Zygoma Quad Compared With 2 Zygomatic Implants: A Systematic Review and Meta-analysis

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Purpose: *The aim of this study was to systematically review and compare the survival rates (SRs) of oral rehabilitations performed with 2 zygomatic implants (ZIs) combined with regular implants (RIs) versus 4 ZI.*

Material and Methods: *An electronic search was performed in several databases for articles published in English between 2007 and 2015. Articles reporting human studies were included in this systematic review.*

Results: *The search yielded to a total of 417 studies, of which 6 were included in this study. ZIs SR weighted mean was 98.0% with a 95% confidence interval (CI) of 96.7% to 99.8%. For the control group (2 ZIs + 2 RIs) and the test group (4 ZIs), the implant SR was 98.6% and 97.4%, respectively, with a 95% CI. No statistically significant differences in terms of SRs were obtained between both groups* $P = 0.286$.

Conclusions: *The data analysis showed favorable results for treatment with 4 ZIs. The results showed no statistical differences in using 1 or another treatment, in terms of survival and failure rates. The reduction on treatment time and morbidity related to regenerative approaches may be its main advantage. In conclusion, the zygoma quad seems to be the treatment of choice for the rehabilitation of the severely atrophic maxilla. (Implant Dent 2018;27:1–8)*

Key Words: atrophied maxilla, edentulous maxilla, zygoma, axial implant

The oral rehabilitation of the atrophic maxilla is a great challenge for the oral and maxillofacial surgeon. The pattern of the facial bone reabsorption associated to age is especially evident in the edentulous maxilla and mandible, being more noticeable in those using complete removable prostheses.[1–9]

There are different treatment options that can lead to an optimal functional and esthetic rehabilitation, such as sinus augmentation, onlay and inlay grafts, split crest technique, pterygoid implants, and osteogenic distraction.[10–13]

Total edentulism after years of wearing removable prosthesis is a characteristic that it is arising among patients aged between 50 and 70 years. However, zygomatic implants (ZIs) have a high success rate as a treatment to those patients.[14–18]

The development of the ZI in the 90s represented a new treatment option for the severely atrophic maxilla. Brånemark first described them in 1998. There are several publications that support the safety of this technique to return the function and aesthetics of the oral cavity. The main advantages of this technique are that it reduces the treatment time only requiring 1 surgical approach, and it avoids further surgeries in donor sites needed for bone harvesting.[19–22]

The number of ZIs may vary from 1 to 4. The most common treatment option for a complete rehabilitation of the maxilla is a combination of 2 ZIs with regular implants (RIs) and/or pterygoid implants or the use of 4 ZIs.[23–26]

The aim of this systematic review was to compare the implant survival rate (SR) of those patients rehabilitated with 2 ZIs combined with RIs and those restored with the use of 4 ZIs. As secondary objectives, we aimed to compare the survival of the ZIs placed in 1 treatment or the other and if any

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differences in the survival between zygomatic and RIs.

MATERIALS AND METHODS

The Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) statement was followed and consulted during the whole process.

Focused Question

What is the SR of patients rehabilitated with 2 ZIs combined with RIs compared with those with only 4 ZIs in terms of oral rehabilitation?

Search Strategy

Systematic electronic and manual searches were conducted in several databases such as MEDLINE-PubMed (MeSh terms), Cochrane Central register of Controlled trials (CENTRAL), Cochrane Oral Health group Trials Register, and EMBASE (EMTREE terms) database. Electronic search was complemented by manual searching and conducted to identify randomized clinical trials, case series, and prospective and retrospective cohort studies on the use of 2 or 4 ZIs in terms of oral rehabilitation. It included studies in English between January 1, 2000, and June 30, 2015, in the dental literature.

The following Medical Subject Headings (MeSH) terms were used:

(Intervention)

[Zygoma implant*] OR [zygomatic implant*]

(Outcome)

In combination with the outcome terms: AND.

