Reliability of Four Zygomatic Implant-Supported Prostheses for the Rehabilitation of the Atrophic Maxilla: A Systematic Review

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Purpose: *The reliability of oral rehabilitation by four zygomatic implants with no anterior support remains to be determined. The aim of this systematic review was to assess the predictability of this approach in regard to implant survival, technical and biologic complications, and quality of life.* ***Materials and Methods:*** *An electronic literature search was conducted from September 2000 to November 2013. Human clinical trials in which oral rehabilitation was achieved by the use of four zygomatic implants with no additional placement of standard implants were included. The primary outcome was the survival rate of the zygomatic implants. In addition, random effects meta-analyses of the selected studies were applied to avoid potential bias caused by methodologic differences among studies.* ***Results:*** *Zygomatic implant survival rate weighted mean (WM) was 96.7% (range, 95.8% to 99.9%), with a 95% confidence interval (CI) of 92.5% to 98.5%. Only a limited number of surgical complications were reported, with orbital perforation the most significant. Similar results were obtained for prosthetic complications (few occurrences). Additionally, patient satisfaction levels were shown to be high, approaching that of the general population.* ***Conclusion:*** *Data from the present systematic review suggest that maxillary rehabilitation by four zygomatic implants with no anterior support is a reliable approach.* Int J Oral Maxillofac Implants 2015;30:293–298. doi: 10.11607/jomi.3691

Key words: *Zygomatic implant, dental implant, endosseous implant, oral rehabilitation, evidence-based dentistry*

Oral rehabilitation by dental implants in the severely atrophic maxilla often represents a challenge. To overcome this difficulty, bone augmentation procedures such as sinus augmentation, guided bone regeneration (GBR), or distraction osteogenesis have been used to obtain adequate bone height and width for proper three-dimensional implant placement.[1–4] To avoid surgical morbidity and shorten treatment length, alternative methods such as short[5,6] or tilted implants,[7] as well as zygomatic implants (ZIs),[8,9] have been proposed and have shown promising outcomes.

The concept of a zygomatic implant–supported prosthesis was originally developed to obtain implant anchorage and stability in the zygomatic bone by increasing the implant length to ≥ 30 mm. In the past two decades, this treatment modality has shown its predictability and high survival rate (> 95%) over a medium- to long-term follow-up. In addition, zygomatic implant–supported prostheses have had very few technical and biologic complications when compared to advanced bone grafting approaches.[10–12] Despite the good zygomatic implant survival rate, the standard implants in the anterior maxilla have shown a higher failure rate (range, 8% to 27%).[13] In an attempt to provide a graft-free procedure and at the same time minimize the risk of standard implant failure, a technique using multiple zygomatic implants was proposed.[14]

Several anatomical studies were conducted to understand the anatomical structures of this area.[8,15–18] Van Steenberghe et al[15] showed that the average width

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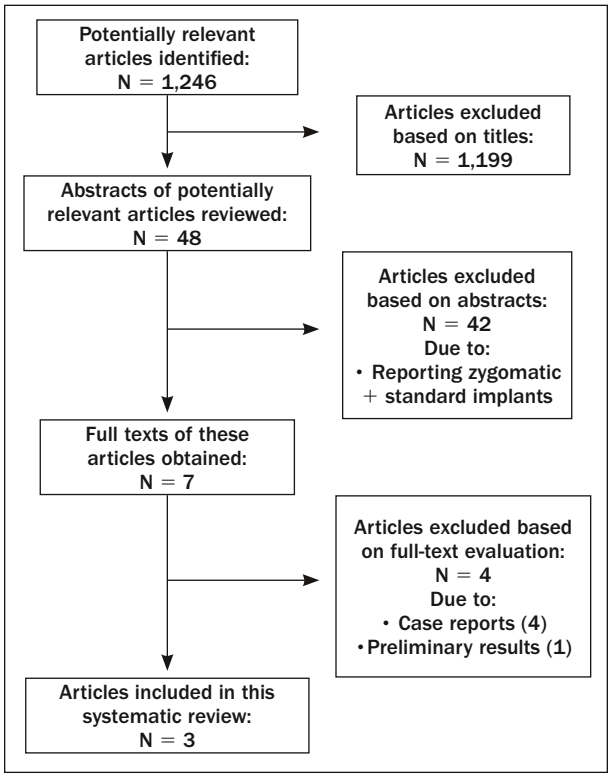

