



Comparative Evaluation of Sinus Complication and Survival Rates of Quad Zygoma versus Bizygoma in Combination with two Regular Implants in Atrophic Maxilla: A Systematic Review and Meta-Analysis

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Abstract

Aim To systematically review existing scientific literature to determine, compare and evaluate the sinus complication and survival rates of quad zygoma against two zygomatic implants with combination of two regular implants in atrophic maxilla in adults.

Methods Review was performed in accordance with preferred reporting items for systematic reviews and meta-analysis guidelines and registered in PROSPERO—CRD42023392721 Electronic databases like PubMed, Google scholar and EBSCO host were searched from 2000 to December 2022 for studies reporting treatment of Atrophic maxilla with either quad zygoma or two zygomatic implants in combination with two regular implants. Quality assessment was evaluated using Cochrane risk of bias-2 tool for randomized controlled trials (RCT). The risk of bias summary graph and risk of bias summary applicability concern was plotted using RevMan software version 5.3. The odds ratio (OR) and standardized mean difference (SMD) were

used as summary statistic measure with random effect model and p value < 0.05 as statistically significant.

Results Eleven studies fulfilled the eligibility criteria and were included in qualitative synthesis, of which only nine studies were suitable for meta-analysis. The pooled estimate through the odds ratio 0.59 signifies that the quad zygomatic implants on an average has 0.59 (0.18–1.93) times or odds of developing sinus complications while the SMD signifies that better survival rate (SR) on an average is 0.35 (–0.61 to 1.30) times more by two zygomatic implants with combination of two regular implants as compared to quad zygomatic implants ($p > 0.05$). Publication bias through the funnel plot showed asymmetric distribution with systematic heterogeneity.

Conclusion Two zygomatic implants in combination with two regular implants provides better survival rate and less sinus complications compared to quad zygoma in 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.

Keywords Sinus complications · Survival rate · Zygomatic implants · Quad zygoma · Atrophic maxilla · Dental implants · Prosthetic rehabilitation

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Introduction

Alveolar ridge resorption is often encountered in dental practice. Treatment of severe maxillary atrophy with an implant has achieved importance in recent years [1–4]. Advanced posterior alveolar ridge resorption combined with increased maxillary sinus pneumatization often leaves insufficient bone for implant anchorage [5]. The severely

atrophied maxilla constitutes a challenging therapeutic problem because bone augmentation is required to enable the placement of a sufficient number and length of implants [6–8].

Different treatment options such as sinus augmentation, on-lay and inlay grafts, split crest technique, pterygoid implants, zygomatic implants, and distraction osteogenesis can lead to optimal functional and aesthetic rehabilitation of atrophied maxilla. Zygomatic implants have stood out in the field of dental implantology as an immediate solution to severe maxillary atrophy. According to the local anatomy of the maxilla and dimensions of the sinus cavity, several approaches have been recommended for the rehabilitation of the maxilla such as tilted implants, combined with bilateral/single zygomatic implants [9, 10]. Zygomatic implants (ZIs) can be placed in different ways: bilateral two implants on each side (quad), bilateral single implant, unilateral single or two implants, and in conjunction with conventional dental implants [11].

Zygomatic implant surgery generally results in least surgical complications or morbidity when compared with grafting options. However, the placement of the zygomatic implant is challenging, since it may involve delicate anatomical structures such as the orbit and sinus. Placement of a zygomatic implant requires an abundance of knowledge and surgical experience. Many complications have been reported in the literature, with sinusitis being the most common [12, 13].

Going through evidence, till date no study has provided a comprehensive, quantitative analysis on a comparative evaluation of the sinus complication and survival rates of quad zygoma (4 ZIs) versus two zygomatic implants (2 ZIs) with a combination of two regular implants (2 RIs) in the atrophic maxilla. Therefore, we started research for related articles and conducted a systematic review to compare and evaluate the sinus complication and survival rates of quad zygoma against two zygomatic implants in combination with two regular implants in the atrophic maxilla in adults through a novel meta-analysis.

Methodology

The review question was to evaluate and assess the sinus complications and survival rate of the quad zygoma and two zygomatic implants in combination with two regular implants. The research question was proposed as “Is there any difference in sinus complication and survival rate of the quad zygomatic implants and two zygomatic implants combined with two regular implants in patients with atrophic maxilla?”

