



Maxillary Overdenture With Dental Implants: A Literature Review

1Dr. Akash G Todsam, 2Dr.Ruchi kasat, 3Dr.Babita Yeshwante, 4Dr. Rani Trimukhe, 5Dr.Sakshi suryawanshi

1Postgraduate Student, 2associate professor, 3HOD and Professor , 4Postgraduate Students, 5Postgraduate Students

1MUHS,

2MUHS,

3MUHS,

4MUHS,

5MUHS

Abstract: The recent literature on maxillary implant overdenture was reviewed in order to clarify its predictability and establish treatment guidelines. Electronic searches were performed using PubMed, Google Scholar and articles about maxillary implant overdenture written after 1990 were reviewed, focusing on the following items: I. implant survival rate, II. maxillary implant overdenture survival rate, III. number of implants, IV. attachment type, V. follow-up period, VI. implant system, and VII. opposing dentition. The review revealed an implant survival rate of 60-100% and an overdenture survival rate of 73-100%. The attachments used included bars, balls, locators, and telescope crowns. The minimum and maximum observation periods were 12 months and 120 months, respectively, and the number of implants used for supporting implant overdenture ranged from 2 to 8. At present, there is no strong evidence to indicate that maxillary implant overdenture is clearly superior for all the items examined. However, the existing data indicate that maxillary implant overdenture has almost the same therapeutic effect as fixed implant superstructures, and is a treatment option that can be actively adopted for patients in whom fixed superstructures cannot be applied for various reasons.

Introduction

The use of dental implants has recently become well established as a treatment option for various dental problems [1,2], and it may sometimes outperform other treatments in terms of patient satisfaction and reliable occlusal support [3,4]. The use of implants was originally introduced for treatment of edentulous patients who required a secure dental superstructure [5-7]. In recent years, however, it has also been applied for single or partial edentulism, and its success rate in terms of stability and prognosis is extremely high [8]. On the other hand, in patients with edentulous jaws, the treatment success rate has been somewhat lower than for single partial edentulism, and various postoperative complications such as peri-implantitis have been documented [9,10]. It is generally accepted that, as the number of implants increases, there is a higher likelihood of prosthodontic and surgical complications; in particular, when a fixed superstructure is selected, clinicians and lab technicians need to have a high degree of clinical skill [11,12]. With the exception of some techniques such as “All on Four”, the use of implants may impose a significant financial and physical burden on the patient [13].

Also, even if the patient desires a fixed superstructure, this may not be possible due to systemic disease or anatomical limitations [14]. Furthermore, it is fully predictable that the general condition of the patient may deteriorate over time, creating a situation where self-management becomes difficult. From this viewpoint, there are many instances in edentulous patients where an implant overdenture should be applied. As indicated previously by the McGill consensus, implant overdenture may be considered the first choice of prosthetic prosthesis for edentulous patients [15]. Among implant overdentures, the mandible implant overdenture is a treatment that has been sufficiently studied both clinically and in literature reviews [16-18], and in recent years, maintaining the implant overdenture with only one implant in the mandible has been a clinical approach [19]. Furthermore, since the mandible often has better bone quality than the maxilla, immediate loading may be performed in some cases, and this is known to be very cost-effective with only minimal surgical invasion [20]. Many of the problems reported by wearers of conventional complete dentures can be eliminated with implant overdenture [21]. Implant overdenture ensures stability of the prosthesis, and patients are able to reproduce a determined centric occlusion. Patients with implant overdentures show better chewing ability than complete denture wearers, and moreover, the maximum occlusal force of a denture wearer may be improved with an implant overdenture [22]. In fact, there are still no established treatment guidelines for maxillary implant overdentures, making their predictability low [23]. As bone quality in the upper jaw is inferior to that in the lower jaw, the success rate of upper jaw implants has tended to be low, and lateral force from the implant overdenture is associated with an increased risk of implant removal [24]. When International Team for Implantology (ITI)'s Straightforward, Advanced, Complex (SAC) classification tool (Basel, Switzerland) is used, just because it is the maxillary implant overdenture, it is classified as Comprehensive in the SAC classification of ITI [25]. Furthermore, in the distal part of the upper jaw, there are cases where implant placement is difficult due to the maxillary sinus [26]. When using implant overdenture for the maxilla, there is no consensus on where and how many implants should be placed, and what attachments should be used. Accordingly, the present literature review on maxillary implant overdenture was conducted in order to clarify its predictability and devise suitable treatment guidelines, based on the patient, intervention, comparison, and outcome (PICO) question "What is the clinical outcome of maxillary implant overdenture?"

Study selection

Electronics researches were performed using PubMed Google Scholar, and articles about maxillary implant overdenture published after 1990 were reviewed (Fig. 1). The search keyword was 'maxillary implant overdenture'. Clinical studies were included, and animal studies were excluded. The following items were examined: I. implant survival rate, II. maxillary implant overdenture survival rate, III. number of implants, IV. attachment type, V. follow-up period, VI. implant system, and VII. opposing dentition

Results

54 papers published between 1992 and 2021 were included. The following items were described below: I. implant survival rate, II. Maxillary implant overdenture survival rate, III. Number of implants, IV. Attachment type, V. Follow-up period, VI. Implant system, and VII. opposing dentition.

