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Meta-Analysis

Surgical outcome of extra sinus zygomatic implants in comparison to conventional implants for the rehabilitation of atrophic maxilla: a systematic review and meta-analysis

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ABSTRACT

Posterior maxillary atrophy in particular presents a challenge for implant-supported dental rehabilitation. The discovery of the zygomatic implant by Branemark and its modifications has brought a much-needed window of hope to most patients with atrophic maxilla. The conventional approach to is believed to be the intra sinus technique but the use of the extra sinus zygomatic implants has advantages like reducing surgical time, the risk of sinus adverse events and improving surgical visualization. A systematic literature search in five databases: Proquest, Google Scholar, PubMed, OVID, Cochrane and a hand search of relevant scientific journals was performed. The meta-analysis done on the included five studies, revealed that the primary outcome, i.e, implant survival rate and prosthesis failure showed no statistically significant difference between the test and the control group. The overall difference between the control (intra sinus zygomatic implants) and test group (extra sinus zygomatic implant) was statistically significant for chronic sinusitis (p=0.0002) and periimplantitis (p=0.01). The use of the extra sinus technique for the placement of zygomatic implants simplified the surgical procedure, improved the prosthetic outcome and reduced the risk of sinusitis and periimplantitis as compared to conventional or intra sinus technique of zygomatic implant placement.

Keywords: Extra sinus zygomatic implants, Intra sinus zygomatic implants, Conventional implants, Atrophic maxilla

INTRODUCTION

Edentulism is a common problem that can occur naturally as an aging process or it can be associated with dental caries, periodontal problems, congenital (e.g. ectodermal dysplasia, complete or partial anodontia) or acquired defects due to maxillofacial trauma or after ablative tumor resection.[1] Tooth loss leads to continues, cumulative and irreversible bone loss mainly in the maxilla. The resorbed residual ridge and the presence of the maxillary sinus in the maxilla makes dental implant placement for implant-supported rehabilitation a challenge.

Edentulism results in decreased chewing ability and alterations in facial aesthetics, potentially causing psychological concerns like depression, diminished self-esteem, and restriction of social activities.[2] Traditionally, partial dentures, complete dentures and fixed bridges have been the go-to options for rehabilitating partially or fully edentulous patients. However, these solutions come with significant drawbacks which includes, accelerated bone loss in both arches, instability in the mandibular arch and potential overloading of adjacent teeth with fixed bridges, all of which can result in patient dissatisfaction. To address these issues, dental implant-based rehabilitation offers a promising alternative.[1]

Placing implants in the maxilla remains challenging, particularly when there is inadequate bone available at the implant site. This shortage is especially pronounced in the maxillary sinus area due to sinus pneumatization, resorption from the alveolar site, ablative tumor surgery involving maxillary bone resection, maxillofacial trauma, congenital defects, failed autogenous bone grafts and cases involving gunshot wounds.[3]

In the light of the maxillary sinus, additional anatomical structures are noted, e.g., septa shape as an inverted gothic arch that may divide the sinus into two or more cavities, which cause impaired turbulent airflow and thickening of the sinus membrane.

Sinus lift surgery is a procedure designed to prepare the bone for the placement of endosseous implants in patients with a low maxillary sinus. However, in cases of extensive bone atrophy and pathological changes in the mucous membrane of the maxillary sinus, performing sinus lift surgery may become unfeasible.[4]

Several bone grafting techniques, such as sinus lift and autogenous bone grafts, have been described as methods to restore the architecture of the atrophic maxillae, allowing implant placement in resorbed sites. Complementary, autogenous bone grafting procedures for full-arch reconstructions often require an extraoral donor site, such as the iliac crest or the outer table of the calvaria bone, which increases the morbidity of the reconstructive procedure, demanding considerable time until final fixed prostheses can be delivered.[5]

In order to optimize the use of residual anatomical bone in the upper jaw, the concept of zygomatic fixtures was introduced by Brånemark in 1988. Zygoma implants were initially designed for the prosthetic rehabilitation of patients with extensive maxillary defects due to tumor resections, traumas and congenital defects. Their use was later extended to severe upper jaw atrophies. The use of zygoma implants is currently indicated in patients who are not eligible for or refuse bone reconstruction surgery and in whom significant rehabilitation time and reduced compliance are expected.

Available literature has outlined two major approaches for the placement of zygoma implants: The intra-sinus approach and the extra sinus approach. With the internal technique, first described by Branemark, the implant site preparation always starts palatal to the residual crest. The zygomatic implant is inserted through the sinus into the zygomatic bone, engaging both the palatal aspect of the residual ridge and the zygomatic bone. Long titanium implants (30-52.5 mm) were placed across the alveolar crest and cortically anchored in the zygomatic bone. The prosthetic platform of the zygoma implant was located on the palatal side of the alveolar process compromising the position and mechanics of the upper prosthetic framework.[6]

The technique requires just one surgical procedure and it allows application of an immediate prosthetic load, thus considerably shortening rehabilitation time. There is no need for mucogingival surgery or donor sites for bone harvesting, thus ensuring less morbidity, less invasiveness and less discomfort to the patient (Balshi et al, Mozzati et al). An adequate rehabilitation is therefore provided in certain patients along with restoring function, improving aesthetics and allowing patients to return to a normal social life.