The PICO criteria for this review were as follows:

P (Participants): Patients with atrophic maxilla

I (Intervention): Use of quad zygoma implants

C (Comparison): Comparison of quad zygoma implants versus two zygomatic implants combined with two regular implants

(Outcome): To assess the sinus complications and survival rate

S (Study designs): Randomized trials, prospective study, retrospective study, comparative study

This review was conducted and performed according to the preferred reporting items for systematic review and meta-analysis (PRISMA) statement [14] and registered in prospective registration of systematic review (PROSPERO)—CRD42023392721.

Eligibility Criteria

Inclusion Criteria

The following were the inclusion criteria.

- 1) Articles published in English language
- 2) Articles having sufficient data on quad zygoma implants and two zygoma implants combined with two regular implants
- 3) Studies published between 2000 and 2022 and having relevant data on the quad zygoma implants versus two zygomatic implants combined with two regular implants and reporting the results in terms of sinus complications and survival rate
- 4) Study designs: randomized trials, prospective study, comparative study
- 5) Articles from open-access journals

Exclusion Criteria

The following were the exclusion criteria.

- 1) Any studies conducted before 2000
- 2) Articles in other than English language
- 3) Reviews, abstracts, letters to the editor, editorials, animal studies, and in vitro studies were excluded
- 4) Articles not from open-access journals

Data Extraction

For all included studies, the following descriptive study details were extracted by two independent reviewing authors and using pilot-tested customized data extraction forms in a Microsoft Excel sheet with the following headings included in the final analysis: author(s), country of study, year of

study, mean age of the participants, sample size, study design, duration of follow-up, outcome, conclusion.

Search Strategy

A comprehensive electronic search was performed till December 2022 for the studies published within the last 22 years (from January 2000 to December 2022) using the following databases: PubMed, Google Scholar, and EBSCO host to retrieve articles in the English language.

The relevant data was searched using the following keywords and their combinations: “zygoma” (MeSH term) AND “implants” (MeSH term); “quad zygoma implant” (MeSH term) AND “two zygomatic implants” (MeSH term); “survival rate” (MeSH term) AND “sinus complications” (MeSH term) AND zygoma (MeSH term); “maxillary atrophy” (MeSH term) AND “atrophy/pathology” (MeSH term) AND “edentulism/surgery” (MeSH term); “rehabilitation” AND “dental implants” (MeSH term).

Screening Process

The search and screening, according to the previously established protocol were conducted by two authors. A two-phase selection of articles was conducted. In phase one, two reviewers reviewed the titles and abstracts of all articles. Articles that did not meet the inclusion criteria were excluded. In phase two, selected full articles were independently reviewed and screened by the same reviewers. Any disagreement was resolved by discussion.

Quality Assessment of Included Studies

The methodological quality among included studies was executed by using the Cochrane collaboration risk of bias (ROB)-2 tool [15, 16]. The tool has various domains like random sequence generation (selection bias), allocation concealment (selection bias), blinding of personnel and equipment (performance bias), blinding of outcome assessment (detection bias), incomplete outcome data (attrition bias), selective reporting (reporting bias) and other biases through their signaling questions in Review Manager (RevMan) 5.3 software. The overall risk for individual studies was assessed as low, moderate, or high risk based on domains and criteria.

Statistical Analysis

The standardized mean difference (SMD) with 95% CI was calculated for continuous outcomes. A fixed effects model

(Mantel–Haenszel method) was used if there was no heterogeneity ($p > 0.05$) or I-squared ≤ 24 . The significance level was kept at $p < 0.05$.

Results

Study Selection

After duplicate removal, a reference list of included studies was screened. Of these, 265 studies were included. After this full-text articles were assessed for eligibility and 120 articles that did not meet the inclusion criteria were excluded. Only eleven studies fulfilled the eligibility criteria and were included in the qualitative synthesis. Out of which only nine studies were included in meta-analysis. A flowchart of identification, inclusion, and exclusion of studies is shown in Fig. 1.

