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ORIGINAL RESEARCH

Role of zygomatic implants for rehabilitation of maxillofacial defects: A systematic review

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ABSTRACT

Aim: The purpose of this systematic review was to evaluate clinical studies on the follow-up survival of implants inserted in the zygomatic bone for maxillary rehabilitation for maxillofacial defects.

Methodology: A comprehensive search of studies published from 2000 to July 2022 and listed in the PubMed/MEDLINE, Embase, and Cochrane Library databases was performed in accordance with the PRISMA statement. Relevant studies were selected according to predetermined inclusion and exclusion criteria. The initial database search yielded 751 titles. After filtering, 313 abstracts were selected, culminating in 42 full text articles. Application of eligibility criteria led to the elimination of 17 articles. Hence 25 full-text articles were considered clinically relevant and were included.

Results: Calculations of the interval survival rates and cumulative survival rates of implants could be carried out on the data extracted from the final list of included studies for the different time intervals. These studies reported the insertion of a total of 1541 zygomatic implants and 33 implant failures. Failure generally occurred during the first year interval and was related to clinical complications, such as recurrent acute and chronic sinusitis. After a 36-month follow-up, the survival rate was 97.86%.

Conclusion: Additional studies with longer follow-up periods, including the number of zygomatic implants inserted and details of the variations in the surgical techniques used and the impact of the maxillary morphology are still required.

Keywords: zygomatic implants; follow-up; dental implants; edentulous maxilla.

INTRODUCTION

Dentures, especially in atrophic jaws, are associated with different kinds of morbidity (stomatitis, traumatic ulcers, and irritation-induced hyperplasia), psychological alterations (depression), and social problems (reduced social interactions, educational opportunities, and job opportunities).[1] Rehabilitation of the masticatory function with dental implants can be achieved with predictable success in various clinical situations, and acceptable long-term results have been presented in patients with sufficient bone volume. However, the problem of insufficient height and width of the alveolar ridge at the implant site remains. The severely atrophied maxilla constitutes a challenging therapeutic problem because bone augmentation is required to enable placement of a sufficient number and length of implants.[2] Advanced posterior alveolar resorption combined with increased maxillary sinus pneumatization often leaves insufficient bone for implant anchorage.[3] Even more challenging are conditions such as cleft deformities, maxillary sinus aplasia, and maxillectomy defects which present a discontinuous maxilla and complex bony and soft tissue anatomy.[4]Bra°nemark et al.[5] and others [6] have suggested that oral implants may be fixed in the zygomatic bone, alone or in combination with conventional implants, for the rehabilitation of an atrophic maxilla, or as an attachment system after a hemimaxillectomy. The zygomatic bone allows anchoring far from the occlusal level and presents regular and compact trabecular bone with 98% of bone density.[7] For these reasons, some have suggested that zygomatic implants could be used as an alternative for fixed rehabilitation in edentulous patients.[8] The use of zygomatic implants increases treatment success and decreases the use of bone grafts, the number of surgical steps, and the length of treatment.[9] However, there are factors that are important to consider during the surgical–prosthetic planning of zygomatic implants, such as the size and extension of the nasal cavities, bone quantity, number and size of the implants, and the surgical technique.[10] Clinical com-plications have been reported after implant insertion, including fracture of the prosthetic veneer and maxillary sinus infections requiring removal of the zygomatic implant.[11]

AIM OF THE PRESENT STUDY

The aim of this systematic literature review was to identify relevant clinical studies on zygomatic implants regarding their failure and clinical complications during follow-up. Two hypotheses were tested: (1) implant survival is reduced during the first year, and (2) the failure rate is not influenced by the number of zygomatic implants in various maxillofacial defects.