In case of the intra sinus approach, implants are placed in close proximity to the maxillary sinus and like any surgical procedure there has been evidence of complications such as difficult surgical visualization and excessive palatal position of the implant head resulting in a bulky prosthesis leading to discomfort and problems with oral hygiene maintenance and speech.[7]

Along with this postoperative sinusitis, oro-antral fistula formation, periorbital and subconjunctival hematoma and facial oedema were also noted (Aastha et al).

The extra sinus approach (extra-maxillary surgical protocol) was first described by Malo et al. Here, the implant osteotomy starts more bucally on the residual crest and a bony dehiscence is created along with planned path of the zygomatic implant from the residual ridge up to the maxillary antral wall, creating a channel where the zygomatic implant will rest in. Particular attention is paid to preservation of the underlying maxillary membrane, especially more inferiorly near to the crest. In this protocol there is no crestal anchorage per se with threads engaging cortical bone, but only buttressing of the implant against the underlying bone is seen.

Hence, the extra sinus surgical approach minimizes the rate of rupture of the sinus membrane during implant insertion compared with the intra sinus approach, thereby reducing the possibility of complications as compared to the intra sinus approach.

Thus, the aim of the current systematic review was to address the focus question "In patient requiring rehabilitation of atrophic maxilla, does an extra sinus zygomatic implant improve the surgical outcome as compared to the conventional or intra sinus zygomatic implant?"

METHODS

Protocol and registration

This review was conducted according to the preferred reporting items for systematic review and meta-analyses (PRISMA) statement, conforming to which a detailed protocol was established. The systematic review was conducted to evaluate the surgical outcome of extra sinus zygomatic implants in comparison to conventional or intra sinus zygomatic implants for rehabilitation of patients with

atrophic maxilla. The protocol has been accepted by Prospero and the registration ID is CRD42022351412 (https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42022351412).

Eligibility criteria

Inclusion and exclusion criteria were fixed and the studies were screened based on the criteria mentioned.

Inclusion criteria

All human prospective and retrospective cohort studies, observational studies and case series and case reports; studies which included patients who underwent zygomatic implant placement by extra sinus technique and conventional technique or intra sinus approach; patients in need for rehabilitation of the maxilla with a complete or partial fixed implant supported prosthesis; studies which included patients with posterior maxillary bone height immediately distal to the canine pillar of 1 to 3 mm maximum (<4 mm). Studies which included patients with at least 8 mm height in the anterior maxilla. Studies published in English language between 01 January 2002 to 31 December 2022.

Exclusion criteria

All in-vitro and animal studies; studies published in any other language; patients with general and local health condition that prevented the use of general anaesthesia and/or intraoral surgery; patients with conditions that could lead to osseointegration problems, such as patients in use of bisphosphonates; patients with poor oral hygiene or pregnancy; patients with history of chemotherapy or radiotherapy; and patients with emotional instability or unrealistic aesthetic demands were excluded.

Information sources

All articles published in English were searched through databases like PubMed, Google scholar, Proquest, Cochrane and Ovid-Medline from 01 January 2002 till 31 December 2022. Cross references were checked for relevant articles and grey literature was also searched for the same. Hand searching of articles was done when the full texts of the relevant studies were not available through electronic database.

Search strategy

Initial search aimed at identifying studies that comprised of extra sinus and intra sinus techniques of zygomatic implant placement. Implant survival rate and prosthetic failure were taken as primary outcomes. Peri-implantitis, chronic sinusitis, mechanical complications, bone loss, functional complications and aesthetic complaints were considered as secondary outcomes. Articles published in English language till 31 December 2022 were selected. Filters were applied for study design and mainly focused on prospective cohort studies, retrospective cohort studies, observational studies, case series and case reports.

Furthermore, hand searching was conducted on the reference list of selected articles to identify additional publications.

Selection process

At each stage of the study screening, two researchers namely RP and RM independently screened the titles and abstracts obtained by search strategy and included them if they met the inclusion and exclusion criteria. Full-text of relevant articles that met the inclusion and exclusion criteria were then reviewed and any uncertainty or disagreements were resolved by discussion with the third author (VJ). The quality assessment of each article was done by two researchers (RP and RM) independently and later it was cross checked. Study characteristics of included studies are depicted in (Table 1).

Finally, the search yielded 5 articles for inclusion in the systematic review. None of the authors were blinded to the journal titles, study authors or the institution where the study was conducted.

Data collection process

A standardized data extraction form was prepared in Microsoft excel with the help of an expert and discussion was done in case of any disagreement.

The following criteria were predetermined for extracting data: the primary outcomes were implant survival rate and prosthesis failure; while, the secondary outcomes were periimplantitis, chronic sinusitis, mechanical complications, bone loss, functional complications and aesthetic complaints.

Finally, the individual data collected by the two reviewers (RP and RM) were combined and any disagreement was resolved by discussion with the third reviewer (VJ).

Risk of bias assessment

The major aim of the quality assessment was to determine the potential for selection bias, eligibility criteria, sampling strategy, sample size, primary outcome (implant survival rate, and prosthesis failure) and secondary outcomes (chronic sinusitis, periimplantitis, bone loss, mechanical complications, functional complications and aesthetic complaints). The risk of bias in the individual studies were assessed using Newcastle Ottawa scale.