Fig 1 Screening selection process.

of the zygomatic bone was 20.5 mm and suggested the possibility of placing two zygomatic implants. The zygomatic bone used to house the zygomatic implants is characterized by a cortical bone with a dense trabecular structure.[16,17] Furthermore, studies have been carried out to assess whether four well-distributed zygomatic implants with no standard implant support in the anterior maxilla can be a predictable method for the rehabilitation of the totally atrophic maxilla.[8,18] It has been shown that when this treatment modality is used, patients have demonstrated satisfaction with their masticatory, phonetic, esthetic, and psychologic conditions.[8]

Therefore, the present review aimed to clarify the current status of the use of four zygomatic implants with no anterior implant support for the rehabilitation of the severely atrophic maxilla. The outcomes of assessment were zygomatic implant survival rate, technical complications, and biological complications.

MATERIALS AND METHODS

Screening Process

An electronic literature search was conducted by two reviewers (FW and AM) in several databases, including PubMed and MEDLINE, for articles written in English from September 2000 to November 2013 (Fig 1). The following PICO (Patient, Intervention, Comparison, and Outcome) question was aimed to be answered: In patients with severe edentulism in the maxilla treated with four zygomatic implants (the quad approach), does this represent a reliable treatment approach in terms of survival rate, technical complications, and biologic complications for oral rehabilitation?

The authors used the guidelines of PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) to evaluate the quad approach using zygomatic implants. The PRISMA methodology was developed to ensure a more consistent study outcome. Thus, the reader can be assured that an appropriate amount of due diligence was performed in the literature search and that it was done in a logical manner.[19] The search terms used were "jaw, edentulous"[mh] OR "alveolar process"[mh] OR "dental implants, single-tooth"[mh] OR "dental implantation"[mh] OR "dental implants"[mh] OR "dental prosthesis design"[mh] AND ("zygomatic"[tiab] OR "restoration"[tiab] OR "bone loss"[tiab]), where *mh* and *tiab* represented *MeSH term* and *title or abstract,* respectively. Additionally, to conduct a better and more focused screening process, the combination of the following key words was also used in the search: "dental implants," "endosseous implants," "oral implants," "zygomatic implant," "four zygomatic implants," and "quad approach." A manual search of implant-related journals, including *Clinical Implant Dentistry and Related Research*, *The International Journal of Oral and Maxillofacial Implants*, *Clinical Oral Implants Research*, *Implant Dentistry*, *European Journal of Oral Implantology*, *Journal of Oral Implantology*, *International Journal of Oral and Maxillofacial Surgery*, *Journal of Oral and Maxillofacial Surgery*, *Journal of Dental Research*, *International Journal of Prosthodontics*, *The Journal of Prosthetic Dentistry*, *Journal of Clinical Periodontology*, *Journal of Periodontology,* and *The International Journal of Periodontics and Restorative Dentistry*, from September 2000 to November 2013 was also performed.

Inclusion and Exclusion Criteria

Articles were included in this study if they fulfilled the inclusion criteria of prospective and retrospective human clinical trials in which oral rehabilitation was achieved by the use of four zygomatic implants with no further placement of standard implants. Furthermore, the articles included had to report the survival rate, technical/prosthetic complications, and biologic complications for at least 12 months after loading. Several factors such as the technique used, implant system, implant-loading protocol, implant diameter and length, healing time, and the type of prosthesis (provisional or definitive) had to be reported in the studies.

Case-report, animal studies, and those studies in which information was not clear or was confusing were excluded from this systematic review. Moreover, studies that included patients who underwent any other type of bone augmentation procedure prior to the zygomatic implant approach as well as preliminary results were also excluded. References in the excluded articles were also inspected for studies that fulfilled the inclusion criteria.

