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Review

Retention systems for extraoral maxillofacial prosthetic implants: a critical review

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Abstract

We describe the techniques available for retention of implant-supported prostheses: bar-clips, O-rings, and magnets. We present reported preferences and, although this is limited by the heterogeneity of methods used and patients studied, we hope we have identified the best retention systems for maxillofacial prosthetic implants. If practitioners know the advantages and disadvantages of each system, they can choose the most natural and comfortable prosthesis. We searched the PubMed and Scopus databases, and restricted our search to papers published 2001–13. MeSH terms used were *Maxillofacial prosthesis* and *Craniofacial prosthesis* OR *Craniofacial prostheses*. We found a total of 2630 papers, and after duplicates had been removed we analysed the rest and found 25 papers for review. Of these, 12 were excluded because they were case reports or non-systematic reviews. Of the remaining 13, 10 described group analyses and seemed appropriate to find practitioner's choices, as cited in the abstract (n = 1611 prostheses). Three papers did not mention the type of prosthetic connection used, so were excluded. The most popular choices for different conditions were analysed, though the sites and retention systems were not specified in all 10 papers. The bar-clip system was the most used in auricular (6/10 papers) and nasal prostheses (4/10). For the orbital region, 6/10 favoured magnets. Non-osseointegrated mechanical or adhesive retention techniques are the least expensive and have no contraindications. When osseointegrated implants are possible, each facial region has a favoured system. The choice of system is influenced by two factors: standard practice and the abilities of the maxillofacial surgeon and maxillofacial prosthetist.

Keywords: Facial prosthesis; Extraoral implants; Craniofacial implants

Introduction

The use of maxillofacial prostheses is important for the social reintegration of patients with deformities, either congenital or acquired.[1] Tumours are one of the main causes of maxillofacial deformities, and most diagnoses are made at an advanced stage of the illness when the treatment generally involves mutilation, and life expectancy has little improvement.[2] The

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method of reconstruction is governed by many factors, the most important of which are the position of the lesion, its size, aetiology, gravity, as well as the patient's age and social factors.

Prosthetic rehabilitation has considerable advantages, in that it offers the surgeon the opportunity to observe wound healing and evaluate recurrence of the illness. Being scar-free, it is aesthetically superior to plastic surgery in cartilaginous sites such as ears, as well as costing less, and being simple to install. These factors often make prostheses the best available method for rehabilitation of facial mutilation.[1]

Facial prostheses require something to keep them in place, and the main methods involve adhesives, anatomical countersinks, glasses, or magnets.[3] During the last two decades, osseointegrated implants have been used to improve the hold and retention of facial prostheses. However, certain factors can still preclude surgical reconstruction, such as radiotherapy, anatomical complexity, recurrence of lesions, and various other aspects of the area to be reconstructed together with the complexity of the procedure.[4]

Implants have been used for retention in the intraoral or extraoral craniofacial regions, and these can offer excellent support and retention, as well as eliminating or reducing the need for adhesives. They allow appropriate orientation and setting of the prosthesis by the patient, but a satisfactory result can be achieved only by careful planning of the number, position, and orientation of the implants, in addition to the correct bonding between the prosthesis and the implant retention structure.[5]

Oncological patients are often treated by resection followed by radiotherapy. Once irradiated, the bone in which the implant could have been placed can be severely compromised or lost. Its osteogenic potential and microvascularisation are reduced. To ameliorate that, hyperbaric oxygen has been suggested after the implant has been placed in the irradiated bone.[6] The effectiveness of this has still not been confirmed, but shows promise.[7]

In recent years, there have been many new developments and advances in extraoral implant retention systems, and in their fixation and anchoring. Modifications have been proposed for dedicated extraoral implant retention systems, which were described in some of the selected papers.[8–10] The main purpose is to reduce the stress on the supporting bone, and so prolong the useful life of the implants. They make an appreciable potential impact on the rehabilitation of patients who require maxillofacial prostheses. In a MEDLINE review from 1969-2002, Abu-Serriah et al[8] presented the most extensive report of the evolution of extraoral implants to date. Their review was therefore considered a milestone from which to establish the time range of our critical review. It is complementary to that published by Barber et al,[11] although we have restricted ours to mandibular and maxillofacial oncological reconstruction.