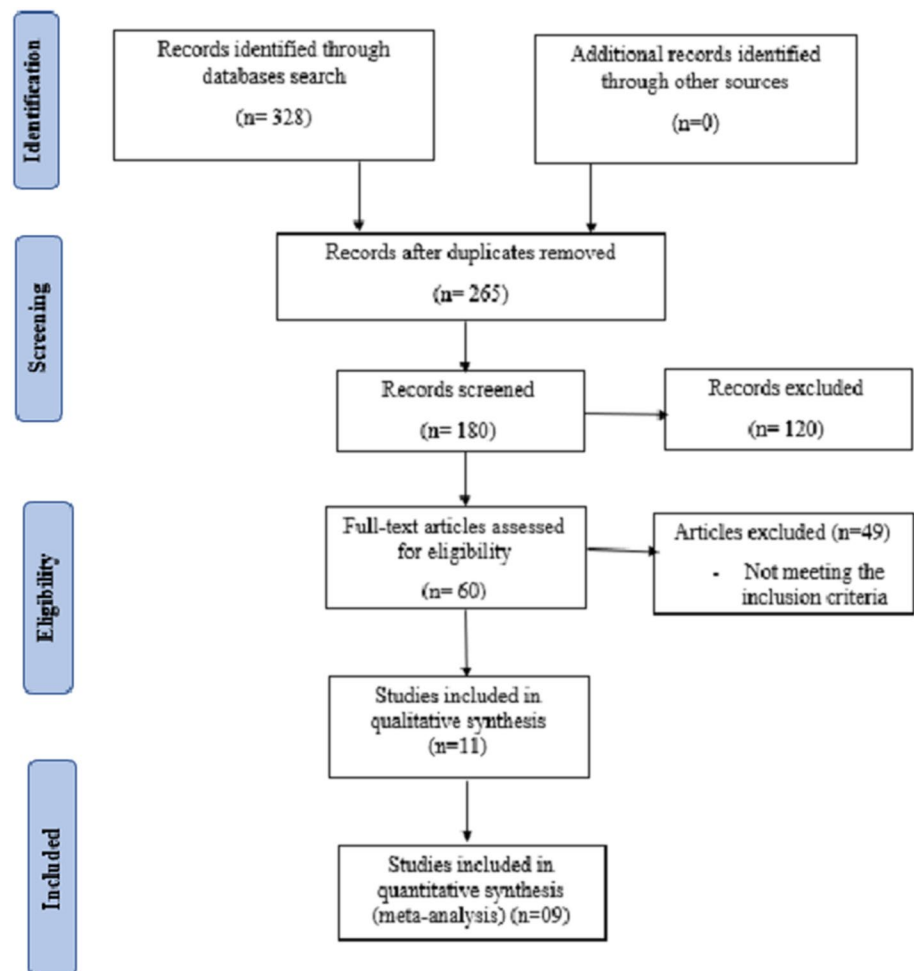
Study Characteristics

A summary of descriptive characteristics of all included studies is shown in Table 1. Data were evaluated from eight studies [17–24] from an aggregate of 684 (n) patients with a mean follow-up of 617 months. A total of 440 quad zygoma implants were placed with a mean survival rate of 98.28%, while a total of 568 two zygomatic implants in combination with regular implants were placed with a mean survival rate of 97.46%. All the included studies reported complications like sinusitis, osseointegration failure, implant mobility, pain, etc.

Assessment of Methodological Quality of Included Studies

All the included studies were largely comparable in methodological quality. Among the included studies, Malevez et al. 2010 [27] followed by Aparacio et al. 2010 [19], Chana et al. 2018 [21] and Degidi et al. 2012 [24] had a high risk of bias compared to all other studies. Coppede et al. 2017 [22] followed by Bedrossian et al. 2010 [20] reported the lowest risk of bias. Domains of random sequence generation (selection bias) followed by blinding of participants and personnel (performance bias), incomplete outcome data (attrition bias), and other biases were given the lowest risk of bias by included studies. The risk of bias in included studies through the Cochrane risk of bias (ROB)-2 tool is depicted in Figs. 2 and 3.

Fig. 1 PRISMA flow chart



Synthesis of Result

Sinus Complications

Five studies [18, 21, 22, 26, 28] evaluated to compare quad zygoma versus two zygomatic implants combined with 2 regular implants for better safety between the two procedures in terms of sinus complications as an outcome.