Data Analyses

The primary outcome was the survival rate of the zygomatic implants. The pooled weighted mean (WM) and the 95% confidence interval (CI) of each variable were estimated using a computer program (Comprehensive Meta-analysis Version 2, Biostat). Random effects meta-analyses of the selected studies were applied to avoid potential bias caused by methodologic differences among studies. Forest plots were produced to graphically represent WM and 95% CI in the primary outcome, zygomatic implant survival rate, for all included studies using the number of participants investigated as the analysis unit. Funnel plots were also examined for publication bias. In addition, heterogeneity among studies was assessed with the chi-square test, and $P < .05$ represents significant heterogeneity.

RESULTS

Zygomatic Implant Survival Rate

Of the included studies, three studies[8,20,21] provided data on the survival rate of zygomatic implants (Table 1). The WM was 96.7% (range, 95.8% to 99.9%), with a 95% CI of 92.5% to 98.5% (Table 2). For the chi-square test, $P = .51$, representing a low heterogeneity among studies. To investigate potential publication bias, the funnel plot of meta-analysis was graphed (Fig 2).

Surgical Complications

Two articles reported surgical complications during zygomatic implant placement and postoperative follow-up (Table 3).[20,21] Only one patient experienced the complication of orbital cavity penetration by drilling during implant insertion. One patient experienced an infection followed by the formation of a fistula at one zygomatic implant. One patient presented with a definitive cheekbone hypoesthesia. Acute inflammation was resolved by treatment of systemic antibiotics in these studies. Some patients in the studies by Stiévenart and Malevez[21] and Duarte et al[8] presented with soft tissue inflammation around the abutments due to poor oral hygiene and/or improper prosthetic design (acrylic material near the keratinized mucosa).

Prosthetic Complications

In the 3 studies included,[8,20,21] 39 patients with 156 zygomatic implants were evaluated for immediate loading (Table 3). One implant was considered as "sleeping" because of unfavorable position. Forty-five patients received screw-retained fixed prostheses with metal frameworks (gold or titanium) and acrylic resin. Three patients were treated with bar overdentures. One patient did not complete the prosthetic therapy because of the failure of three zygomatic implants 7 to 9 months after insertion. Furthermore, in the study by Davó and Pons,[20] fracture was noted on one abutment screw and two prostheses. No other prosthetic complications were reported in these studies.

Patient Satisfaction

The patient satisfaction evaluation was reported only by Davó and Pons.[20] The Oral Health Impact Profile (OHIP-G14) was used to assess the subjective treatment outcome. A high level of oral health–related quality of life (2.7) was obtained, demonstrating that patient satisfaction was similar to the normal population. Furthermore, Duarte et al[8] reported that all patients were greatly satisfied with the treatment outcome due to the improvement in their masticatory, esthetic, phonetic, and psychologic conditions (Table 3).

DISCUSSION

To date, zygomatic implants (ZIs) associated with conventional dental implants have been considered as a predictable treatment modality for patients with an atrophic maxilla.[9,10,13] However, in the most severe anterior maxilla bone deficiency cases, additional advanced bone grafting is often required to facilitate the ideal prosthetic three-dimensional implant placement. The additional grafting procedure increases the number of surgical procedures, overall cost, and treatment duration as well as donor site morbidity. All these issues reduce patients' acceptance of implant treatment for oral rehabilitation in the cases of atrophic maxilla. Compared with major bone grafting, zygomatic implant placement is a less invasive technique and can be used in patients in whom bone grafts cannot be harvested. Furthermore, zygomatic implants have been reported to have a high survival rate of 96.7% to 100%.[13] On the contrary, standard implants in the atrophic anterior maxilla, either with or without bone grafting, have shown a relatively higher failure rate of 8% to 27%.[13] Also, implants placed in the native pristine bone have shown a higher success rate than implants placed in grafted bone.[22–25] Hence, a prosthesis supported by four zygomatic implants was introduced as an alternative to major advanced bone grafting