[Success] OR [survival] OR [outcome]

Table 1. Descriptive Information of the Included Studies

Author, year	Study Design	No. Patients	ZIs	RIs	Total ZIs	Brand	Surface	SR	Failure Rate	Follow-up of Implants (mo)
Bedrossian, 2010	Prospective	36	2	2 (23 patients) and 4 (13 patients)	74	Nobel Biocare	Machined	NR	2 of 74 (2.7%)	84
Degidi et al, 2012	Prospective	10	2	2	20	Nobel Biocare	NA	100%	0%	12
Duarte et al, 2007	Prospective	12	4	0	48	Nobel Biocare	Machined	NA	2 of 20 (10%)	30
Stievenart et al, 2010	Retrospective	20	4	0	80	Nobel Biocare	NA	96%	4% (3 of 80)	40
Davó and Pons, 2015	Prospective	17	4	0	68	Nobel Biocare	NA	98.5% success	NA	36
Davó et al, 2007	Retrospective	18	2	2 (2 patients) and 4 (12 patients)	36	Nobel Biocare	Machined	100%	0%	14 (from 6 to 29)

(continued) Author, year	Healing Period (mo)	Loading Protocol	Immediate Prosthesis	Definitive Prosthesis	Follow-up Implants (mo)
Bedrossian, 2010	6 mo	NA	Provisional	Fixed	84
Degidi et al, 2012	NA	Day of surgery	Definitive	Fixed	12
Duarte et al, 2007	NA	Day of surgery	Definitive	Hibrid	30
Stievenart et al, 2010	2, 3, 4 and 5 mo	Within 14 wk	19 provisional/1 definitive	19 fixed + 1 overdenture	40
Davó and Pons, 2015	6 mo	24–48 h	Provisional	15 screw + 2 overdentures	36
Davó et al, 2007	6 mo	24–48 h	Provisional	Hibrid	14 (from 6 to 29)

(continued) Author, year	Failure (Loaded/Not Loaded)		Treatment
	ZIs	CIs	
Bedrossian, 2010	Not loaded (6 mo evaluation)	0	Replacement failed implants, total osseointegration achieved
Degidi et al, 2012	0	0	None
Duarte et al, 2007	At 6 and 30 mo	0	Replacement in 1 of the patients
Stievenart et al, 2010	Loaded (same patient)	0	Removed but not replaced
Davó and Pons, 2015	Unfavorable position	0	Not loaded
Davó et al, 2007	0	3 CIs at 3 mo recall	Not available

CI indicates conventional implant; NA, not available.

(([Zygoma implant*] OR [zygomatic implant*])) AND ([Success] OR [survival] OR [outcome])

The following journals between 2007 and 2015 inclusive were handsearched for relevant articles: *Clinical Oral Implants Research*, *International Journal of Oral & Maxillofacial Implants*, *International Journal of Oral and Maxillofacial Surgery*, *Journal of Periodontology*, *Journal of Clinical Periodontology*, and *Journal of Oral Implantology*.

Eligibility (Inclusion/Exclusion) Criteria and Selection of Studies

In the first phase of study selection (Table 1), the title and abstract of all identified publications were screened by 2 reviewers (S.A.H.C.) and (A.L.A.) to evaluate their eligibility in this systematic review depending on the predetermined inclusion and exclusion criteria. A third reviewer (M.G.H.) screened the included articles in case of any disagreement.

The inclusion criteria were as follows:

1. Articles published in English dental Journals dating from 2000 to 2015.
2. *In vivo* studies.
3. Studies conducted in human subjects >18 years old.
4. Studies reporting the presence of at least ten patients.
5. Publications including the use of 2 or 4 ZIs.
6. A clear report of the total number of each type of implants used.
7. A follow-up period of ≥12 months.

The following exclusion criteria were agreed:

1. Studies involving 1, 3, or more than 4 ZIs.
2. Single case reports.
3. Smoking status (>10 cigarettes/day)
4. Medical or systemic diseases (ie, congenital malformations, posttraumatic injury, past or current radiotherapy, or chemotherapy).
5. Studies that did not follow the inclusion criteria.