METHODOLOGY

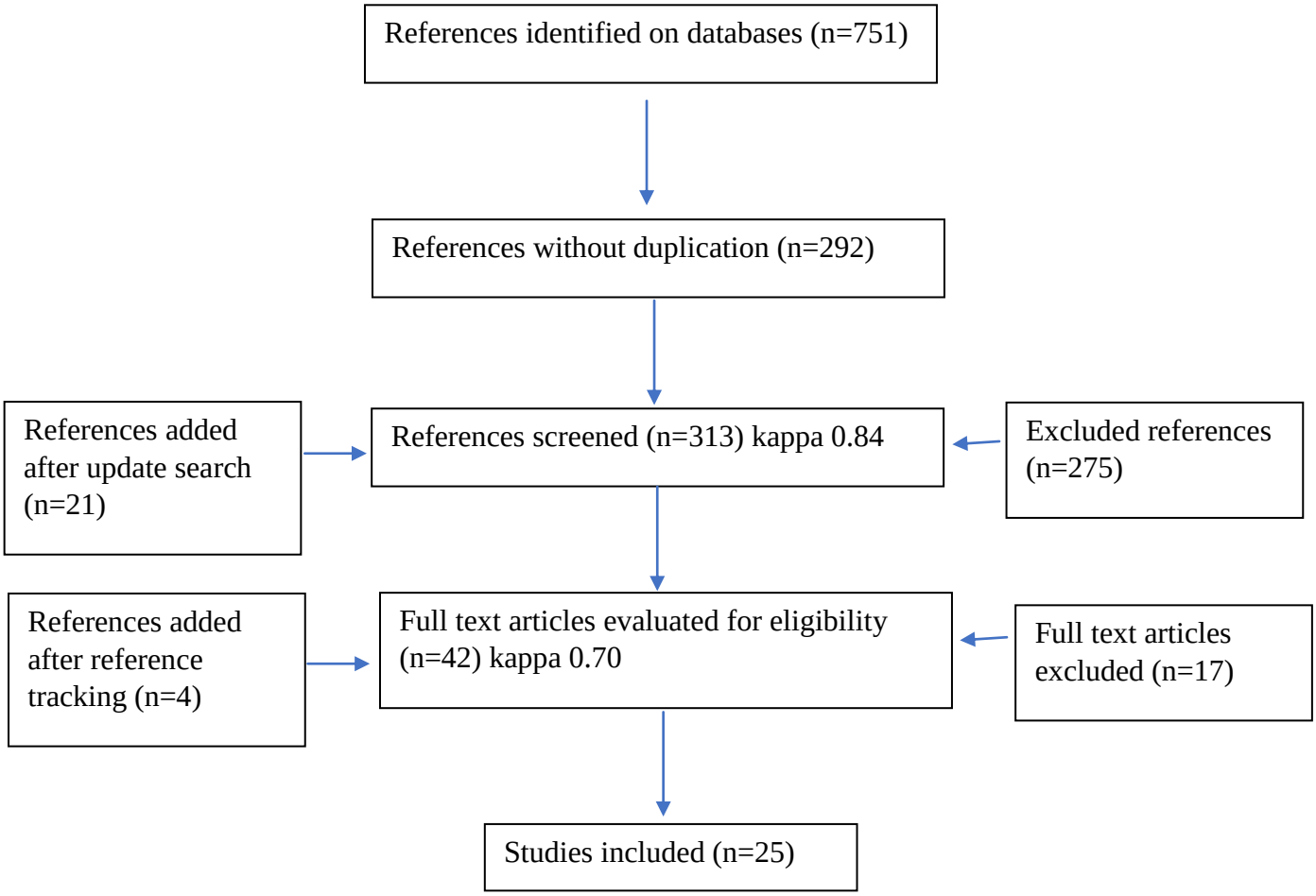
This systematic review was performed in accordance with the PRISMA statement18 and Cochrane guidelines. PubMed/MED-LINE, Embase, and Cochrane Library databases were searched for relevant articles published in English from 2011 to July 2021. The studies were grouped according to whether they evaluated zygomatic implants for maxillary rehabilitation. A broad search strategy was pursued to capture relevant studies on zygomatic implants, grafting, bone resorption, techniques for the insertion of zygomatic implants, implant complications and failures, and patient satisfaction. The key-words ‘zygomatic implants’, ‘follow-up’, ‘clinical study’, ‘dental implants’, and ‘edentulous maxilla’ were used. Data from longitudinal studies were included, and article references were searched to identify additional relevant studies. Studies were selected on the basis of their titles and abstracts according to the exclusion criteria for abstracts and full text articles. The inclusion criteria were: studies reporting clinical series of zygomatic implants with a follow-up period of at least 2 years; studies including patients with severely deficient edentulous maxillas, oro-nasal communication, and cases of tumour resection of the maxilla that could not be rehabilitated