Newcastle-Ottawa quality assessment form for cohort studies selection

Representativeness of the exposed cohort: truly representative (one star), somewhat representative (one

star), selected group, and no description of the derivation of the cohort.

Selection of the non-exposed cohort: drawn from the same community as the exposed cohort (one star), drawn from a different source, and no description of the derivation of the non-exposed cohort.

Ascertainment of exposure: secure record (e.g., surgical record) (one star), structured interview (one star), written self-report, no description, and others.

Demonstration that outcome of interest was not present at start of study: yes (one star) or no.

Comparability

Comparability of cohorts on the basis of the design or analysis controlled for confounders: the study controls for age, sex and marital status (one star), study controls for other factors (one star), and cohorts are not comparable on the basis of the design or analysis controlled for confounder.

Outcome

Assessment of outcome included: independent blind assessment (one star), record linkage (one star), self-report, no description, and others.

Was follow-up long enough for outcomes to occur: yes (one star) or no.

Adequacy of follow-up of cohorts included: complete follow up- all subject accounted for (one star); subjects lost to follow up unlikely to introduce bias-number lost less than or equal to 20% or description of those lost suggested no different from those followed (one star); follow up rate less than 80% and no description of those lost; and no statement.

Synthesis of results

A comprehensive meta-analysis was carried out after assessing the risk of bias of the individual studies. No heterogeneity was found with respect to study designs. The primary outcome measured were implant survival rate and prosthesis failure. The secondary outcome measured were chronic sinusitis and peri-implantitis.

The 95% confidence interval (CI) of each variable were estimated and a fixed effects model was applied for the meta-analysis. Forest plots were produced to graphically represent the primary and secondary outcomes. Heterogeneity was assessed with the I^2 test, which ranges between 0% and 100%, (0-40%: minimal heterogeneity, 30-60%: moderate heterogeneity, 50-90%: representing substantial heterogeneity, and 75-100%: considerable heterogeneity). In addition, funnel plots were used to assess the presence of publication bias.

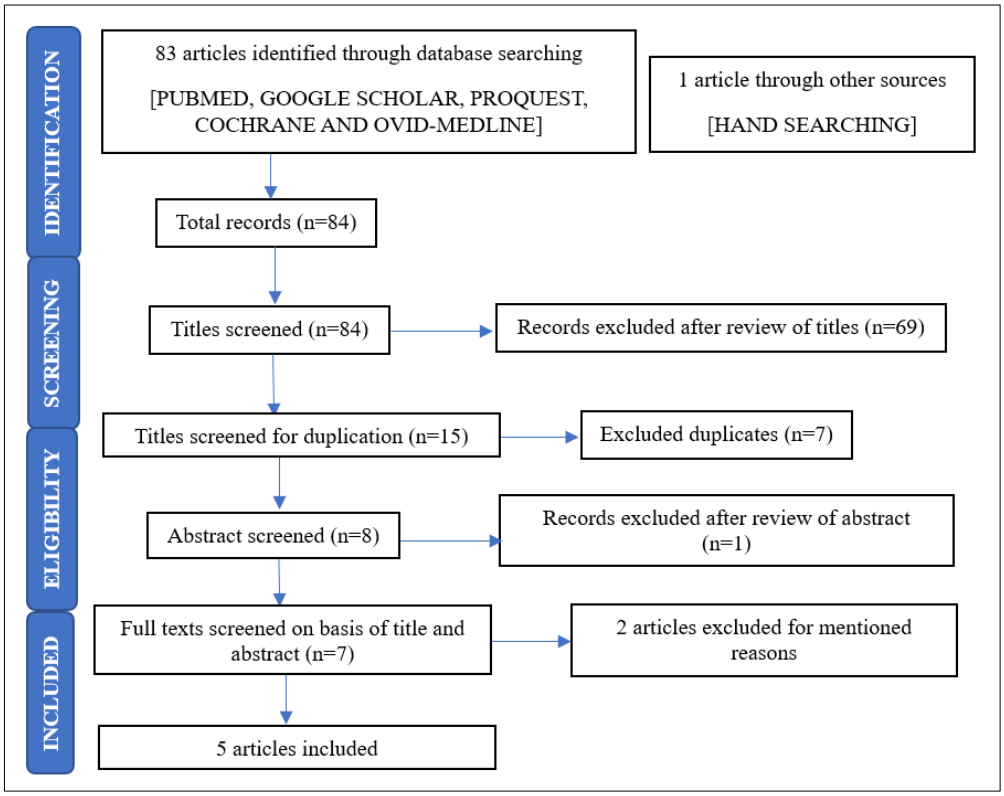

Figure 1: Flow diagram depicting the process of selection and exclusion of articles at each step.