As shown in Fig. 4, the odds ratio is 0.59 (0.18–1.93) and the pooled estimates favours quad zygomatic implants. This signifies that the quad zygomatic implants on average have 0.59 times the odds of developing sinus complications compared to two zygomatic implants combined with regular implants but this difference is not statistically significant ($p=0.38$).

Among all the included studies, Chana et al. 2018 had the highest weightage at the overall pooled estimate, while the lowest weightage was observed for Aparicio et al. 2006 at the pooled estimate.

By employing the random effect model the I^2 statistic showed 54%, the heterogeneity for T^2 was 0.90, χ^2 being $p < 0.00001$, and the overall effect for Z value being 0.88 ($p=0.38$).

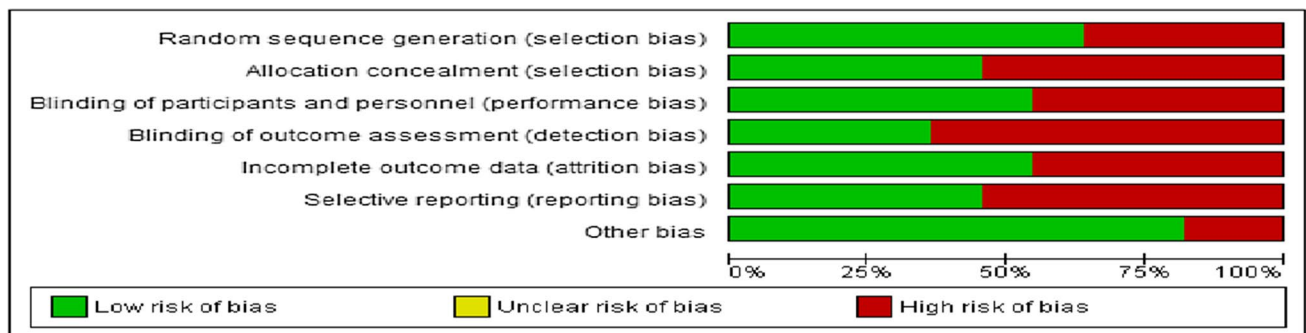
The funnel plot did show significant asymmetry, indicating the presence of publication bias as shown in Fig. 5. Funnel plot showing asymmetric distribution with the presence of systematic heterogeneity of individual study compared to the standard error, showing a presence of publication bias in the meta-analysis.

Survival Rates

Four studies [19, 23–25] containing data on 150 ($n=150$) participants, of which ($n=75$) participants were evaluated by quad zygomatic implants and ($n=75$) patients were evaluated by two zygomatic implants combined with regular implants for the evaluation or the better effectiveness between the two procedures in terms of better success rate as an outcome.

Table 1 Showing descriptive study characteristics of included studies

S. No	Author (Year)	Sample size (n)	Follow-up (months)	Quad zygoma implants (n)	Survival rate (%)	Two zygoma with 2 RIs	Survival rate (%)	Complications
1	Aparicio et al. (2006) [18]	69	60	60	100	7	99	Sinusitis
2	Aparacio et al. (2010) [19]	25	36–48	17	100	4	100	Abutment screw fracture
3	Bedrossian et al. (2010) [20]	36	84	44	97.2	80	100	Regular implant failure
4	Chana et al. (2018) [21]	45	216	12	94.32	4	94.32	Sinusitis, implant mobility, pain
5	Coppede et al. (2017) [22]	42	36	6	98.9	27	97.7	Osseointegration failure
6	Davo et al. (2015) [23]	17	14	68	100	26	95.6	Drill penetration in orbit, fistula, sinusitis
7	Degidi et al. (2012) [24]	10	12	20	100	20	100	Sinusitis, implant mobility, fistula
8	Duarte et al. (2007) [25]	12	30	48	95.8	31	92.3	Osseointegration failure, sinusitis, implant mobility, pain
9	Malevez et al. (2004) [26]	55	6–48	12	100	103	97.5	Sinusitis
10	Malevez et al. (2010) [27]	21	45	102	96.7	52	97.8	Osseointegration failure, peri-implant mucositis
11	Malo et al. (2014) [28]	352	6–84	51	98.2	214	97.9	Sinusitis, implant mobility

**Fig. 2** Showing risk of bias graph: review authors' judgments about each risk of bias item presented as percentages across all included studies

As shown in Fig. 6, the standardized mean difference is 0.35 (−0.61 to 1.30) and the pooled estimates favors two zygomatic implants combined with regular implants. This signifies that the better success rate on average is 0.35 times more by two zygomatic implants combined with two regular implants as compared to quad zygomatic implants but this difference is not statistically significant ($p=0.48$).