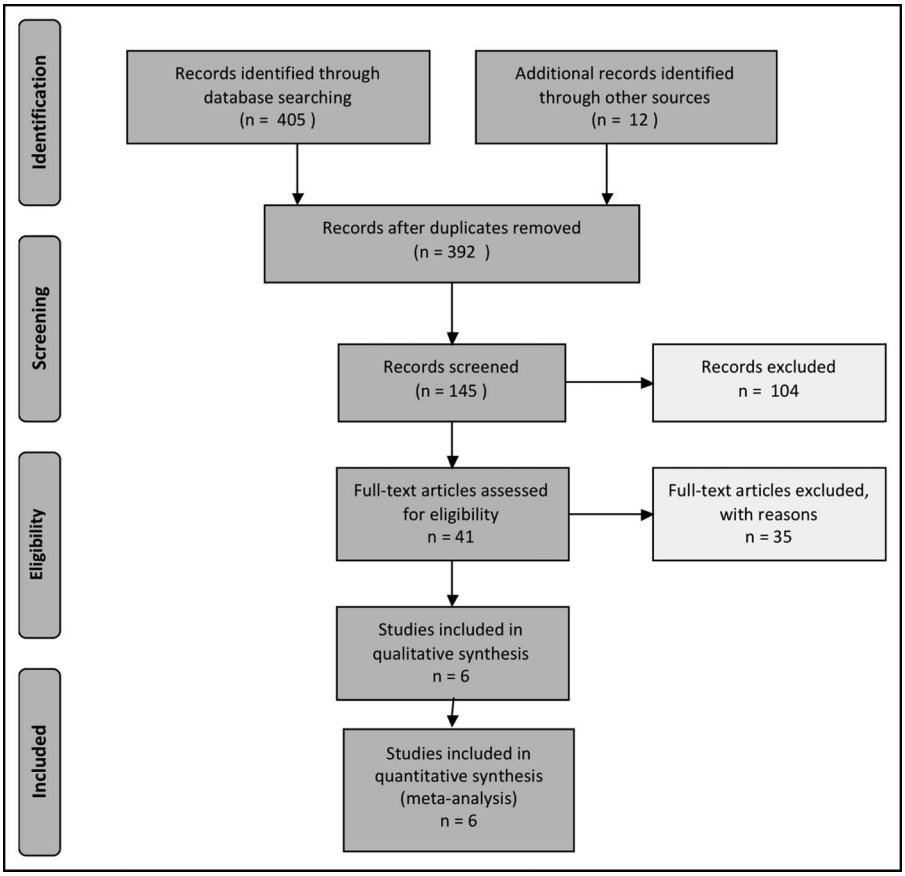

Fig. 1. PRISMA 2009 flow diagram. The PRISMA statement (preferred reporting items for systematic reviews). Followed method to conduct and report the research for a systematic review.

In the second phase of selection, the complete articles of all studies selected in the first phase were acquired. These studies were evaluated independently, based on the inclusion/exclusion criteria, by both reviewers (S.A.H.C. and A.L.A.).

Any disagreement between authors was resolved by discussion with a third reviewer (M.G.H.). If more than 1

Table 2. Two ZIs + RIs Per Patient

	Patients	Follow-up (mo)	ZIs	SR ZIs (%)	Failed ZIs	RIs	SR of RIs (%)	Failed RIs
Bedrossian, 2010	36	84	74	97.2	2	98	100	0
Davó et al, 2007	18	14	36	100	0	68	95.6	3
Degidi et al, 2012	10	12	20	100	0	20	100	0
Total	64		130		2	186		3

Table 3. Four ZIs Per Patient

	Patients	Follow-Up (mo)	ZIs	SR ZIs (%)	Failed ZIs
Davó and Pons, 2015	17	36	68	100	0
Duarte et al, 2007	12	30	48	95.8	2
Stiévenart and Malevez, 2010	20	40	80	96	3
Total	49		196		5

article corresponded to the same clinical study, the article with the most recent data was selected for this systematic review.