except with conventional dental implants due to a lack of bone; partially or totally edentulous patients; studies in which immediate or late function protocols were applied. Randomized controlled clinical trials (RCTs), cohort studies, case–control studies, and cross-sectional studies were included. The exclusion criteria were: studies without an initial evaluation at 6–12 months after implant/prosthesis loading; case reports, comments, systematic reviews, and animal studies; non-oral implants (hip/knee). If necessary, the exclusion criteria were reviewed and the abstracts were reassessed until a complete definition of the exclusion criteria was determined. For each study included, the following information was extracted: year of publication; number of patients in whom zygomatic implants were placed; setting and country of the study; whether the patients used partial or complete dentures; implant manufacturer and instruments for measuring failure; whether the implant had a treated surface; type of implant loading; type of prosthesis installed; clinical complications reported before and after insertion of the final prosthesis, including other prosthetic complications reported during the follow-up period; whether the zygomatic/conventional implant was removed; length of the zygomatic implant; surgical protocol used; number of zygomatic implants placed and failed; number of conventional implants placed and failed; follow-up period range; and survival rate of the zygomatic implants. Studies were evaluated regarding feasibility of data synthesis (qualitative and quantitative). All implants were classified into failure and survival groups. Failures included implants removed regardless of the cause, and survivals represented stable implants without signs of pathology, mobility, resistance to removal torque, pain, and peri-implantitis. Clinical and radiographic examinations evaluating peri-implant bone loss or a residual sinus disease, as well as the use of instruments for measuring zygomatic implant integrity, were also recorded. The results were summarized in tables and charts. The survival of zygomatic implants was calculated by Kaplan–Meier method. The failure rate was determined as the percentage of implants lost relative to the number of implants inserted for each study. The statistical analysis was performed using IBM SPSS version 25.0 statistical software.

RESULTS

The search retrieved 751 references, including 382 from Medline, 264 from PubMed, 91 from Embase, and 14 from the Cochrane Library. After duplicate references had been removed, 292 studies were selected for the data synthesis. The search update resulted in 21 additional abstracts. After the 292 abstracts and 21 additional abstracts had been analyzed, 38 studies were selected (inter-reader agreement, kappa = 0.84). Reference tracking revealed an additional four papers, for a total of 42 full-text papers in the eligibility assessment. After the full-texts of these articles had been examined, 25 studies were included in the final review (inter-reader agreement, kappa = 0.70). (Table 1)

Table 1- Literature search and results.



The number of patients with zygomatic implants ranged from 4 to 76, with a mean of 29.9 patients; there was a predominance of female patients. Patients were usually completely edentulous or individuals with a partially edentulous maxilla. The implants exhibited different surface treatments. Fifteen studies conducted late loading (prosthesis insertion at 4–6 months after initial implant loading), whereas 10 studies reported immediate loading. Fixed dentures and overdentures were fabricated, and crowns were veneered with acrylic resin and ceramic. Recurrent acute and chronic sinusitis was reported before and after prosthesis insertion. In eight studies, some of the zygomatic implants were removed from the infected area. Prosthetic complications included fracture of the artificial teeth, removal of a fixed denture or overdenture, and allergy to the metal framework. The zygomatic implant length ranged from 25 to 60 mm. The studies reviewed showed limitations in terms of poor clinical evaluation of the zygomatic implants during follow-up. Some studies used conventional radiography instead of computed tomography (CT) scans as additional resources for verifying whether the implants had failed. CT scans offer three-dimensional images that allow the surgeon to evaluate the zygomatic/bone interface in more detail and to measure the peri-implant bone density. In a detailed analysis, 13 studies showed failures of zygomatic implants with the loss of 33 zygomatic implants that would have supported the prosthesis. However only eight studies reported removal of these zygomatic implants; the others studies did not provide this information. The 25 studies reported a mean follow-up of 42.2 months (range 0–144 months). A total of 1541 zygomatic implants were inserted, and 33 failures/losses were reported. Among the 25 studies, 14 showed a cumulative survival rate of 100%. The survival

rate of zygomatic implants for the 25 studies was 97.86% after 36 months. This value remained constant up to the last follow-up period. Loading decreased the survival of implants after 12 months for late implants and after 24 months for immediate implants. (Table 2)