Among all the included studies, Bedrossian et al. 2010 had the highest weightage at the overall pooled estimate,

while the lowest weightage was observed for Degidi et al. 2012 at the pooled estimate.

By employing the random effect model the I^2 statistic showed 86%, the heterogeneity for T^2 was 0.81, χ^2 being $p<0.00001$, and the overall effect for Z value being 0.71 ($p=0.48$).

The funnel plot did not show significant asymmetry, indicating the absence of publication bias as shown in Fig. 7. Funnel plot showing symmetric distribution with

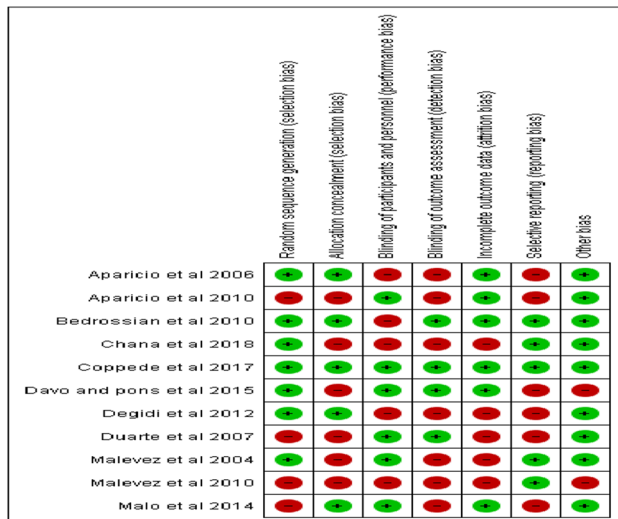


Fig. 3 Showing risk of bias summary: review authors' judgments about each risk of bias item for each included study

the absence of systematic heterogeneity of individual study compared to the standard error, showing an absence of publication bias in the meta-analysis.

Discussion

Zygomatic implants have stood out in the field of dental implantology as an immediate solution to severe maxillary atrophy [9]. According the anatomy of the maxilla and dimensions of the sinus cavity, several approaches have been recommended for the rehabilitation of the maxilla with tilted implants, combined with bilateral/single zygomatic implants [10].

The present study identified 11 studies based on the eligibility criteria for systematic review, of which only nine studies were eligible for meta-analysis.

Perez et al. 2022 conducted a systematic review of the literature on zygomatic implants for the treatment of severe maxillary atrophy and 196 publications were included in the

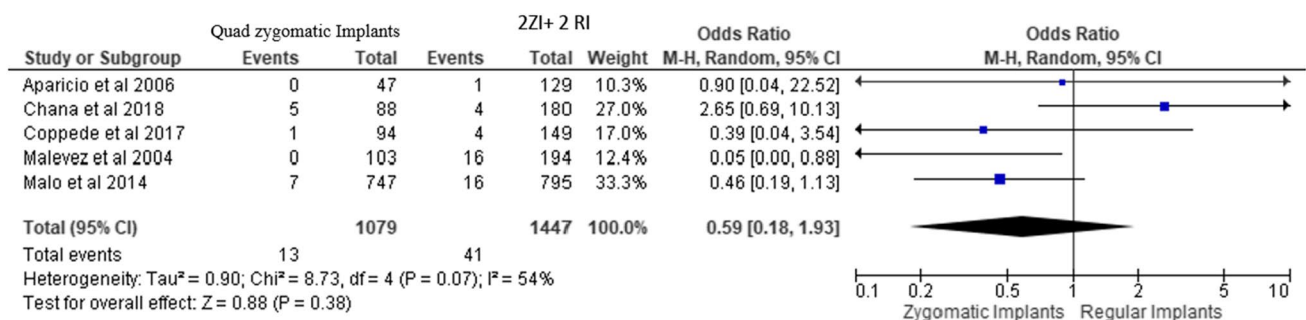


Fig. 4 Showing Forest plot showing zygomatic implants versus regular implants with regard to the sinus complications as an outcome [17]