Data Collection

From the studies included in the final analysis, the following data were extracted: year of publication, study design, number of patients, smoking habits, number of zygomatic and RIs, survival and failure rates, implant healing period, type of prosthetic rehabilitation, and follow-up period. Contact with authors was performed when missing information in the publications. The statistical unit for "implant survival" and "implant failure" was the implant.

Risk of Bias and Quality Assessment

The criteria used to assess the quality of the included studies were modified according to the PRISMA 2009 checklist statement, which consists of a 27-item checklist and a four-phase flow diagram (Fig. 1). The checklist provides guidelines for transparent reporting of a systematic review. The degree of bias was categorized as low risk if all the criteria were met, moderate risk when only 1 criterion was missing, and of high risk if 2 or more criteria were missing.

Assessment of Heterogeneity

Statistical heterogeneity between all the studies included in this systematic review was not assessed because all the studies had different number of patients, observational periods, and descriptive methods, making a comparison nearly impossible.

RESULTS

Study Selection

Electronic and manual search yielded to a total of 417 abstracts. Titles and abstracts were screened by 2 reviewers. A number of 104 articles were excluded because they did not meet the inclusion criteria. In the second phase of study selection, full-text analysis was performed for 41 articles, resulting in 6 that met the inclusion criteria and were,

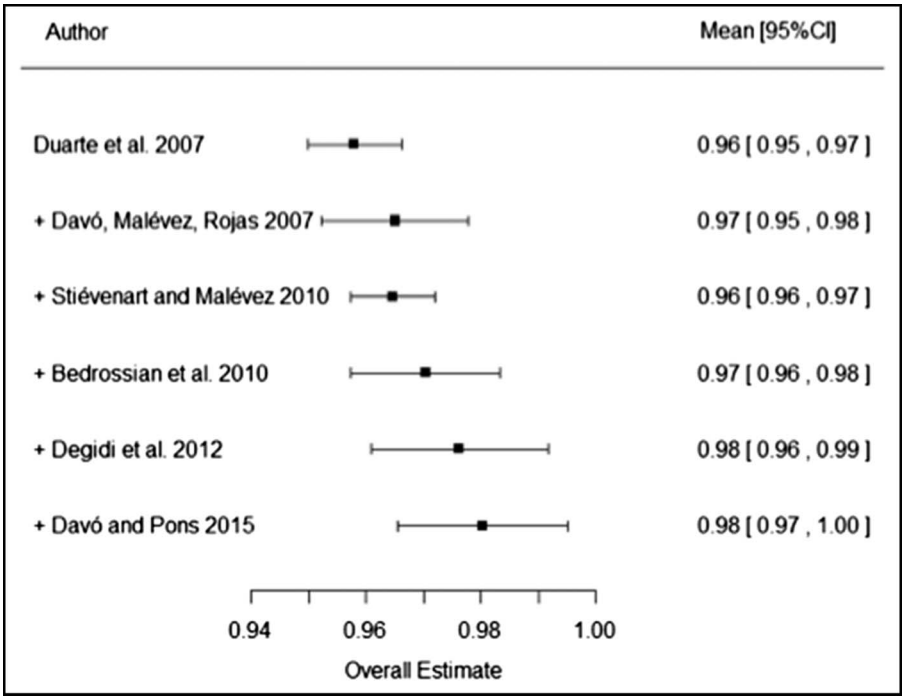

Fig. 2. Mean SR (%) of RIs. The SR tends to increase over the years.