Table 1 Descriptive Information on the Included Studies

Authors (Year)	Study design	No. of patients	Mean age of patients (Range)	No. of implants	Implant surface modification	Implant length (mm)	Implant width (mm)	Presurgical design
Davó and Pons[20] (2013)	Prospective	17 (10 female, 7 male)	57.7 (41–78)	68	64 TiUnite surface; 4 machined	35–52.5	4/4.5	Nobel Biocare software
Duarte et al[8] (2007)	Prospective	12	NA	48	Machined	NA	4–5	3D reconstruction with CT scan
Stiévenart and Malevez[21] (2010)	Retrospective	20 (19 female, 1 male)	56 (35–75)	80	NA	30–52.5	NA	Procera software

3D = three-dimensional; CT = computed tomography; NA = not available.

Table 2 Meta-analysis for the Survival Rate Among Selected Studies

	Success					
	N	N	SR (%)	Lower limit	Upper limit	Weight %
Duarte et al[8] (2007)	48	46	95.8	84.8	99.0	36.16
Stiévenart and Malevez[21] (2010)	80	77	96.3	89.0	98.8	54.48
Davo and Pons[20] (2013)	68	68	99.9	89.5	100.0	9.36
All	196	191	96.7	92.5	98.5	100.0

0% 50% 100%

The weighted mean (WM) of survival rates was 96.7% (range, 95.8% to 99.9%), with a 95% CI of 92.5% to 98.5%.

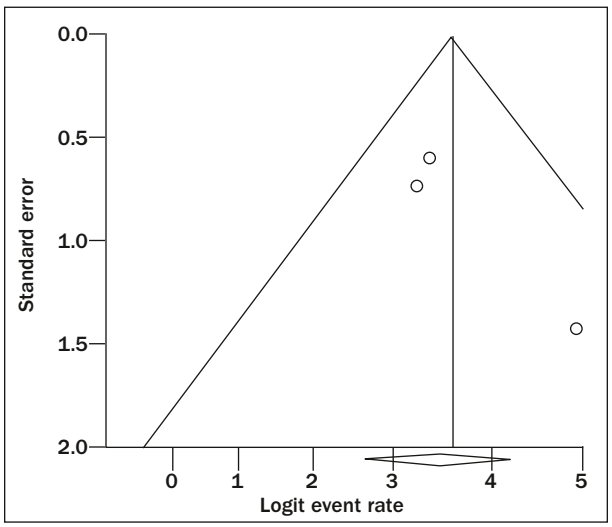

Fig 2 Funnel plot for the meta-analysis of implant survival rate.

procedures. The present systematic review showed that four zygomatic implants with no additional anterior implant support is a successful approach in restoring function in the severely atrophic maxilla. However, this data should be interpreted with caution because limited qualified papers were included for the analysis.

Several studies have evaluated the use of zygomatic implants combined with standard implants for immediate loading and have reported a high survival rate of 95.8% to 100%,[24,26–28] which implies that zygomatic implants may be used with immediate function protocols. A total of 39 cases in the review underwent immediate loading for edentulous maxilla rehabilitation with four zygomatic implants and showed very promising results. The reasons behind these good results may include, but not be limited to, careful patient selection, good primary stability, and cross-arch stabilization to counteract bending forces. Postsurgical sinusitis has been reported as one of the major biologic complications for zygomatic implants.[12,23,29–32] In the study by Davó and Pons,[20] zygomatic implants were placed using the intrasinus approach, suggesting that the sinus membrane was exposed, which might lead to higher incidence of sinusitis. Nevertheless, the other two studies did not report the surgical approach in detail.[8,21] A modification of the zygomatic implant placement technique, the so-called sinus-slot technique[29] has been developed to minimize postsurgical sinusitis by avoiding introducing a foreign object into the sinus, thereby reducing the risk of postsurgical sinusitis.[20,33,34] Another method of reducing postsurgical sinusitis may be immediate loading, because a two-stage approach with multiple connections and disconnections of the transepithelial implant components may slow the reestablishment of the soft tissue barrier. This may lead to an increased risk of oroantral communication; consequently, immediate loading may have the advantage of decreasing the risk of developing postsurgical sinusitis.[30,31]