There are four ways to retain a prosthesis: anatomically, mechanically, surgically, or by adhesion.[12] In the present study the anatomical, mechanical, chemical, and surgical anchoring types that do not use implants for rehabilitation were described as "non-osseointegrated" systems, and the surgical anchoring types that use implants to retain maxillofacial prostheses as "osseointegrated" or "implant retention" systems. Fig. 1 shows external hexagon system extraoral implant analogues transferred into the cast model for the laboratory phase of an auricular prosthesis.

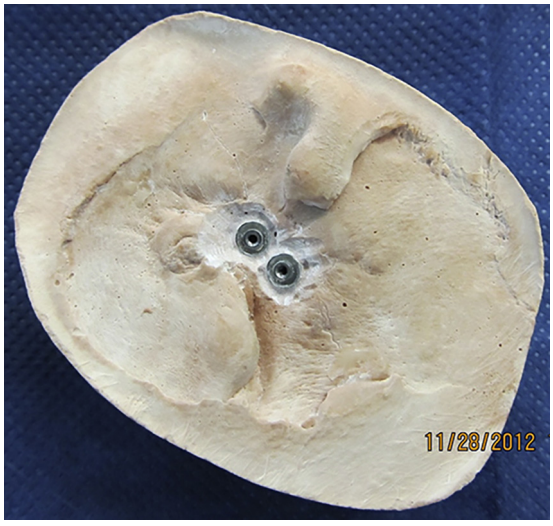

Fig. 1. Cast model with external hexagon system of extraoral implants analogues.

The purpose of this paper was to review the evolution of osseointegrated retention systems of maxillofacial prosthesis from 2001-2013. The inclusion criteria are limited to those based on bar-clip, O-ring, or magnet retention.

Material and methods

To collect the relevant references we made a bibliographic search of electronic databases. We focused on papers that reported the use or the evolution of systems of fixation and retention in maxillofacial prostheses. PRISMA guidelines were followed, but we did not search the Cochrane Database because this study is exploratory.

We used EndNote® software (Thomson-Reuters Corporation, New York, NJ, USA) to store and organise the references found during our searches.

We wanted to answer the following question: how have osseointegrated retention techniques for maxillofacial prostheses in patients with facial defects been adopted in clinical practice over the period 2001-13? The period was chosen to cover a time range different from that of existing previous, non-systematic, reviews accessed from 10/10/2012 to 04/17/2014.[8,9,13–15]

We wanted to compare existing osseointegrated implant systems by analysing variables including survival rate of implants over time, mean age of patients, aetiology of the facial defect, and site of the retention system related to the type of prosthesis. We developed a protocol with inclusive cri-

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teria based on the PICO (Patient, Intervention, Comparison, Objectives) classification, as follows: **P** = patients in need of rehabilitation with an extraoral facial prosthesis; **I** = system of retention of the extraoral prosthesis; **C** = osseointegrated systems compared with non-osseointegrated systems; and **O** = type of retention used to fix the extraoral prosthesis.

The following were excluded: reviews and case reports; papers not written in English, German, or Portuguese; papers that did not fulfill the inclusion criteria; and papers that were not published between 2001 and 2013. We searched for papers using both PubMed and SCOPUS, as they focus on the health sciences and have large databases of papers available to search.

To extract keywords for our search we started by randomly choosing a few papers that dealt with facial rehabilitation. Their main subjects were retention, fixing, and anchoring extraoral systems, and they also provided evidence of other possible studies to be included in the systematic review. A group of keywords that was relevant to our objectives was then extracted from the selected papers; and from them we extracted the most relevant descriptors. Free words were used to filter the results obtained in the descriptor search. Finally; we assembled a bank of descriptors of Medical Subject Headings (MeSH-PubMed); among the most relevant of which was the term was "Maxillofacial Prosthesis" and in the free terms "Craniofacial Prosthesis OR Craniofacial Prostheses".