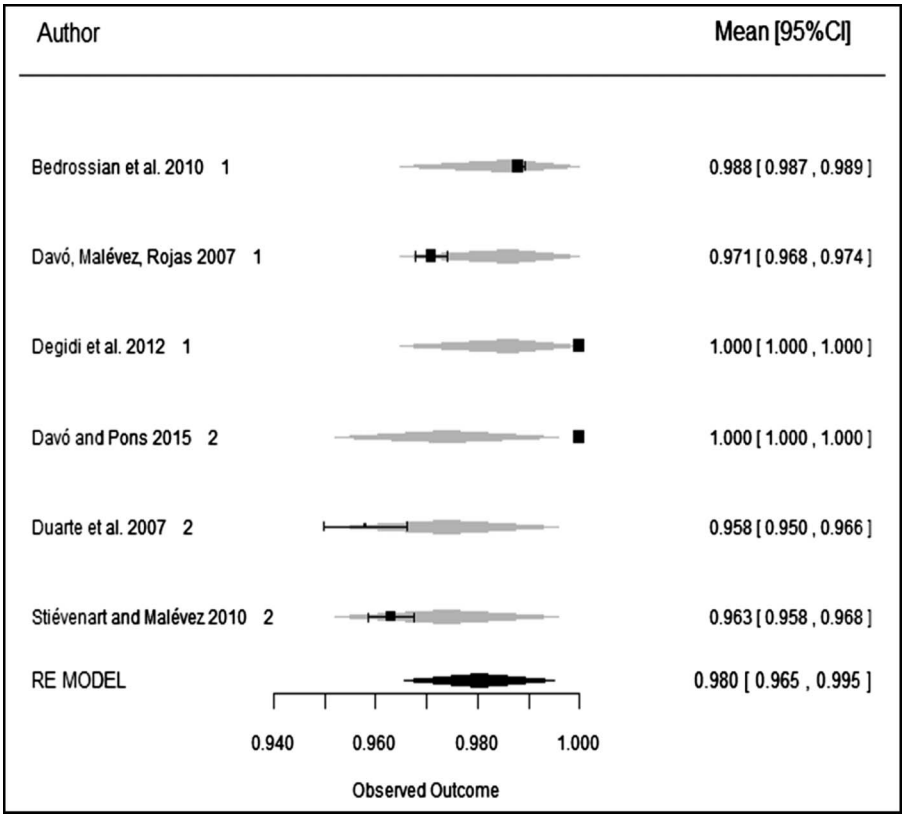

Fig. 3. Funnel plot description for the meta-analysis of implant SR (treatment plan 1 with 4 ZIs and treatment plan 2, combination of 2 zygomatic and RIs). No statistical differences were seen between the use of both treatments.

therefore, included in this systematic review (Fig. 1).

Qualitative Analysis

This review of the literature is based on 4 prospective and 2 retrospective case series studies of articles published from January 1, 2007, to June 30, 2015.

Data collected were reported from each study in relation to:

1. Number of zygomatic and RIs per patient.
2. SR for both implant systems.
3. Provision of immediate prosthesis.
4. Failure rate and different treatment options when implant failure.

Quantitative Analysis

Six articles were included in the meta-analysis (Tables 2 and 3). The total number of ZIs studied was 326 in 113 patients and 186 RIs placed in 64 patients, which corresponds to a total sample size of 512 implants.

Because of the high heterogeneity of the number of RIs placed in combination with ZIs, only 2 and 4 RIs were considered. All studies were based on Brånemark System implants, Nobel Biocare, Göteborg, Sweden, with lengths ranging from 30 to 52.5 mm and a diameter of 4 to 5 mm.

Meta-analysis Survival Results

The estimated SR was 98% for all implants. It is also important to note that the SR tended to increase with time (Fig. 2). The mean implant SR for the treatment with 2 ZIs (treatment plan 1) was 98.6% in comparison with 97.4% obtained when using 4 ZIs (treatment plan 2). No statistical significant differences were found between both treatments (Fig. 3).

When assessing the survival of ZIs, the total mean SR was 98.3%, being 99.1% and 97.4% for the treatment plan 1 and 2, respectively. Although there was a difference of 1.7 points, there were no statistical significant differences between them.

Three studies were introduced in the meta-analysis to compare the survival of ZIs (test group) and RIs (control group), with 130 and 186 implants on each group, respectively. An odds ratio of 1.21 with 95% confidence interval was obtained, which indicates no statistical differences between both groups ($P = 0.853$) (Fig. 4). Therefore, the risk of failure for ZIs is similar to RIs (Table 4).