Table 2- Life-table survival analysis showing the cumulative survival rate of zygomatic implants for the 25 selected studies.

Follow-up intervals of the study (months)	No. of implants in each interval	No. of failures in each interval	Survival rate within each interval (%)	Cumulative survival rate (%)
0–12	1541	27	98.25	98.25
12–24	1398	2	99.86	98.12
24–36	1068	2	99.81	97.99
36–48	533	2	99.62	97.86
48–60	432	0	100.0	97.86
60–72	215	0	100.0	97.86
72–84	51	0	100.0	97.86
>84	4	0	100.0	97.86

DISCUSSION

The data in this study suggest that zygomatic implants may be used as an alternative for patients with severe maxillary resorption. Both hypotheses were accepted: the survival rate decreased considerably after the first year of implant insertion (98.12%), and the results were similar regardless of the loading type. After the first year of loading, the survival rate continued to decrease, and then remained constant from 36 months until the last follow-up period (>84 months). Previous studies have indicated that the insertion of implants in the four regions of the zygomatic cortical bone with thick trabeculae provides anchoring that is resistant to the distribution of occlusal forces.[12] This fact may explain the good long-term results for these implants. Studies have suggested that zygomatic implants may be used as an alternative to bone grafts in patients with severe maxillary resorption because the insertion of zygomatic implants does not require additional grafting.[13] The surgical protocol is less invasive and more predictable. In the present study, the Le Fort I, crestal, and palatal incisions were the most commonly applied approaches. The Le Fort incision provides oral access to the nasal and lateral zygoma opening, whereas the crestal incision allows the insertion of a unilateral zygomatic implant. Such techniques pro-vide excellent prosthetic stabilization. Complications may result from the loss of osseointegration and inflammation of the soft tissues surrounding the abutments (zygomatic implants have deeper pockets compared to those of conventional implants). This situation can lead to contamination and communication between the implant screw and mouth. Some authors have treated the implant surface in the maxillary sinus to avoid biofilm formation and tissue accumula-tion.[14] Most studies that have used zygomatic implants with immediate loading have used modified implant surfaces to maintain the primary stability. Furthermore, frequent and correct oral hygiene to avoid peri-implant inflammation was suggested in all studies. In some studies, the implants failed because initial stability was not present in the low-quality bone during insertion. This situation may be due to the rotating of the apical part of the implant to a more lateral position compared to the initial drilling. In the study of Schmidt et al., two of the three patients who experienced zygomatic implant failure had received radiation therapy.[15] The length of the zygomatic implants ranged from 25 to 60 mm. The zygomatic implants were typically associated with conventional implants for posterior prosthetic rehabilitation. The main stress in the zygomatic implant is distributed at the confines of the lateral wall of the maxillary sinus and the fixture–abutment joint. There is a significant biomechanical disadvantage regarding the long lever arm and the small amount of bone integration. The

biomechanics of the zygomatic implant could be improved by inserting angled implants connected to conventional fixtures.[16] The reduction of the cantilever by zygomatic implants may also result in long-term positive effects in terms of the distribution of the load on the conventional implants. In this situation, the occlusal forces are directly transferred to the zygomatic bone instead of the anterior or posterior atrophic maxilla.

CONCLUSION

Zygomatic implants appear to be an effective alternative for the treatment of an atrophic maxilla. The survival rate decreases during the first year after surgery and is more related to local infection than to the number of zygomatic implants. The survival of osseointegrated implants may also be related to the use of suitable presurgical examinations and the parameters used during the surgical procedures.

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