The selection of terms for the database search was wide, to avoid missing out relevant papers. For the searches of Medline (PubMed), we used the "advanced search" feature: strategy 1- MeSH Terms + Maxillofacial Prosthesis; strategy 2 - all fields: Craniofacial prosthesis OR Craniofacial prostheses; and filter – from 2001 to 2013.

For Scopus, we used the same terminology as the search in Medline, with the caveat that Scopus does not have controlled vocabulary. Our strategies were: strategy 1–ALL ("maxillofacial prosthesis"); strategy 2–ALL ("craniofacial prosthesis" OR "craniofacial prostheses"); and filter – 2001 to 2013.

The selection of papers to be included in the review was based on the following steps:

First, after searching the databases we evaluated the titles of all the papers. Secondly, the papers with titles that matched our review proposition were preselected, and then we read the abstracts. Thirdly, if the papers had abstracts that indicated relevance to our objective we read the whole paper to check whether they fulfilled our inclusion requirements, or were to be eliminated. If there was doubt after reading only the abstract, we read the entire text to avoid research bias. Finally, investigators who were not involved in the review analysed the paper and applied the inclusion and exclusion criteria.

For the aggregated results we analysed 2630 references according to titles and abstracts, and duplicates were rejected according to the PRISMA procedure (Fig. 2). After this analysis we chose 25 papers, and two investigators not involved in the research reviewed and evaluated these papers according to the inclusion and exclusion criteria. Papers for which the investigators' responses differed from our own were reassessed to achieve a consensus that avoided bias.

Results

The results of the searches of the Medline and Scopus databases that were filtered filtered according to PRISMA were exported to the reference manager EndNote®. The duplicated references in both databases were excluded (Table 1).

Of the remaining 25 selected papers, 13 were included in this study (Table 2), while the other 12 were excluded.

From the included papers we recorded mean age (years), aetiology, type of prosthesis, region of placement of implant, choice of retention system/maxillofacial region, number of implants, diameter and length of implants, use of radiotherapy, implants in irradiated area before and after radiotherapy, and number of lost implants. Even though the research subjects could have been treated over the years before the date of paper publication, this did not disqualify them from investigation (Table 2).

The data collected show the different approaches of the workers, mainly regarding the choice of prosthetic system over implants. Another important feature is the heterogeneity of both aetiology and age range. Hatamleh et al did not give any information about the patients, but they presented valuable data about practitioners' choices for maxillofacial prosthetics.[22]

Practitioners' choices of extraoral maxillofacial prosthetic implant retention systems

We prefer the term "practitioners' choices" because implants may have been placed by a maxillofacial surgeon, and the extraoral prosthesis could either be designed and made by the same practitioner or by – for example – a prosthodontist.

Each group of authors described a different preference about the method of retention. To overcome the difficulty of comparing the methods, the outcomes have been expressed as percentages. Osseointegrated implant retention systems (bar-clip, O-ring, or magnet) that were widely commercially available were considered in this review, while unique osseointegrated implant retention systems with different designs have been omitted.

The bar-clip was the choice for all auricular prostheses by Schoen et al,[16] Karakoca et al,[19] Visser et al,[13] Karayazgan-Saracoglu et al,[15] and Karakoca-Nemli et al.[26] Hatamleh et al[22] describe the bar-clip as the choice for 71% of the auricular prostheses inserted in the UK. Curi et al[28] used a bar-clip for 10% of their auricular prostheses.

For the nasal region, Visser et al[21] used a bar-clip in all their prosthesis, while Karakoca et al[19] chose the bar-clip for 78% of their patients. Curi et al,[28] however, used the bar-clip for only 4% of their prostheses in the midface complex.