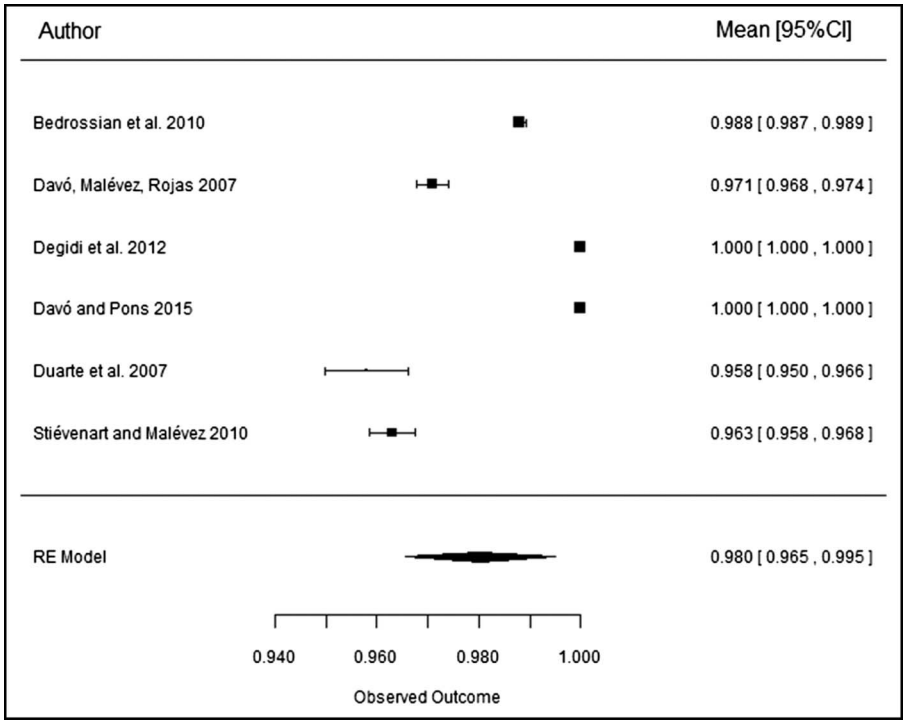

Fig. 4. Confidence interval (CI) of *P*-value and survival funnel plot among the selected studies. Only 3 studies could be selected for meta-analysis to compare both groups. An odds ratio of 1.21 with 95% CI was obtained, which indicates no statistical differences between both groups ($P = 0.853$).

Table 4. Risk of Failure of the ZIs

Study	OR	CI 95% Inferior Limit	CI 95% Superior Limit	*P*
Bedrossian, 2010	6.82	0.32	144.01	0.102
Davó et al, 2007	0.26	0.01	5.10	0.201
Degidi et al, 2012	1.00	0.02	52.99	1.000
Total	1.21	0.16	9.03	0.853

The risk of failure of the treatment plan 2 group was similar to those in treatment plan 2 ($P = 0.853$).
CI indicates confidence interval; OR, odds ratio.

DISCUSSION

To date, there are several publications of case series with large sample size and long-term follow-up as well as systematic reviews concerning the rehabilitation of the atrophic maxilla with ZIs. To the best of the author's knowledge, there are currently no systematic reviews either meta-analysis that compare the treatment with 4 ZIs with no additional anterior implant support versus 2 ZIs combined with anterior RIs. Both treatment options differ substantially in the overall costs of the treatment and its surgical procedure. Three studies were based on the treatment of the atrophic maxilla with 2 ZIs and a combination of 2 or 4 anterior RIs.[3,10,12]