RESULTS

Study selection

The electronic and manual searches identified 84 articles, 5 articles in PubMed, 71 in Google Scholar, 7 in Proquest and 0 in OVID - Medline and Cochrane and 1 article from hand searching. The title screening was done. Of the 15 articles selected after title screening, 7 articles were excluded as duplicates. Further, abstract screening was done for 8 articles and 1 article was excluded. Full text screening of remaining 7 articles was done and further 2 articles were excluded. 5 articles which met the inclusion criteria were selected. The surgical outcome (implant survival rate) of extra sinus zygomatic implant was compared to intra sinus or conventional zygomatic implants in patients with completely or partially edentulous maxilla.

The reference numbers allotted to the included articles in the tables will be used throughout the rest of the review (Table 1).

Study characteristics

Characteristics of included studies

A total of 5 eligible articles were included in this review that evaluated the surgical outcome (implant survival rate) of extra sinus zygomatic implant as compared to intra sinus or conventional zygomatic implants in patients with completely or partially edentulous maxilla. Three of the included studies were retrospective cohort studies and two were prospective cohort studies. They were published in English from the year 2012 to 2018. The sample size (No. of implants placed) of the included studies was 35, 169, 1542, 273 and 114 respectively. The included studies were conducted in Brazilian population (Coppede et al and Reginaldo et al), Portuguese population (Paulo Malo et al) and Polish population (Pawel et al).[2,4,5,9,11]

Characteristics of participants

All the participants with the need of rehabilitation in atrophic maxillary posterior region were included in the study. All the five studies, mentioned about the number of female and male patients included in the study. Four studies specified about the age range of the included patients, while in the study by Reginaldo et al, the age range was not mentioned.[2] The age group of individuals incorporated in the studies that were included in this review was in the range of 17 to 85 years. The mean age of the patients was mentioned in all the studies (Pawel et al, Paulo Malo 2014 et al, Paulo Malo 2013 et al, Abilio Coppede et al, and Reginaldo et al) (Table 2).[2,4,5,9,11]

Characteristics of the intervention

All the studies evaluated the comparison of surgical outcomes (implant survival rate) of extra sinus zygomatic implant as compared to intra sinus or conventional zygomatic implants in patients with completely or partially edentulous maxilla. Study conducted by Pawel et al was a retrospective study in which there was a comparison carried out between two groups: extra sinus zygomatic implants and intra sinus zygomatic implants.[4] Outcome measures were assessed using various parameters. In the original P-I Branemark zygoma protocol the implants were passing through the sinus, which resulted in chronic sinusitis in some patients and malposition of the prosthetic platform toward the palate. These complications can be avoided by the extra-sinus placement of zygoma implants as suggested in this study.

Paulo Malo et al conducted a retrospective cohort study where he analysed the various primary and secondary outcomes that were used to compare extra sinus and intra sinus zygomatic implants.[11] Abilio Coppede et al conducted a prospective cohort study to evaluate the clinical outcomes of extra sinus zygomatic implants, installed laterally to the maxillary sinus compared to the conventional or intra sinus zygomatic implants. Outcome measures were assessed using various parameters.[5]

Characteristics of outcomes

The summarized treatment outcomes of all the included articles are given in Tables 3 and 4.

The primary outcomes included were: Implant survival rate and prosthesis failure.

The secondary outcomes included were: chronic sinusitis, periimplantitis, bone loss, mechanical complication, functional complications and aesthetic complaints.

Implant survival rate

None of the implants were lost among all the 5 selected studies. Pawel et al reported 97.15% of implant survival rate in test group and 93.87% in the control group.[4] Paulo Malo et al 2014 reported implant survival rate of 98.8% and 100% in the test and control group respectively.[11] Paulo Malo et al 2013 reported implant survival rate of 98.2% and 97.9 % in the test and control group respectively.[9] Abilio Coppede et al reported implant survival rate of 98.9% and 97.9 % in the test and control group respectively.[5] Reginaldo et al reported implant survival rate of 97.5% and 95.9 % in the test and control group respectively.[2]

Prosthetic failures

Pawel et al reported 0 prosthesis failure in test group and 2 prosthesis failure in the control group.[4] Paulo Malo et al 2014 reported 1 and 0 prosthesis failure in the test and control group respectively.[11] Paulo Malo et al 2013 reported 4 prosthetic failure and 0 prosthesis failure in the test and control group respectively.[9] Abilio Coppede et al reported 0 prosthetic failure in both the test and control

group.[5] Reginaldo et al reported 1 and 3 prosthesis failure in the test and control group respectively.[2]

Chronic sinusitis

In the study by Pawel et al chronic sinusitis occurred in 4 patients (11.42%) who received zygomatic implants in the standard protocol through the sinus (intra sinus approach).[4] None of the extra-sinus zygoma patients developed either acute or chronic sinusitis. In the study conducted by Paulo Malo et al 2014 the incidence rate of maxillary sinus pathology was 16% in the control group (intra sinus zygomatic implants).[11] No significant chronic sinusitis was associated with the test group (extra sinus zygomatic implant). In the study by Paulo Malo et al 2013 the incidence rate of maxillary sinus pathology was very low, 7% (n=26 patients) in the control or intra sinus group.