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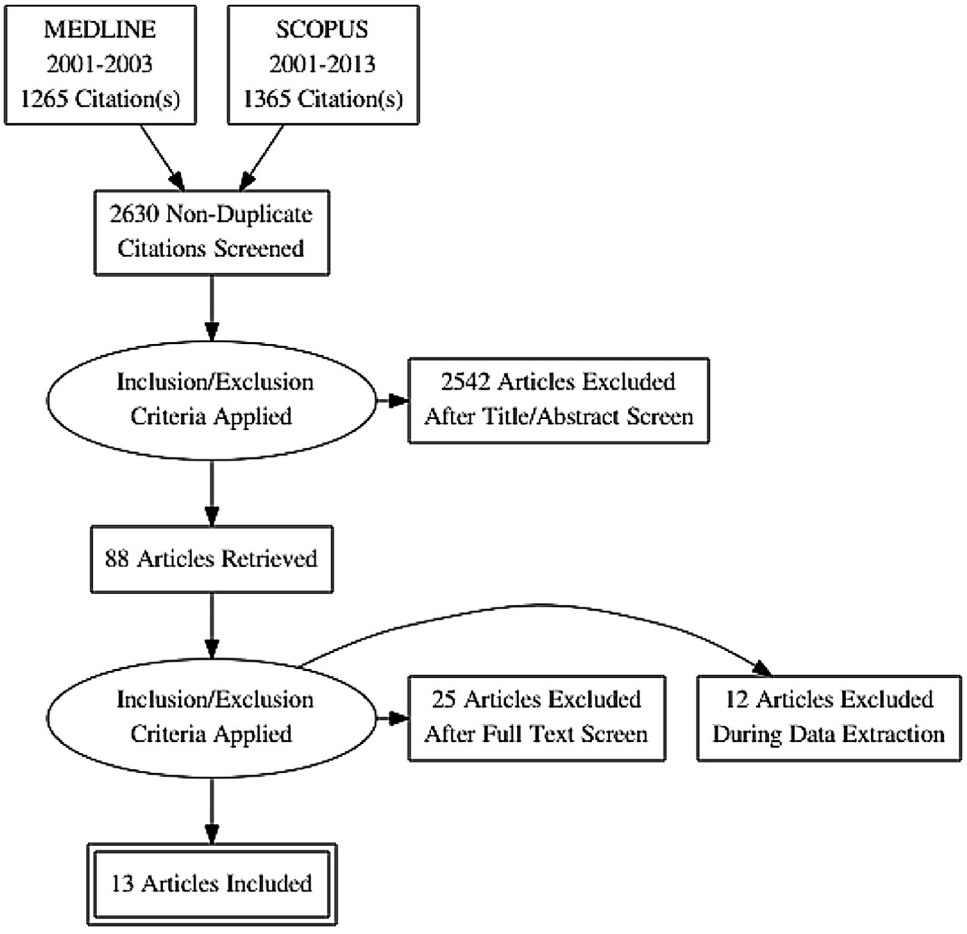

Fig. 2. Flow chart showing the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).

Table 1
Result of searches in database according to employed strategies.

Database	Search term	No of papers found	No of papers selected
Medline 1	Maxillofacial prosthesis	416	9
Medline 2	Craniofacial prosthesis OR Craniofacial prostheses	849	32
Medline 1 + 2	Total	1265	41
Scopus 1	Maxillofacial prosthesis	462	12
Scopus 2	Craniofacial prosthesis OR Craniofacial prostheses	903	35
Scopus 1+ 2	Total	1365	47
Medline + Scopus	Total	2630	25

Karakoca et al[11] chose bar-clip retention for 20% of patients in the orbital region, while Hatamleh et al[22] used it for 4%.

Magnet retention was the choice for all sites by Miles et al,[18] whereas Schoen et al[16] used magnets for all orbital prostheses and Scolozzi and Jaques[17] used them for 10% of cases in the orbital region. Karayazgan-Saracoglu et al[23] reported retention by magnets for all nasal and midface prostheses, and Karakoca et al[19] chose them for 22% of nasal prostheses. Hatamleh et al[22] reported 8% practitioner's choice for magnets in the nasal region. Curi et al[28] described 11% magnet retained prostheses in the midface complex.

