					JDEvolution	UR-central incisor	D 3.7 mm, H 13 mm	80
					JDPterygo	UL-second molar	D 4 mm, H 13 mm	80
					JDEvolution	UL-Central incisor	D 3.7 mm, H 10 mm	80
					JDEvolution	UL-canine	D 3.7 mm, H 13 mm	80
4	60	Y	Flap	6	JDPterygo	UR-third molar	D 4 mm, L 13 mm	60
					JDEvolution	UR-canine	D 4.3 mm, L 15 mm	80
					JDEvolution	UR-central incisor	D 3.7 mm, L 15 mm	80
					JDEvolution	UL-central incisor	D 3.7 mm, L 15 mm	80
					JDEvolution	UL-canine	D 4.3 mm, L 15 mm	80
					JDPterygo	UL-second molar	D 4 mm, L 13 mm	80
5	51	Y	Flap	6	JDPterygo	UL-second molar	D 4 mm, L 15 mm	45
					JDEvolution S	UL-first premolar	D 3.2 mm, L 15 mm	45
					JDEvolution S	UL-central incisor	D 3.2 mm, L 13 mm	45
					JDEvolution S	UR-central incisor	D 3.2 mm, L 13 mm	80
					JDEvolution S	UR-canine	D 3.2 mm, L 15 mm	45
					JDPterygo	UR-first molar	D 4 mm, L 15 mm	80
6	56	/	Flap	4	JDPterygo	UL-second molar	D 4 mm, L 15 mm	70
					JDEvolution	UL-lateral incisor	D 3.7 mm, L 13 mm	45
					JDEvolution S	UR-lateral incisor	D 3.2 mm, L 11.5 mm	45
					JDPterygo	UR-second molar	D 4 mm, L 15 mm	60
7	66	/	Flap	6	JDEvolution	UL-canine	D 3.7 mm, L 11.5 mm	60
					JDEvolution	UL-central incisor	D 3.7 mm, L 10 mm	80
					JDEvolution	UR-lateral incisor	D 3.7 mm, L 10 mm	80
					JDEvolution	UR-first premolar	D 3.7 mm, L 8 mm	80
					JDPterygo	UL-third molar	D 4 mm, L 18 mm	45
					JDPterygo	UR-second molar	D 4 mm, L 18 mm	70
8	59	Y	Flap	6	JDEvolution	UL-canine	D 3.7 mm, L 13 mm	60

Continues

Pt	Age	Smoker	Flap/flapless	Implant number	Implant type	Position	Size	Torque (NCM)
					JDEvolution S	UL-central incisor	D 3.2 mm, L 15 mm	70
					JDEvolution S	UR-lateral incisor	D 3.2 mm, L 11.5 mm	60
					JDEvolution S	UR-first premolar	D 3.2 mm, L 11.5 mm	60
					JDPterygo	UL-second molar	D 4 mm, L 18 mm	60
					JDPterygo	UR-second molar	D 4 mm, L 18 mm	45
9	57	/	Flapless	6	JDPterygo	UR-second molar	D 4 mm, L 11.5 mm	45
					JDEvolution	UR-canine	D 4.3 mm, L 13 mm	45
					JDEvolution	UR-central incisor	D 3.7 mm, L 13 mm	80
					JDEvolution	UL-central incisor	D 3.7 mm, L 13 mm	70
					JDEvolution	UL-canine	D 4.3 mm, L 13 mm	45
					JDPterygo	UL-third molar	D 4 mm, L 13 mm	45
10	61	/	Flap	6	JDEvolution	UL-central incisor	D 3.7 mm, L 11.5 mm	70
					JDEvolution	UR-central incisor	D 3.7 mm, L 11.5 mm	60
					JDEvolution	UL-canine	D 3.7 mm, L 15 mm	80
					JDEvolution	UR-canine	D 3.7 mm, L 15 mm	80
					JDPterygo	UL-second molar	D 4 mm, L 15 mm	45
					JDPterygo	UR-second molar	D 4 mm, L 15 mm	45
11	65	/	Flap	5	JDEvolution	UR-lateral incisor	D 3.7 mm, L 8 mm	60
					JDEvolution	UR-second premolar	D 3.7 mm, L 13 mm	50
					JDEvolution	UL-lateral incisor	D 3.7 mm, L 8 mm	50
					JDPterygo	UL-second molar	D 4 mm, L 15 mm	70
					JDEvolution S	UL-first premolar	D 3.2 mm, L 13 mm	60
12	66	/	Flap	5	JDEvolution	UR-Lateral incisor	D 3.7 mm, L 11.5 mm	45
					JDEvolution	UR-second premolar	D 3.7 mm, L 13 mm	80
					JDEvolution	UL-canine	D 3.7 mm, L 13 mm	60
					JDPterygo	UL-second molar	D 4 mm, L 15 mm	80
					JDEvolution	UL-lateral incisor	D 3.7 mm, L 11.5 mm	70
13	66	/	Flap	6	JDEvolution	UL-canine	D 3.7 mm, L 11.5 mm	60
					JDEvolution	UL-central incisor	D 3.7 mm, L 10 mm	80
					JDEvolution	UR-lateral incisor	D 3.7 mm, L 10 mm	80
					JDEvolution	UR-first premolar	D 3.7 mm, L 8 mm	80
					JDPterygo	UL-second molar	D 4 mm, L 18 mm	45
					JDPterygo	UR-second molar	D 4 mm, L 18 mm	70
14	60	Y	Flap	6	JDPterygo	UR-second molar	D 4 mm, L 13 mm	60
					JDEvolution	UR-canine	D 4.3 mm, L 15 mm	80
					JDEvolution	UR-central incisor	D 3.7 mm, L 15 mm	80
					JDEvolution	UL-central incisor	D 3.7 mm, L 15 mm	80
					JDEvolution	UL-canine	D 4.3 mm, L 15 mm	80
					JDPterygo	UL-second molar	D 4 mm, L 13 mm	80
15	62	/	Flap	6	JDEvolution	UL-central incisor	D 3.7 mm, L 11.5 mm	80
					JDEvolution	UL-canine	D 3.7 mm, L 11.5 mm	80
					JDEvolution	UR-canine	D 3.7 mm, L 11.5 mm	80
					JDPterygo	UL-second molar	D 4 mm, L 15 mm	60
					JDPterygo	UR-second molar	D 4 mm, L 15 mm	45
					JDEvolution S	UR-central incisor	D 3.2 mm, L 11.5 mm	60