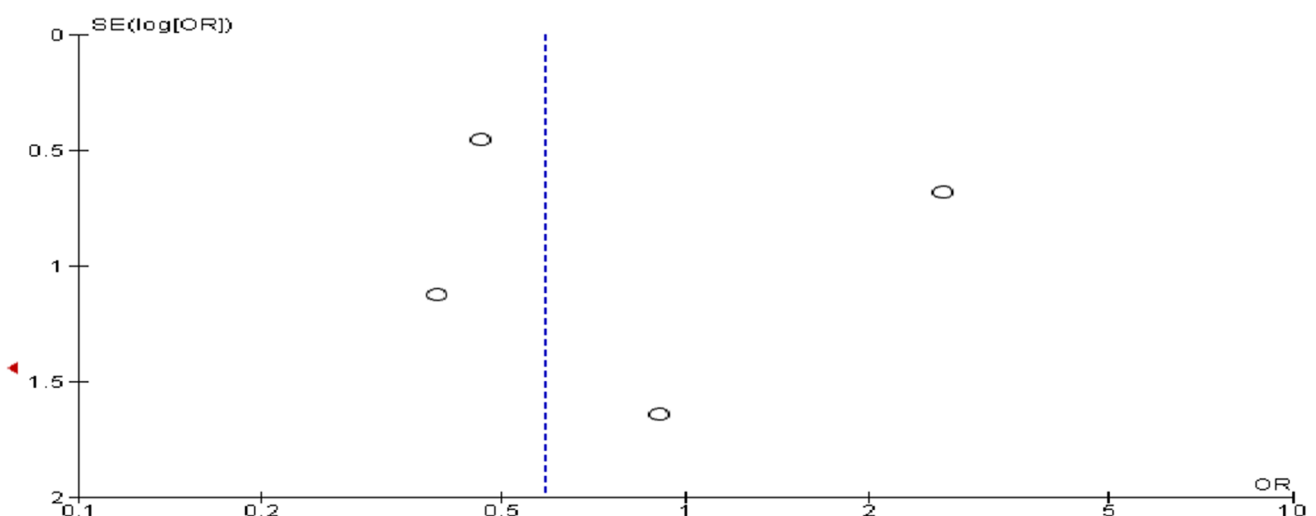


Fig. 5 Showing Begg's funnel plot with 95% confidence intervals demonstrating symmetric distribution without systematic heterogeneity of individual study compared with the standard error of each study, indicating a presence of publication bias

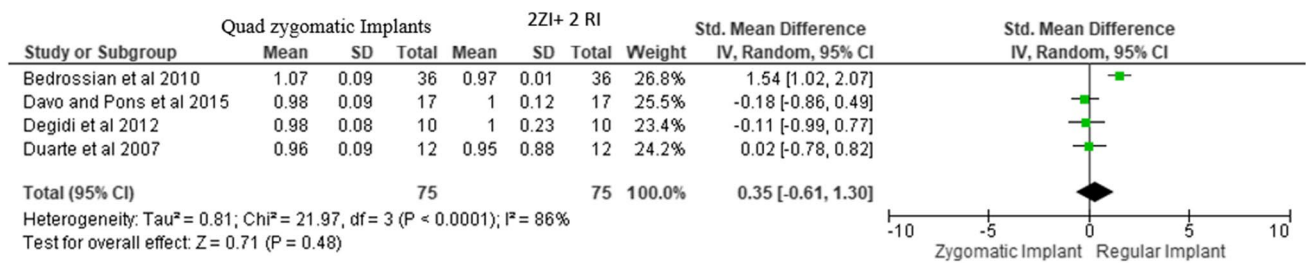


Fig. 6 Showing forest plot showing zygomatic implant versus regular implant with regard to the better survival rates as an outcome