Peri-implantitis

In the study by Pawel et al peri-implantitis was detected with only 3% of intra sinus zygomatic implants.[4] In the study by Paulo Malo et al 2013 peri-implant pathology was observed in 54 patients. The situations were resolved in 43 patients: in 34 patients through nonsurgical treatment with scaling and irrigation with chlorhexidine; in 4 patients through the administration of nonsurgical treatment together with antibiotics; and in 5 patients through surgical intervention (removal of granulation tissue and decontamination of the implant surface with chlorhexidine 0.2%). In 11 patients the situation was not resolved (1 patient who was lost to follow-up, 1 patient in active chemotherapy, and 9 patients who presented an inability to maintain a minimum-standard level of oral hygiene, though the implants clinically remained stable during the follow-up period of the study). In the study conducted by Abilio Coppede et al 1% peri-implantitis occurred in the test group (extrasinus zygomatic implants) and no peri-implantitis with the intra sinus zygomatic implant group. None of the zygomatic implants in the test and control group showed peri-implantitis.

Complications

In the study conducted by Paulo Malo et al 2014, mechanical complications occurred in total 6 patients which included 3 fractured prostheses in 3 patients; abutment screw loosening in 1 patient and prosthetic screw loosening in 2 patients.[11]

In the study done by Paulo Malo et al 2013 mechanical complications were observed in 156 patients (44%) which included 101 fractures of the prosthesis, loosening of prosthetic components in 53 patients and crown avulsions in 2 patients.[9] Biologic complications were observed in 80 patients (22.7%). In the study done by Abilio Coppede et al no soft tissue complications were observed in the zygomatic implants.[5] Minor technical complications like fractures or detachments of one or more acrylic teeth, which were all repairable were observed in 5 implant-supported restorations (14.7%). In the study done by Reginaldo et al no loosening or fractures of the abutments or the prosthetic screws were recorded but two patients reported difficulty in cleaning around the abutment connected to the zygomatic implant.[2]

Functional complications and aesthetic complaints

Functional complications and aesthetic complaints were also considered as secondary outcomes. No functional complications or aesthetic complaints were registered during the follow up of the study by Paulo Malo et al 2014, Paulo Malo et al 2013 and Abilio Coppede et al.[5,11] In the study by Reginaldo et al two patients with intra sinus zygomatic implant reported difficulty in cleaning around the abutment connected to the zygomatic implant.[2]

Excluded studies

Out of 7 articles, two articles were excluded from this review because they didn't fulfill the criteria of the systematic review. Jain et al compared extra sinus and intra sinus zygomatic implants, but the parameters assessed very different and didn't meet the primary and secondary outcomes of the review.[1] Post-operative pain, swelling and zygomatic bone fracture was assessed between the two groups.

Similarly, Carlos Aparicio et al also assessed for different parameters which didn't meet the selected outcomes of the review.[10] The parameters considered in the study were implant stability, mean distance of the zygomatic implant to the central part of the residual crest. Hence, for the following reasons these two studies were excluded from the systematic review.

Risk of bias across the studies

In the present systematic review, risk of bias in individual studies was assessed using Newcastle Ottawa scale, since the included studies were cohort studies. It is widely used and recommended by Cochrane.

From the Newcastle Ottawa scale it was interpreted that studies by Pawel et al, Paulo Malo et al, and Paulo Malo et al were fair quality studies (total score- 7/9), whereas, studies by Abilio Coppede et al, and Reginaldo et al were good quality studies (total score- 8/9).[2,4,5,9,11]

Risk of bias conclusion

Studies by Abilio Coppede et al and Reginaldo et al were considered to show low risk of bias whereas there was moderate risk of bias with respect to study done by Pawel et al, Paulo Malo et al and Paulo Malo et al.[2,4,5,9,11]

Meta-analysis

For meta-analysis all the 5 studies were selected. Since there was not much heterogeneity observed among all the

selected studies fixed effect model was used as shown in the forest plots.

The funnel plot was also assessed for all the included studies.

Primary outcome

The primary outcomes assessed in all the studies for meta-analysis was the implant survival rate and the prosthesis failure. In case of implant survival rate the overall difference between the control (intra sinus zygomatic implants) and test group (extra sinus zygomatic implant) was not statistically significant, p=0.23. The overall heterogeneity (I^2) from baseline to end points was 0% (Figure 2a and b).

In case of prosthesis failure, the overall difference between the control (intra sinus zygomatic implants) and test group (extra sinus zygomatic implant) was not statistically significant, p=0.65. The overall heterogeneity (I^2) from baseline to end points was 0% (Figure 3a and b).

Secondary outcome

The secondary outcomes assessed in all the studies for meta-analysis was chronic sinusitis and peri-implantitis. In case of chronic sinusitis, the overall difference between the control (intra sinus zygomatic implants) and test group (extra sinus zygomatic implant) was statistically significant, p=0.0002. The overall heterogeneity (I^2) from baseline to end points was 0%.

In case of peri-implantitis, the overall difference between the control (intra sinus zygomatic implants) and test group (extra sinus zygomatic implant) was statistically significant, p=0.01. The overall heterogeneity (I^2) from baseline to end points was 16%. Meta-analysis was not possible for other secondary parameters like bone loss, mechanical complications, functional complications and aesthetic complaints. Since there was heterogeneity noted among these parameters.

Table 1: Characteristics of the included studies.