UL, Upper left; UR, Upper right.

close to the posterior wall of the maxillary sinus, and is therefore not at risk of haemorrhage if using implants shorter than 20 mm[5].

Rodriguez et al. found by means of CBCT examinations that the density in the pterygoid area was 139.2% greater than in the tuberosity zone[14]. Patients with severely atrophic posterior maxilla have been reported to have preserved sufficient bone corridor (about 80%) to allow the transit and insertion of implants with lengths between 13 to 20 mm[15]. Rodriguez et al. found, in another CBCT study, that to properly engage the pterygoid process it is necessary to insert implants with angulations of between 70.4±7.2° and 74.19±3.13° to the distal and 81.09±2.65° to the palatal relative to the Frankfort plane, and that an implant of at least 15 mm long should be used in order to take advantage of the quantity and quality of the bone in the pterygomaxillary region[14,16,17]. Other anatomical and radiological studies have proposed that pterygoid implants should be at least 13 mm long to engage the dense cortical pterygoid plate[15]. The 18-mm-long implant is that deemed most suitable to fit in the pterygoid area[17].

A few studies have provided limited data on the use of pterygoid implants. Curi et al., in their retrospective study, evaluated the outcomes of pterygoid implants placed in 56 patients with atrophic posterior maxilla. Outcomes considered were pterygoid survival rate and prosthesis survival rate at 3 years post-loading, and the values reported were 99% and 97.7% respectively. Several short- and medium-term studies were published between 1992 and 2013, reporting a pterygomaxillary region implant success rate ranging from 80% to 99%[18]. However, in a retrospective study, Holtzclaw et al. investigated the survival rates of pterygoid dental implants placed in 16 patients and found a success rate of 100% at follow-up times ranging from 6 to 40 months[19]. In their study, Wu et al. observed a 97.8% survival rate at 1-year follow-up with pterygoid implants placed in 25 patients. The marginal bone loss they reported for pterygoid implants was around 0.66 mm.[20] Araujo et al., on the other hand, analysed the survival rate of pterygoid implants across 6 studies. They found rates of implant loss varying between 2.39% and 10.9%, likely due to the heterogeneity of the patient selection and the different implant surface treatments described in those studies[15].

Investigations that describe the use of implants in the posterior maxillary sites often use imprecise nomenclature, calling implants used in this region tuberosity implants, pterygoid plate implants[21-23] or pterygomaxillary implants[5]. The different terminology used has been linked to the various anatomic structures that may be engaged when placing implants in the posterior maxilla. In the present study, only participants with pterygoid implants were included. To our knowledge, this trial is also the first to be published on pterygoid implants immediately loaded with full-arch prostheses. The high success rate found may be due to a combination of the following factors: the accuracy of the preoperative planning and surgical procedure, patient compliance, and favourable participant characteristics. The limitations of the present study include the small sample size and the short follow-up period (3 years). However, it should be noted that, according to Araujo et al., most implant failures occur within 6 months of implant surgery[15].

Future investigations should assess larger populations, stratified according to the degree of maxilla atrophy and/or the presence of comorbidities, in order to provide further information about the utilization of pterygoid implants in clinical practice.

CONCLUSIONS

Three years after loading, immediately loaded pterygoid implants bearing a full-arch fixed prosthesis showed high survival rates with minimal complications in patients with severe atrophy of the posterior maxilla. Clinicians may therefore consider this treatment option as a valid alternative to maxillary sinus lift or grafting procedures, pending the outcome of longer follow-up.