For the orbital region, Karayazgan-Saracoglu et al[23] chose magnet retention for all cases. Curi et al[28] applied magnets for 86% of the orbital prosthesis. Karakoca et al[19] chose magnet retention for 80% of patients. Hatamleh et al[22] chose magnets for 32% in the orbital region.

Leonardi et al[20] did not specify the site, but stated that 75% of their prostheses were retained by magnets and 25% by bar-clips.

As far as implant-supported methods were concerned, each one had to fit with both the practitioners' abilities and the quality of the bone. For instance, magnets are less stressful than bar-clips and may allow longer useful life for the

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Table 2
General data.

First author and reference number	Year	No of patients	Sex	No treated with radiation	Mean (range) age (years)	Years	Aetiology	Total no of prostheses
Schoen[16]	2001	26	20 M 6 F	12	(23–86)	1988–1998	Neoplastic	26
Scolozzi[17]	2003	26	13 M 13 F	18	67 (32–87)	1995–2001	Neoplastic	26
Miles[18]	2006	32	24 M 8 F	1	29 (2–66)	1994–2004	Congenital n = 9 Neoplastic n = 6 Trauma n = 8 Burns n = 7 Fungus n = 1 Syndrome n = 2	34
Karakoca[19]	2008	33	23 M 10 F	9	45 (10–75)	2003–2007	Congenital n = 5 Neoplastic n = 19 Trauma n = 6 Burns n = 3	33
Leonardi[20]	2008	33	–	4	–	2002–2008	Congenital n = 12 Neoplastic n = 8 Trauma n = 8 Infection n = 7	35
Visser[21]	2008	95	65 M 30 F	33	(8–86)	1988–2003	Congenital n = 24 Neoplastic n = 59 Trauma n = 12	95
Hatamleh[22]	2010	220 maxillofacial prosthetists and technologists (MPT)	–	–	–	1 year	–	1193
Karayazgan-Saracoglu[23]	2010	52	35 M 17 F	21	47 (7–78)	7 anos	Congenital n = 4 Neoplastic n = 41 Trauma n = 7	52
Benscoter[24]	2011	8	6 M 2 F	4	46 (15–77)	2003–2010	Congenital n = 1 Neoplastic n = 5 Trauma n = 1	8
Pekkan[25]	2011	10	5 M 5 F	3	37 (13–62)	2001–2006	Congenital n = 4 Neoplastic n = 5 Trauma n = 1	10
Karakoca-Nemli[26]	2012	20	14 M 6 F	7	34 (10–72)	2007–2009	Congenital n = 6 Neoplastic n = 10 Trauma n = 4	20
Oliveira[27]	2013	59	41 M 18 F	14	–	1995–2010	59 neoplastic	59

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implant, but it depends on the quality of the bone before installation of the implant.

The ages of patients rehabilitated, and the aetiology of their facial defects, are shown in Table 2.

Discussion

Success rates of implants in non-irradiated compared with irradiated areas

Table 3 (supplementary data, online only) shows that non-irradiated areas tended to have the best success rates with no loss of implants, as described by Schoen et al,[16] Karacoca-Nemli et al,[26] and Benscoter et al.[24]

Advantages and disadvantages of osseointegrated compared with non-osseointegrated systems

While the primary scope of this review is extraoral maxillofacial osseointegrated retention systems, other non-osseointegrated and mixed region retention methods (chemical or mechanical) were cited in some papers. Three of the reviewed papers considered intraoral-extraoral combination implants. Scollozzi and Jacques[17] included the orbitonasomaxillary regions (intraoral-extraoral combination) in their results. In this case, retention was entirely by the bar-clip system. Curi et al[28] considered both magnets and bar-clip systems for complex midfacial regions. Karayazgan-Sarocoglu et al,[23] however, used only magnets for the midface. The advantages and disadvantages of mechanical or adhesive retention over any of the osseointegrated retention systems (O-ring, bar-clip, or magnets) are given below.