S. no.	Author	Year of public-ation	Study design	Total no. of implants	Location of study	Year of study
1	Pawel et al[4]	2018	Retrospective cohort	35	Department of Periodontology of the Medical University of Lublin, Poland	2004-2017
2	Paulo Malo et al[11]	2014	Retrospective cohort	169	Private clinics, Portugal	January 2006-March 2012
3	Paulo Malo et al[9]	2013	Retrospective cohort	1542	Private rehabilitation center at Lisbon, Portugal;	January 2006-July 2012
4	Abilio Coppede et al[5]	2016	Prospective cohort	273	Department of Periodontology and Oral Implantology, Dental Research Division, Brazil	November 2010-July 2014
5	Reginaldo et al[2]	2012	Prospective cohort	114	Private dental office at Campinas city, Brazil	January-December 2003

Table 2: Characteristics of participants in the included studies.

S. no.	Author	Sex (M/F)	Age (years)	Mean age
1	Pawel et al[4]	11 (M), 11 (F)	33-69	50.4
2	Paulo Malo et al[11]	9 (M), 30 (F)	32-77	53.5
3	Paulo Malo et al[9]	71 (M), 281 (F)	17-85	55.2
4	Abilio Coppede et al[5]	10 (M), 32 (F)	37-79	58
5	Reginaldo et al[2]	8 (M), 13(F)	ND	55.14±6.66

Table 3: Summary of primary treatment outcomes.

S. no.	Author	Primary outcomes			
		Implant survival rate (%)		Prosthesis failure	
		Test group	Control group	Test group	Control group
1	Pawel et al[4]	97.15	93.87	0	2
2	Paulo Malo et al[11]	98.80	100	1	0
3	Paulo Malo et al[9]	98.20	97.90	4	0

Continued.

S. no.	Author	Primary outcomes			
		Implant survival rate (%)		Prosthesis failure	
		Test group	Control group	Test group	Control group
4	Abilio Coppede et al[5]	98.90	97.90	0	0
5	Reginaldo et al[2]	97.50	95.90	1	3

Table 4: Summary of secondary treatment outcomes.

S. no.	Author	Chronic sinusitis (%)		Periimplantitis (%)		Bone loss (mm)		Mechanical complications (%)		Functional complication		AC
		T	C	T	C	T	C	T	C	T	C	
1	Pawel et al[4]	0	11.42	0	3	ND	ND	ND	ND	ND	ND	ND
2	Paulo Malo et al[11]	0	16	2.5	5	0	1.16	0	19	NC	NC	NC
3	Paulo Malo et al[9]	0	7	3.12	15	ND	ND	4	ND	NC	NC	NC
4	Abilio Coppede et al[5]	0	0	1	0	1.34	1.10	0	14.7	NC	NC	NC
5	Reginaldo et al[2]	0	0	0	0	ND	ND	0	0	ND	2	ND

T: Test, C: control, ND: not defined, AC: aesthetic complaints, NC: no complaints

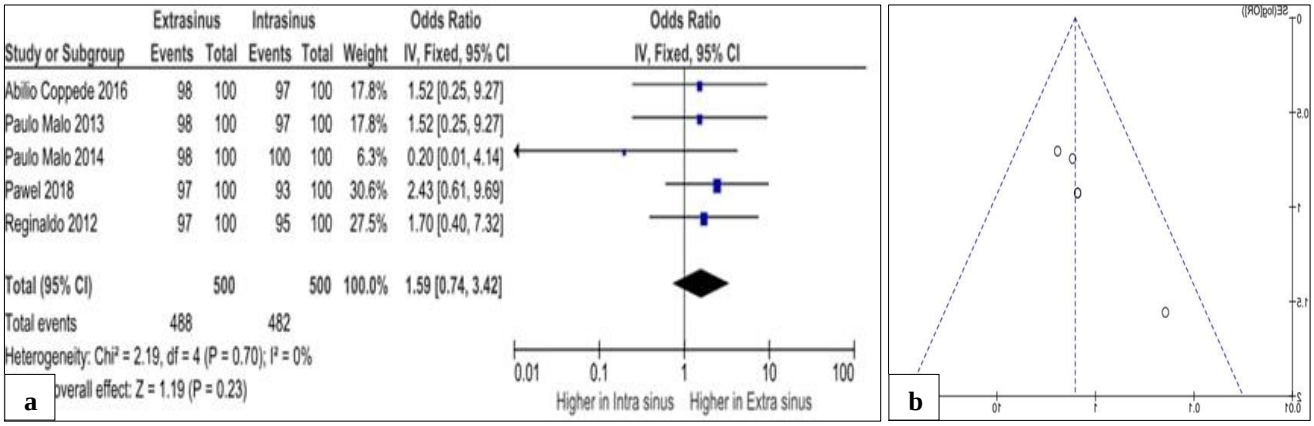

Figure 2: (a) Forest plot showing implant survival rate among extra sinus and intra sinus zygomatic implants; and funnel plot showing implant survival rate among extra sinus and intra sinus zygomatic implants.