Implant survival rate

Table 1 shows data for the survival rate [27-67]. When an implant was used to support the maxillary implant overdenture, the success rate was found to be lower than that of fixed prostheses for partial edentulism and mandible implant overdenture that had been reported previously. In comparison with fixed prostheses for edentulous jaws, the success rate was almost equivalent. In general, maxillary complete dentures were more mobile than mandibular ones due to the large amount of mucosal pressure deviation. As a result, it was considered that the implant body of the implant overdenture (especially when stud attachments were used) receives lateral force, which affects the survival rate of the implant overdenture in the maxilla. From these results, maxillary implant overdenture was sufficiently selectable as a treatment option for the maxilla. Further research is needed for confirmation of the true success rate and long-term stability.

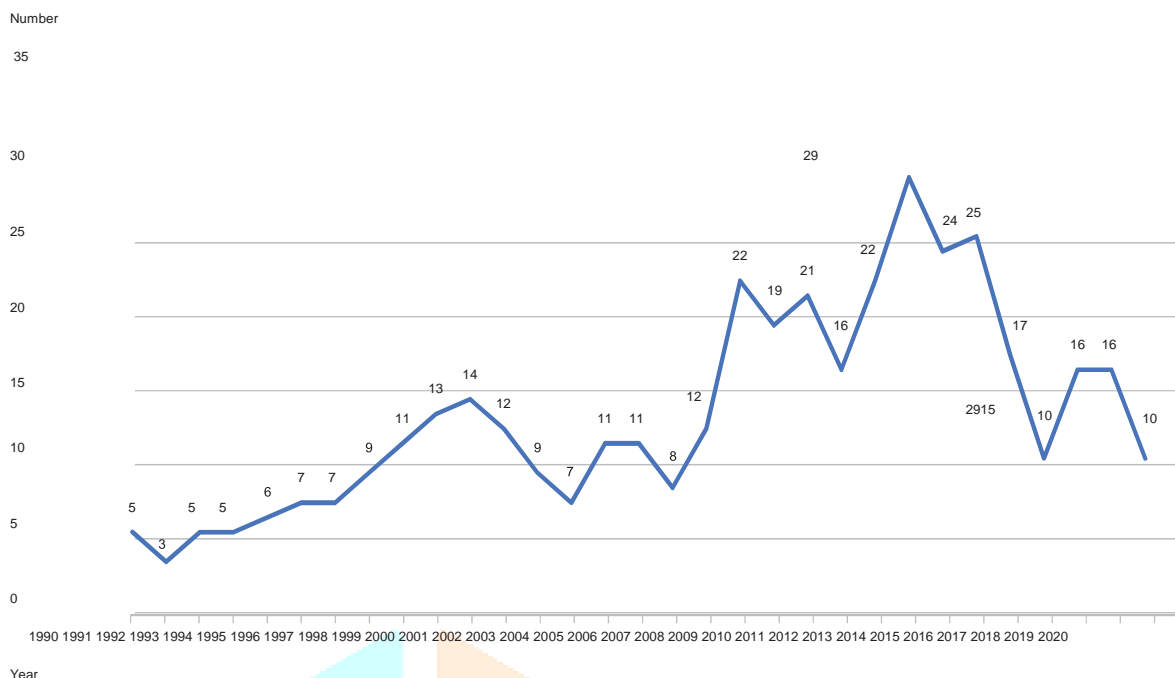


Fig. 1 Published manuscript on maxillary implant overdentures from 1990 to 2020

Maxillary Implant overdenture survival rate

The survival rate of maxillary implant overdenture was also very high, similar to that of the implant itself. When the number of implants placed was 4 or more, the implant overdenture was maintained even if the implant was lost. However, if fewer than four implants were used as abutments, it appeared difficult to maintain the implant overdenture if even one implant was lost. These findings indicate that when bone quality is poor, it is necessary to plan treatment with an eye on the prognosis, such as increasing the number of implants to be placed. If the implant overdenture can be maintained, it may be considered as a treatment that allows subsequent complications to be easily dealt with.

Number of implants

Very few studies involved placement of two implants. It was common to insert four or more implants, and six were embedded in some studies. However, if this number of implants is used, a fixed upper structure was considered to be available, and unfortunately there is no valid reason to support an implant overdenture more strongly than the fixed upper structure in the upper jaw. Based on these facts, the choice of whether an implant superstructure is removable or fixed depends on the purpose of the prosthesis, such as lip support and intermaxillary relationships, rather than simply the financial circumstances of the patient or patient/clinician preferences. Thus, the decision on the number of implants should be made comprehensively based on the purpose of the prosthesis.