Advantages

There is less discolouration and degradation of prostheses because adhesives and solvents were not used; improvement in the quality of life; more effective fixation giving more security; proper prosthetic positioning; implants may be inserted during or after ablative surgery; longer prosthetic durability; predictable retention; better aesthetics and disguise because the rims of the silicon prostheses are thinner; osseointegration is more likely to be successful; retention is safer, which permits a more active life; sport is possible without concern about sweating and dissolving adhesives; it is more hygienic; and follow-up is easier, as is premature detection of possible recurrence.

Disadvantages

They cost more; they require special laboratory procedures; they take longer to insert; control appointments with practitioners are needed; difficulty with cleaning leads to a risk of infection; they need input from multiple disciplinary specialists; and they need a separate intervention.

Conclusion

Given the complexity of the process and wide range of types of intervention, there is a wide range of information available about retention systems for maxillofacial prostheses as a result of the heterogeneous research in this area. However, some consensus of practitioner's preferences can be gleaned from their publications.

The papers reviewed do not present consistent evidence of change or development of practice, based on patients' responses. Indeed, they report a diversity of preferences favoured in individual centres. The retention systems for extraoral maxillofacial prosthetic implants have evolved more as a result of the biological responses from the tissues and the aesthetic factors than from the patients' preferences. The practitioners' abilities and availability of resources also play a big part.

Whenever it is possible to use osseointegrated implants they are the first choice, because they provide the best retention for extraoral maxillofacial prostheses. It is important to stress that there is commonly a preference depending on the area of the implant. For an auricular prosthesis, the bar-clip was the most common. In the oculopalpebral and nasal regions, either a bar-clip or magnets may be selected. The choice is principally governed by two factors: indication and the practitioner's ability.

There are several choices for the retention of extraoral maxillofacial prostheses, where non-osseointegrated mechanical or adhesive retention techniques are valuable. They are the least expensive and have no contraindications.

Future work in the retention of maxillofacial prostheses should seek a standard research design, with common variables for evaluation such as outcomes reported by patients (for instance, the World Health Organization Quality of Life Instruments – WHOQoL).[29]

We suggest that analysis should be standardised through protocols and multicentre studies to overcome the difficulties associated with sample size, thereby facilitating the establishment of scientific evidence of different controversial clinical issues to help the development of future systematic reviews of the area.

Ethics statement/confirmation of patients' permission

Not necessary.

Conflict of interest

We have no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.bjoms.2017.04.012.