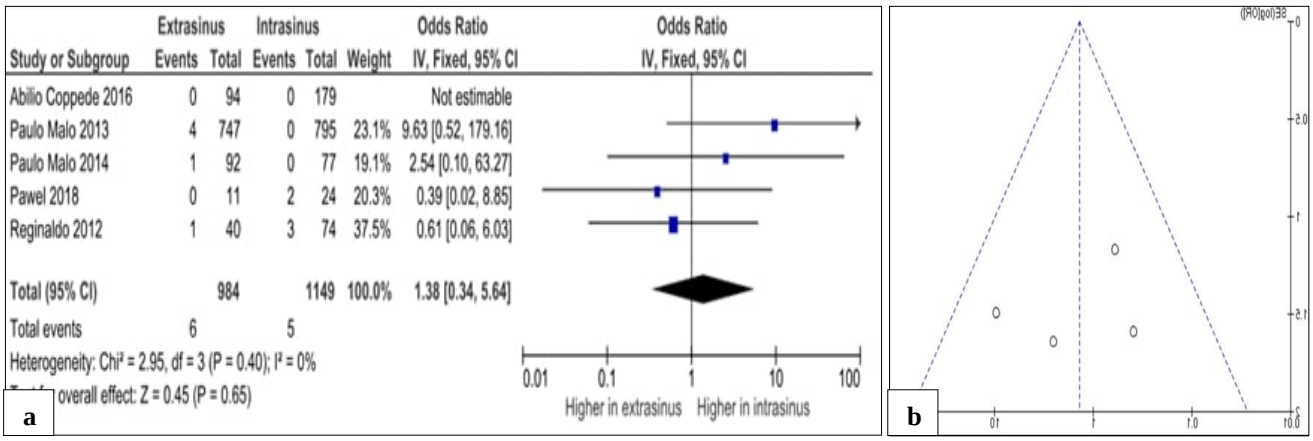

Figure 3: (a) Forest plot showing prosthesis failure among extra sinus and intra sinus zygomatic implants; and (b) funnel plot showing prosthesis failure among extra sinus and intra sinus zygomatic implants.

Table 5: Risk of bias assessment using Newcastle Ottawa scale.

Study	Selection				Compar-ability	Outcomes			Total 9/9
	Represen-tativene-ss of exposed cohort	Selecti-on of non-expo-sed cohort	Ascertain-ment of exposure	Outcome not present at the start of the study		Assessme-nt of outcomes	Length of follow-up	Adequa-cy of follow-up	
Pawel et al	*	*	0	0	**	*	*	*	7/9
Paulo Malo et al 2014	*	*	0	0	**	*	*	*	7/9
Paulo Malo et al 2013	*	*	0	0	**	*	*	*	7/9
Abilio Coppede et al	*	*	0	*	**	*	*	*	8/9
Reginaldo et al	*	*	0	*	**	*	*	*	8/9

DISCUSSION

Tooth loss is a very common problem, hence research on dental implant design, materials and techniques used has increased in the past few years. Rehabilitation of the patient by fixed prosthesis using dental implants has gained popularity in the last two decades. Although it is not considered as cost-effective treatment option, it has many other advantages such has better survival rate, no alteration in the structure of adjacent teeth is needed and no requirement of support from adjacent dentition. For these reasons people are preferring fixed prosthesis using dental implants.

Often, limited bone quantity and poor bone quality limit the use of conventional implants, particularly in the posterior segments of maxilla with pneumatization of the maxillary sinus thus, making the rehabilitation of the severely atrophic maxilla challenging.[8] First alternative to overcome such challenge was using bone grafting procedures to reconstruct the maxilla and provide enough support for the use of conventional implants. However, disadvantages associated with surgical technique, such as the postsurgical morbidity (in the situation of using autogenous bone graft from different donor sites) or the extended healing period of the graft, limited the use of immediate function in the rehabilitation process of these patients, eliminating the option of implant insertion, abutment and prosthesis connection on the same day of the surgery.[9]

Efforts have been made to pursue alternatives to grafting procedures. During the last two decades, the zygoma implant has proven to be an effective option in the management of the atrophic edentulous maxilla, as well as for maxillectomy defects.

The Branemark zygoma implant was introduced for the prosthetic rehabilitation of patients with extensive defects of the maxilla caused by tumor resections, trauma and congenital defects. The bone of the zygomatic arch was used for anchorage of a long implant, which, together with ordinary implants, could be used as an anchor for epistheses, prostheses and obturators. The technique has enabled sufficient rehabilitation of these patients, providing restored function, improved esthetics, thereby resulting in a normal social life.[10]

According to Corvello et al, there are two main methods of zygomatic implant placements described in the currently available literature on implant dentistry. The original technique was devised and described by the father of implantology, Branemark, and is known as the intra-sinus technique. It is a technique where the implant passes through the maxillary sinus with a window technique and most commonly used when the concavity formed between the maxillary sinus, ridge crest and the site of implant placement is small. The extra-sinus technique as described by Aparicio et al, implies that the implant passes outside the maxillary sinus; it is commonly used when there is a bigger concavity in the area formed by the maxillary sinus, the ridge crest and the site of implant placement.

The present systematic review compared the surgical outcomes (implant survival rate) of zygomatic implant placed by intra sinus and extra sinus approach. After the final search, 5 articles- Pawel et al, Paulo Malo et al 2014, Paulo Malo et al 2013, Abilio Coppede et al and Reginaldo et al were selected for the review.[2,4,5,9,11] The primary outcomes evaluated in the systematic review were implant survival rate and prosthesis failure. While the secondary outcomes were chronic sinusitis, peri-implantitis, bone loss, mechanical complications, functional complications and aesthetic complaints.