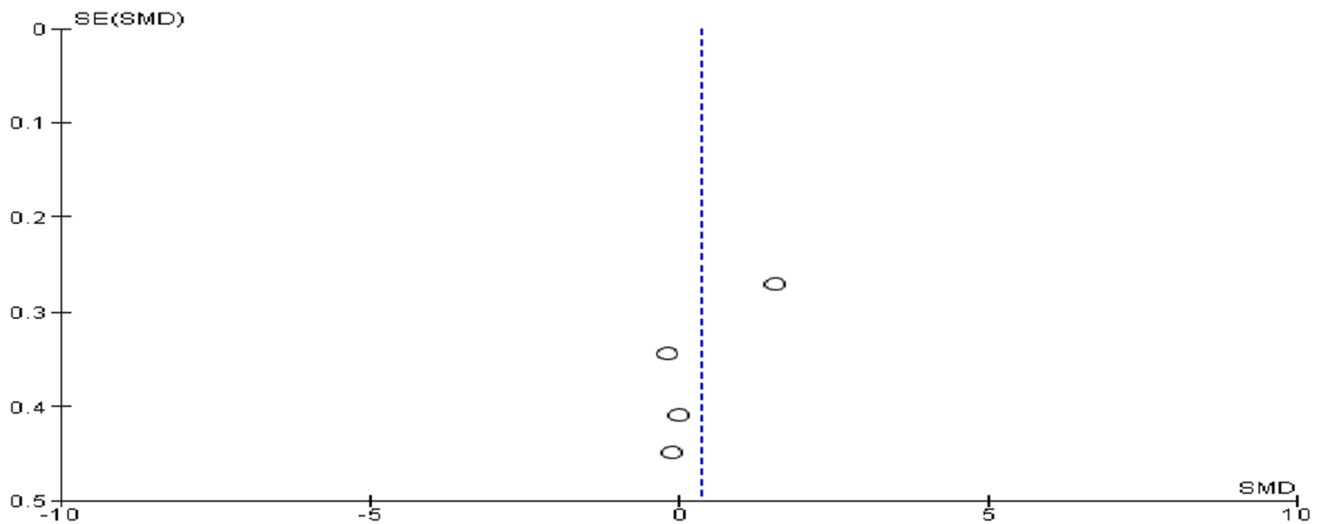


Fig. 7 Showing Begg's funnel plot with 95% confidence intervals demonstrating symmetric distribution without systematic heterogeneity of individual study compared with the standard error of each study, indicating an absence of publication bias

study. The cumulative success rate of zygomatic implants for the treatment of severe maxillary atrophy was 98.5% at < 1 year, 97.5% between 1 and 3 years, 96.8% between 3 and 5 years, and 96.1% after more than 5 years. The most commonly reported complications were soft tissue dehiscence, rhinosinusitis, and prosthetic failures [29].

Centenero et al. 2018 carried out a study 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 ZIs. 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 [30]. They concluded that the data analysis showed favourable results for treatment with 4 ZIs, whereas our study favors two zygomatic implants combined with two regular implants with a survival rate 0.35 times greater than quad zygoma.

Agliardi et al. found in their prospective clinical trial that the main surgical complication was the perforations of the Schneiderian membrane, occurring in five patients and seven sinus cavities [31]. In our meta-analysis, we found that quad zygomatic implants on average have 0.59 times the odds of developing sinus complications compared to zygoma combined with regular implants but this difference is not statistically significant.

As regards to the expenses of the treatment, the use of 4 ZIs instead of 2 implies higher costs because these are more expensive than RIs. However, the costs still lower than what would be involved if a patient were to undergo grafting followed by regular implant placement instead [32].

However, a few limitations were also present. Going through evidence, there is a scarcity and paucity of literature on comparative evaluation between quad zygoma versus two zygomatic implants with a combination of two regular implants on assessing outcomes like sinus complications and survival rates. Only eleven studies were included in our systematic review, while only nine studies were included in our meta-analysis. There is a need to conduct more randomized

controlled trials comparing quad zygoma versus two zygomatic implants with a combination of two regular implants.

Conclusion

The use of quad zygomatic implants is a successful approach showing a survival rate of 97.4% when treating the severely atrophic maxilla. And, the combined option treatment of using 2 Zygomatic Implants in combination with 2 regular implants also offers a high survival rate (98.6%), but this technique might require bone-grafting procedures in the anterior region increasing the morbidity. The quad zygomatic implants on average have 0.59 times the odds of developing sinus complications compared to two zygomatic implants combined with regular implants. Despite the high survival rate observed, there is a need to conduct more randomized controlled clinical trials to examine their efficacy in comparison with other techniques. This systematic review will help future studies to understand the Survival Rate and complications of Zygomatic Implants.

Declarations

Conflict of interest The authors have no conflicts of interest.

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