REFERENCES

1. Salinas-Goodier C, Rojo R, Murillo-González J, Prados-Frutos JC. Three-dimensional descriptive study of the pterygomaxillary region related to pterygoid implants: A retrospective study. Sci Rep 2019;9:16179.
2. Tulasne JF. Implant treatment of missing posterior dentition. In: Albrektsson T, Zarb GA (eds): The Branemark Osseointegrated Implant. Chicago: Quintessence 1989;103.
3. van Eijden TMGJ. Three-dimensional analyses of human bite-force magnitude and moment. Archives of Oral Biology 1991;36:535-9.
4. Sahoo PK, Awinashe V, Bali Y, Gupta N, Parihar AS, Jagadeesh KN, Babaji P. A cone-beam computed tomography evaluation of bone density for insertion of pterygoid implants in dentulous and edentulous patients. Tzu Chi Med J 2021;34:82-7.
5. Balaji VR, Lambodharan R, Manikandan D, Deenadayalan S. Pterygoid Implant for Atrophic Posterior Maxilla. J Pharm Bioallied Sci 2017;9:S261-3.
6. Venturelli A. A modified surgical protocol for placing implants in the maxillary tuberosity: clinical results at 36 months after loading with fixed partial dentures. Int J Oral Maxillofac Implants 1996;11:743-9.
7. Reiser GM. Implant use in the tuberosity, pterygoid, and palatine region: Anatomic and surgical considerations. In Nevins M, Mellonig JT (eds): Implant Therapy: Clinical Approaches and Evidence of Success, Vol 2. Chicago, Quintessence, 1998:197.
8. Bidra AS, Huynh-Ba G. Implants in the pterygoid region: a systematic review of the literature. Int J Oral Maxillofac Surg 2011;40:773-81.
9. Graves SL. The pterygoid plate implant: a solution for restoring the posterior maxilla. Int J Periodontics Restorative Dent 1994;14:512-23.
10. Balshi SF, Wolfinger GJ, Balshi TJ. Analysis of 164 titanium oxide-surface implants in completely edentulous arches for fixed prosthesis anchorage using the pterygomaxillary region. Int J Oral Maxillofac Implants 2005;20:946-52.
11. Fuh LJ et al. Variations in bone density at dental implant sites in different regions of the jawbone. J Oral Rehabil 2010;37:346-51.
12. Candel E, Peñarrocha D, Peñarrocha M. Rehabilitation of the atrophic posterior maxilla with pterygoid implants: a review. J Oral Implantol 2012;38:461-6.
13. Signorini L, Faustini F, Samarani R, Grandi T. Immediate fixed rehabilitation supported by pterygoid implants for participants with severe maxillary atrophy: 1-Year postloading results from a prospective cohort study. J Prosthet Dent 2021;126:67-75.
14. Rodríguez X, Lucas-Taulé E, Elnayef B, Altuna P, Gargallo-Albiol J, Peñarrocha Diago M, Hernandez-Alfaro F. Anatomical and radiological approach to pterygoid implants: a cross-sectional study of 202 cone beam computed tomography examinations. Int J Oral Maxillofac Surg 2016;45:636-40.
15. Araujo RZ, Santiago Júnior JF, Cardoso CL, Benites Condezo AF, Moreira Júnior R, Curi MM. Clinical outcomes of pterygoid implants: Systematic review and meta-analysis. J Craniomaxillofac Surg 2019;47:651-60.
16. Rodríguez X, Rambla F, De Marcos Lopez L, Méndez V, Vela X, Jiménez Garcia J. Anatomical study of the pterygomaxillary area for implant placement: cone beam computed tomographic scanning in 100 patients. Int J Oral Maxillofac Implants 2014;29:1049-52.
17. Rodríguez X, Méndez V, Vela X, Segalà M. Modified surgical protocol for placing implants in the pterygomaxillary region: clinical and radiologic study of 454 implants. Int J Oral Maxillofac Implants 2012 Nov-Dec;27:1547-53.
18. Curi MM, Cardoso CL, Ribeiro Kde C. Retrospective study of pterygoid implants in the atrophic posterior maxilla: Implant and prosthesis survival rates up to 3 years. Int J Oral Maxillofac Implants 2015;30:378-83.
19. Holtzclaw D, Telles R. Pterygoid Fixated Arch Stabilization Technique (PFAST): A Retrospective Study of Pterygoid Dental Implants used for Immediately Loaded Full Arch Prosthetics. J Implant Advanc Clinil Dent 2018;10:6-17.
20. Wu J, Liu K, Li M, Zhu ZJ, Tang CB. Clinical assessment of pterygoid and anterior implants in the atrophic edentulous maxilla: a retrospective study. Hua Xi Kou Qiang Yi Xue Za Zhi 2021;39:286-92.
21. Balshi TJ, Hy L, Hernandez RE. The use of pterygomaxillary implants in the partially edentulous patient. Int J Oral Maxillofac Implants 1995;10:89-99.
22. Bahat O. Osseointegrated implants in the maxillary tuberosity: report on 45 consecutive patients. Int J Oral Maxillofac Implants 1992;7:459-67.
23. Khayat P, Nader N. The use of osseointegrated implants in the maxillary tuberosity. Pract Periodontics Aesthet Dent 1994;6:53-61.