A total of 130 ZIs and 186 conventional implants were placed in 64 patients. Regarding the SR of the ZIs, Degidi et al[10] and Davó et al[12] got an SR of 100% over a period of 12 months, whereas Bedrossian[3] got an SR of 97.2% (2 failed implants of 74) at 7-year follow-up. In regards to the RIs, a 100% SR was obtained at 1- and 7-year follow-up[3,10]; however, in the study of Davó et al,[12] they got an SR of 95.6% (3 failures of 68 implants)

after 14 months of follow-up. In the study of Degidi et al,[10] an immediate definitive prosthesis was placed the day of the surgery, whereas the other 2 studies provided immediate provisional prostheses which were replaced into definitive after 6 months of healing time.[3,10,12]

Regarding the treatment of the edentulous upper maxilla with 4 ZIs, only 3 publications were retrieved.[5,8,11] A total of 196 ZIs were placed in 49 patients. SRs were above 95% in all cases with a follow-up period between 30 and 40 months. An SR of 100% was obtained for Davó and Pons.[8] One implant was not used because of unfavorable position. Duarte et al[5] and Stiévenart and Malevez[11] obtained an SR of 95.8% (2 implant failures of 48 implants) and 96%, respectively. In the study of Duarte et al,[5] all patients were rehabilitated with definitive prostheses the day of the surgery. On the other side, Stiévenart and Malevez[11] provided provisional prosthesis in all of their patients. Davó and Pons[8] loaded all the patients but one. Provisional prosthesis was replaced 6 months after the surgery.[5,8,11]

All of the patients treated with ZIs, either 2 ZIs combined with anterior RIs or 4 ZIs, were restored with an immediate loaded fixed prosthesis the day of the surgery up to 2 weeks after. The immediate loading of the implants is a valuable treatment option as it reestablishes the function and the aesthetics immediately, without having to wait for the conventional healing time necessary when using other approaches.[3,5,7,8]

The authors also describe different treatment options when facing a failure of a ZI. The most accepted option was the replacement of a failed implant.[3,5,15,17–19] In some cases, implants were removed but not replaced.[11] In 1 case, where the implant was not osseointegrated, it was disconnected from the prosthesis to allow osseointegration and loaded 2 months after.[14] In other situations, a modification of the final prosthetic design was necessary to allow prosthetic rehabilitation.[14–17,22]

It is remarkable to note that in this study only the SRs of ZIs were reported because a clinical evaluation method of these implants is not possible. A specific success criterion for ZIs is necessary and authors as Aparicio et al[19] have proposed a zygomatic success code. This zygomatic success code takes into consideration the description of specific criteria (divided in A: individually tested ZI; B: sinus pathology associated; C: periimplant soft tissue condition; and D: prosthetic offset) and classifying zygoma implants as successful (grades I, II, or II) or failed (grade IV).[19]

About the expenses of the treatment, the use of 4 ZIs instead of 2 implies higher costs because these are more expensive than RIs. However, when considering the combined option of zygomatic and RIs, the cases with severe atrophic anterior maxilla will require additional grafting procedures to facilitate the ideal prosthetic 3-dimensional implant placement.[1] The additional grafting procedures would increase the overall costs, which can exceed those if only using 4 ZIs. Also, the regenerative procedure can increase the number of surgical procedures and, therefore, the length of the treatment from the initial surgery until the definitive restoration. This is a key factor to take into consideration because the patient acceptance will mainly rely on having the masticatory function restored in the shortest time as possible to improve patient's quality of life. Currently, dentistry aims to shorten the treatment time providing the ideal prosthetic outcome, functional and aesthetically.[1,2,24–26]

Each surgical procedure can be associated with different anesthetic options depending on the case: local anesthesia, local anesthesia combined with sedation, or general anesthesia. There are no standardized protocols in regards to the anesthesia used when placing 2 or 4 ZIs with or without anterior RIs and regenerative procedures. Therefore, it is basically the surgical team decision to use 1 type or another, depending on their experience, the expected surgical time, and the available means. It is widely common to combine local anesthesia with sedation in those cases where only 2 ZIs are required; however, the use of general anesthesia when placing 4 ZIs is less frequent. It is also extended the use of general anesthesia when major bone-grafting procedures are required where the donor site is located extra-orally (ie, iliac crest, calvaria, etc).[2,6,24]