References

1. Goiato MC, Tabata LF, Archangelo CM, et al. Use of osseointegrated implants associated with retention systems in rehabilitation with bucomaxillofacial prostheses: literature review. *Pesquisa Brasileira em Odontopediatria e Clínica Integrada* 2007;**7**:331–6 (paper in Portuguese).
2. Antunes AA, de Carvalho RW, Neto AL, et al. The use of osseointegrated implants for oral and maxillofacial prosthodontic retention: literature review. *Revista de Cirurgia e Traumatologia Bucomaxilofacial Surgery* 2008;**8**:9–14 (paper in Portuguese).
3. Cardoso RJ, Gonçalves EA, editors. *Occlusion/TMJ/prosthesis/implant-supported prosthesis/bucomaxillofacial prostheses*. São Paulo: Artes Medicas; 2002 (book in Portuguese, not checked).
4. Fornelli RA, Fedok FG, Wilson EP, et al. Squamous cell carcinoma of the anterior nasal cavity: a dual institution review. *Otolaryngol Head Neck Surg* 2000;**123**:207–10.
5. Nadeau J. Special prostheses. *J Prosthet Dent* 1968;**20**:62–76.
6. NaBadalung DP. Prosthetic rehabilitation of a total rhinectomy patient resulting from squamous cell carcinoma of the nasal septum: a clinical report. *J Prosthet Dent* 2003;**89**:234.
7. Allen PF, Watson G, Stassen L, et al. Peri-implant soft tissue maintenance in patients with craniofacial implant retained prosthesis. *Int J Oral Maxillofac Surg* 2000;**29**:99–103.
8. Abu-Serriah M, McGowan D, Moos K, et al. Extra-oral craniofacial endosseous implants and radiotherapy. *Int J Oral Maxillofac Surg* 2003;**32**:585–92.
9. Federspil PA. Implant-retained craniofacial prostheses for facial defects. *GMS Curr Top Otorhinolaryngol Head Neck Surg* 2009;**8**:Doc03.
10. Federspil PA. Craniofacial prosthesis for facial defects. *HNO* 2010;**58**:621–31 (paper in German).
11. Barber AJ, Butterworth CJ, Rogers SN. Systematic review of primary osseointegrated dental implants in head and neck oncology. *Br J Oral Maxillofac Surg* 2011;**49**:29–36.
12. Cordeiro PG, Disa JJ. Challenges in midface reconstruction. *Semin Surg Oncol* 2000;**19**:218–25.
13. Granström G. Craniofacial osseointegration. *Oral Dis* 2007;**13**:261–9.
14. Goiato MC, Santos DM, Danelon M, et al. Hyperbaric oxygen: therapy for patients with maxillofacial implants? *J Craniofac Surg* 2009;**20**:1519–22.
15. Ihde S, Kopp S, Gundlach K, et al. Effects of radiation therapy on craniofacial and dental implants: a review of the literature. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2009;**107**:56–65.
16. Schoen PJ, Raghoebar GM, van Oort RP, et al. Treatment outcome of bone-anchored craniofacial prosthesis after tumor surgery. *Cancer* 2001;**92**:3045–50.
17. Scolozzi P, Jaques B. Treatment of midfacial defects using prostheses supported by ITI dental implants. *Plastic Reconstr Surg* 2004;**114**:1395–404.
18. Miles BA, Sinn DP, Gion GG. Experience with cranial implant-based prosthetic reconstruction. *J Craniofac Surg* 2006;**17**:889–97.
19. Karakoca S, Aydin C, Yilmaz H, et al. Survival rates and periimplant soft tissue evaluation of extraoral implants over a mean follow-up period of three years. *J Prosthet Dent* 2008;**100**:458–64.
20. Leonardi A, Buonaccorsi S, Pellacchia V, et al. Maxillofacial prosthetic rehabilitation using extraoral implants. *J Craniofac Surg* 2008;**19**:398–405.
21. Visser A, Raghoebar GM, van Oort RP, et al. Fate of implant-retained craniofacial prosthesis: life span and aftercare. *Int J Oral Maxillofac Implants* 2008;**23**:89–98.
22. Hatamleh M, Haylock C, Watson J, et al. Maxillofacial prosthetic rehabilitation in the UK: a survey of maxillofacial prosthetists' and technologists' attitudes and opinions. *Int J Oral Maxillofac Surg* 2010;**39**:1186–92.
23. Karayazgan-Saracoglu B, Zulfikar H, Atay A, et al. Treatment outcome of extraoral implants in the craniofacial region. *J Craniofac Surg* 2010;**21**:751–8.
24. Benscoter BJ, Jaber JJ, Kircher ML, et al. Osseointegrated implant applications in cosmetic and functional skull base rehabilitation. *Skull Base* 2011;**21**:303–8.
25. Pekkan G, Tuna S, Oghan F. Extraoral prosthesis using extraoral implants. *Int J Oral Maxillofac Surg* 2011;**40**:378–83.
26. Karakoca-Nemli S, Aydin C, Yilmaz H, et al. Stability measurements of craniofacial implants by means of resonance frequency analysis: 1-year clinical pilot study. *Int J Oral Maxillofac Implants* 2012;**27**:187–93.
27. Oliveira JA, Abrahao M, Dib LL. Extraoral implants in irradiated patients. *Braz J Otorhinolaryngol* 2013;**79**:185–9.
28. Curi MM, Oliveira MF, Molina G, et al. Extraoral implants in the rehabilitation of craniofacial defects: implant and prosthesis survival rates and peri-implant soft tissue evaluation. *J Oral Maxillofac Surg* 2012;**70**:1551–7.
29. The World Health Organization Quality of Life Assessment (WHO-QOL) development and general psychometric properties. *Soc Sci Med* 1998;**46**:1569–85.

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