Total 2133 implants were placed in 476 patients out of which 984 were extra sinus zygomatic implants and 1149 were intra sinus zygomatic implants. The implant survival rate was more in the zygomatic implant placed through the extra sinus technique as compared to the intra sinus

technique in all the studies. There was no statistically significant difference seen between the test and the control group. Similarly, for the prosthesis failure among the test and the control group there was no statistically significant difference seen.

In case of chronic sinusitis there was a statistically significant difference seen between the test and the control group. The incidence of chronic sinusitis was 11.42% (Pawel et al), 16% (Paulo Malo et al) and 7% (Paulo Malo et al) more in the control group as compared to the test group.[4,9,11] Thus, the chronic sinusitis seems to be more prevalent in the intra sinus zygomatic implants as compared to the extra sinus zygomatic implants. Patients with a previously diagnosed maxillary sinusitis and/or a disrupted maxillary sinus membrane during surgery seems to be at a higher risk of maxillary sinus infection. Hence it is recommended that patients with a previous history of sinusitis should be rehabilitated with zygomatic implants inserted extra maxillary trying to avoid the rupture of the sinus membrane in order to decrease the probability of sinus infection.

The incidence of peri-implantitis was less with the extra sinus zygomatic implants. There was a statistically significant difference between the extra sinus zygomatic implants and intra sinus zygomatic implants (Pawel et al, Paulo Malo et al and Paulo Malo et al).[4,9,11] Periodic professional maintenance of oral hygiene with strict biofilm control protocol probably improves the success rate and decreases the biological complications.

The marginal bone loss in studies done by Paulo Malo et al and Abilio Coppede et al was comparable to previously proposed success criteria for dental implants.[5,11] It was 1.16 mm for the control group in the study by Paulo Malo et al and 1.34 and 1.10 for test and control group respectively in the study by Abilio Coppede et al.[5,11] This was below the threshold of 2 mm.

In study done by Paulo Malo et al, mechanical complications occurred in 6 patients (19%).[11] These results were within the interval period reported in previous studies, that is between 14% and 55%. Half of the mechanical complications reported were minor (prosthetic components loosening) and were easily resolved.[11] In the study by Abilio Coppede et al mechanical complications were 14.7% in the control group as compared to the test group.[5]

Similar outcomes were noted in studies conducted by various authors. Ji-Youn et al conducted a study to evaluate the effectiveness of the extra sinus technique. In all the eleven patients restored with the extra sinus technique, they found that all the zygomatic implants were well maintained after five years of function with a cumulative success rate of 100%.[12] These findings were coherent with the findings of the current review where a high success rate was recorded when the extra sinus technique was used.

To further evaluate the behavior of the maxillary sinus after the placement of zygomatic implants with the intra-sinus technique in patients with severe atrophy, Hilario et al conducted a 10-15-year retrospective follow up study. In the 18 patients that they reviewed with a total of 34 zygomatic implants placed, seven implants failed, resulting in a survival rate of 79.5%. Seven patients (38.8%) had involvement of the maxillary sinus. One of the patients was diagnosed with rhino sinusitis and 6 patients with odontogenic sinusitis. A total of 3 implants were removed due to mobility and four implants had their coronal component cut off through a window in the sinus. These results closely resemble the findings of the intra-sinus technique in the present systematic review.

Another issue with the intra-sinus technique was palatal emergence of the implant head which lead to serious difficulties with phonetics, comfort, hygiene and its effect on the future of the prosthesis (Branemark et al). For this reason, wherever possible, extra-sinus implants were preferred since they can improve the intra-oral emergence towards a more crestal position as well as reduce sinus complications (Nocella et al).[13]

Contrary to the findings in this study, Davo et al and Balshi et al who had reported a higher success rate with the intra sinus technique (95% and 96.37% respectively).[14]

In the present systematic review and meta-analysis, it can be concluded that there were no statistically significant differences in the primary outcome parameters like implant survival rate and prosthesis failure between the test and the control group. While, there was a statistically significant difference noted in the secondary outcome parameters between the test and the control group. The incidence of chronic sinusitis and peri-implantitis were comparatively low with the extra sinus zygomatic implants as compared to the conventional or intra sinus zygomatic implants.

Posterior maxillary atrophy presents a challenge for implant-supported dental rehabilitation. Zygomatic implants allow for optimum and predictable implant-supported dental rehabilitation whilst avoiding the morbidities associated bone-augmentation procedures.

CONCLUSION

Through this systematic review we can conclude that extra sinus zygomatic implants placed in immediate function is a viable treatment for rehabilitation of patients with atrophic maxilla. The extra sinus technique aims to simplify the surgical procedures and to improve prosthetic outcomes. According to this technique, zygomatic implants are installed out of the maxillary sinus, reducing surgical time, the risk of sinus adverse events and improving surgical visualization. The prosthetic profile of the restoration is considerably improved. Also, the implant head is positioned on the top of the crest, resulting in a more normal extension of the bridge framework.

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