When planning the type of anesthesia that will be used, it requires patient's opinion also. A general anesthesia requires an extended recovery period, whereas sedation is generally associated to a fast recovery time. Therefore, it seems that different anesthesia techniques are 1 factor that may influence the patient's decision when choosing between different treatments and the appropriate surgical team.[4–6]

After the surgical placement of 4 ZIs, the use of a provisional fixed prosthesis it is a described secure and effective process. Patients have their definitive prosthesis 6 months after the surgery. By the time, the patient has a clear improvement in its quality of life.[5,6,19,21]

On the contrary, regenerative surgery is associated with greater treatment time. There is a minimum of 4 to 6 months to wait for bone neoformation in regenerated places until the surgeon could place the implants.[20]

Allegedly, between 10 and 12 months is the time of the whole treatment since implant placement to prosthetic loading. Hence, treatment time, motivation, and willingness are important outcomes for patients to bear in mind to follow and conclude the treatment.[6]

At the present time, the current tendency is to shorten the treatment times giving to the patient the possibility of enjoying an ideal functional and esthetic result as soon as possible. The use of ZIs is a predictable treatment option in terms of severe maxillary atrophy in comparison with regenerative procedures with intraoral or extraoral bone grafts. Quantity, quality, and morbidity of the donor site are some of the disadvantages described in the literature for regenerative processes with autologous bone.[1,2,4–6]

The morbidity associated with regenerated sites is high. Severe bone atrophies need large quantity of bone availability, which we do not have. Onlay grafts are the most common used for big regenerations.[2,6]

Tension areas in the sutures have to be considered more carefully when placing an onlay bone graft covered by a titanium membrane. Dehiscence and exposure of the membrane may occur and, therefore, infection and/or loss of the barrier.[1,5,20]

This problem may not exist in the cases of ZI placement. The mucoperiosteal flap is then sutured at the same level as it was before the surgery. That diminishes the risk of any of the other disadvantages mentioned above. Nevertheless, temporal injuries of the infraorbitary nerve while placing the implants have been described in the literature and are not frequent. They have also mentioned other postoperative risks such as acute sinusitis although they rarely occur in most cases.

Conclusion

The use of 4 ZIs is a successful approach showing an SR of 97.4% when treating the severely atrophic maxilla. Despite the high SR observed, there is a need to conduct more randomized controlled clinical trials to examine their efficacy in comparison with other techniques. This statement should be taken with caution due to the nature of the studies published that mainly included case series. Meanwhile, the combined option treatment of using 2 ZIs and RIs also offers a high SR (98.6%), but this technique might require bone-grafting procedures in the anterior region increasing the patient's morbidity. The results of this study showed no statistical differences in using 1 or other treatment in terms of survival and rate failures.

Overall, the placement of ZIs requires experienced surgeons. It is not a risk-free technique because delicate anatomical structures such as the orbita may be involved. This systematic review will help for future studies to understand the SR of ZIs in the long term.

Disclosure

The authors claim to have no financial interest, either directly or indirectly, in the products or information listed in the article.

Roles/Contributions by Authors

Samir Aboul-Hosn Centenero: researcher, article reviser, proposed the initial idea to perform the study, codirected PhD on ZIs, data dissemination on congresses (national: SECOM and international: EFOMBS), more than 20-year clinical experience with ZIs, private practice at Plató Hospital, and chief of the oral and maxillofacial surgery department. Aida Lázaro: researcher, manuscript author and article reviser, public results divulgation in national congresses: SECOM, SECIB. Maria Giralt-Hernando: manuscript author, article reviser, corresponding author, public divulgation in national (SECOM) and international (EAO) congresses, statistical analysis, figures and table author, and editor. Federico Hernández-Alfaro: article reviser, directed PhD on ZIs, main investigator of a current study on zygoma quad at International University of Catalonia (UIC), data dissemination on congresses (national: SECOM and international: EFOMBS), more than 30-year clinical experience with ZIs, private practice at Teknon medical Centre, and chief of the oral and maxillofacial surgery department.

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