Loading protocol	Provisional prosthesis	Permanent prosthesis	No. of dropouts (no. implants)	Follow-up (mo)	No. of implant failures	Survival rate
Immediate	Acrylic resin with metal wire	2 patients with bar overdenture; 15 patients, NA the material	0	363	0	100%
Immediate	Acrylic resin with gold framework	Acrylic resin with gold framework	0	30	2 (1 at 6 months; 1 at 30 months after insertion)	95.8%
10 standard loading; 10 immediate loading	Acrylic resin (10 patients with immediate loading)	18 patients with acrylic/titanium framework Procera bridge; 1 with bar overdenture	0	40	3 (in 1 patient, 7–9 months after insertion)	96%

Table 3 Surgical and Prosthetic Complications and Patient Satisfaction for the Included Studies

Authors (Year)	Surgical complications	Prosthetic complications	Patients' satisfaction
Davó and Pons[20] (2013)	One patient, orbital penetration; one patient, infection followed by a fistula; two patients developed sinusitis	One implant "sleeping" because of unfavorable position. One fracture of the abutment screw. Two fractures of the definitive prostheses	OHRQoL score 2.7, indicating satisfactory and comparable with the normal population
Duarte et al[8] (2007)	No	No	High
Stiévenart and Malevez[21] (2010)	One patient, unilateral sinusitis; one patient, definitive cheekbone hypoesthesia; three patients, soft tissue inflammation	NA	NA

NA= not available; OHRQoL = Oral Health–Related Quality of Life

It is important to note that among the five failed zygomatic implants, three (60%) were lost in a single patient due to problems related to the customized surgical guide, which led to the implant malpositioning.[21] Hence, comprehensive preoperative planning and a well-designed surgical guide are critical in reducing the risk of intraoperative complications or zygomatic implant failures. Regarding the restorative considerations, two studies[8,20] reported the use of a rigid connector (metal wire or gold framework) and acrylic resin as provisional fixed prostheses. Once implants are splinted together with a rigid connector, the individual implant becomes part of an integrated system to distribute and share the occlusal load.

The length and position of zygomatic implants are determined by the anatomy of the zygomatic process and the surrounding structures; hence, a presurgical design using a three-dimensional computerized tomography scan and implant design software can be very beneficial. The procedure for the placement of two zygomatic implants unilaterally demands good knowledge of the anatomical area involved. Kahnberg et al[35] cautioned that if additional zygomatic implants implants are needed, the anterior zygomatic implants might involve the wall of the orbit. For this reason, penetration of the orbital cavity is a potential risk that should be carefully considered during implant site preparation.[7] Similar concern was also reported by Davó and Pons.[20]

In regard to the emergence of zygomatic implants, it was originally proposed to locate the implant head at the level of the lateral incisor or canine and second premolar or first molar for the anterior and the posterior, respectively.[8,21,27,32] One of the potential disadvantages of multiple zygomatic implants is a greater palatal inclination than natural dentition when the classical intrasinus approach is used. This might affect the available space for the tongue, which will adversely affect the patient's speech articulation. Bothur and coworkers[18] reported that a mild deterioration in speech is expected in patients with a zygomatic implant–supported fixed dental prosthesis. To overcome this problem, Davó et al used the extrasinus approach, which enables a more crestal emergence of the implants and, consequently, a wider space for the tongue.[22–23]

CONCLUSION

Data from the present systematic review that identified three studies with a total of 196 implants placed in 49 patients suggest that maxillary rehabilitation by

four zygomatic implants with no anterior support is a reliable approach. The data to date show a high zygomatic implant survival rate, minimal technical and biologic complications, and high patient acceptance and satisfaction. However, the concept should be further tested for its viability in the long term and with a larger sample size study.

ACKNOWLEDGMENTS

This study was partially funded by Science and Technology Commission of Shanghai Municipality (13ZR1424000) and by FEDICOM Foundation (Foundation for the Study of Implantology and Oral and Maxillofacial Surgery, Badajoz, Spain). The authors do not have any financial interests, either directly or indirectly, in the products or information listed in the paper.

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