Attachment type

Bars, locators, and balls were used in common with the existing lower jaw implant overdenture. In recent years, research using locator attachments, which are expected to exert loose pressure on the implant body, seems to have been increasing. However, considering that the implant survival rate and implant overdenture residual rate for the maxilla are inferior to those for the mandible, the maxillary implant can be firmly connected using a bar attachment when the implant overdenture is used as the superstructure. This may be more resistant to lateral stress. Attachments should also be decided by comprehensive judgement based on factors such as bone quality and the intermaxillary relationship.

Follow-up period

Papers detailing a minimum observation period of 2 months and a maximum of 10 years were reviewed. This confirmed that the implant survival rate remained relatively high even in the long term. From the fact that most instances of implant shedding generally occur in the early stages after implantation, it is clear that the implant body, once it has bonded to bone, does not break easily even if the superstructure is implant overdenture. Since some studies documented a high survival rate during an observation period of 10 years or more, there is a good possibility that maxillary implant overdenture would function in the oral cavity in the long term if properly treated.

Implant system

Although various implant systems have been used, this review did not confirm any tendency for differences in survival rate among them. Except for systems that are used only at the extremely local level, any system that is distributed internationally can be considered to have a high survival rate. In the past, there were attachments that could not be used due to differences between systems, but now there are no such differences. Therefore, it is possible to apply any system familiar to clinicians to patients.

Opposing dentition

There were various cases involving opposite dentition such as an implant-fixed superstructure, natural dentition, implant overdenture, and complete denture, but no differences in survival rate among them could be confirmed. However, if there is concern about the quality of bone around the implant that is used as the abutment, the condition of the opposing dentition must be fully considered. Furthermore, it may be appropriate to select a connecting attachment if the paired dentition is expected to exert a strong occlusal force.

Discussion

Several studies have documented the failure of dental implants and their prostheses in implant-supported maxillary overdentures. The maxilla may not allow a sufficient implant diameter or length due to poor bone volume and quality. Therefore, it is considered that the risk of loss of implants and overdentures is higher than for the mandible. As documented, the short-term survival rate for 4 or more implants with bar anchorage is over 95%, and using bar attachment anchored by 4 to 6 implants to strengthen the structure of overdentures has been advocated. However, no reliable long-term observation data have been available. If a maxillary overdenture is supported by 6 implants, adjustment of the overdenture to retain the prosthesis can be done if one implant is lost, and no additional surgical procedure is required. However, in the case of an overdenture supported a minimum of 4 implants, the stability of the overdenture cannot be maintained if one implant is lost. At present, therefore, it is considered stable to use 6 or more implants for overdenture support when considering possible implant failure and complications.

Clinicians need to predict future implant failures and conditions resulting from progressive bone resorption. Thus, it is important to analyze marginal bone resorption using a method that allows continuous evaluation. However, most studies use panoramic X-ray images, making it often difficult to assess small changes in marginal bone loss. In the few studies that have used standardized intraoral X-ray images, additional studies have been necessary to legitimately assess long-term marginal bone resorption around implants. The mucosal index, bleeding with probing, and pocket depth around dental implants yield data indicative of soft tissue health. Implant overdentures may be sometimes difficult to clean, depending on the type of attachment, and as a result can compromise the health of the soft tissue surrounding the implant. Peri-implant mucositis and peri-implantitis are also frequent biological complications. Gingival hyperplasia is usually observed in the space under the bar attachment to the oral mucosa. These surroundings make oral health challenging, and this phenomenon is one of those witnessed most frequently by clinicians. In addition to difficulty of using maxillary Implant overdenture, long-term RCTs are needed to compare maxillary implant overdentures with finely tuned implant prostheses (cost, prosperity, patient preferences, patient quality of life, etc.). There are no long-term RCTs such as comparing cost, prosperity, patient preferences, patient quality of life, etc. When these factors are rigorously evaluated using evidence-based dental implant treatment concepts for maxillary

edentulous, strong future clinical guidelines in this field should emerge.

At present, there is no strong evidence to show that maxillary Implant overdenture is clearly superior in terms of all the parameters examined. However, maxillary Implant overdentures has almost the same therapeutic effect as fixed implant superstructures, and is therefore a treatment option that can be actively adopted for patients in whom fixed superstructures cannot be applied for various reasons.

Conflict of interest

The authors have no conflicts of interest, financial or otherwise, to declare.

References

1. Jung RE, Zembic A, Pjetursson BE, Zwahlen M, Thoma DS (2012) Systematic review of the survival rate and the incidence of biological, technical, and aesthetic complications of single crowns on implants reported in longitudinal studies with a mean follow-up of 5 years. *Clin Oral Implants Res* 23 Suppl 6, 2-21.
2. Howe MS, Keys W, Richards D (2019) Long-term (10-year) dental implant survival: a systematic review and sensitivity meta-analysis. *J Dent* 84, 9-21.
3. Adler L, Liedholm E, Silvegren M, Modin C, Buhlin K, Jansson L (2016) Patient satisfaction 8-14 years after dental implant therapy - a questionnaire study. *Acta Odontol Scand* 74, 423-429.
4. Canallatos JE, Hobbs GR, Bryington MS, Dye BD (2020) The effect of implant prosthesis complications on patient satisfaction. *J Prosthet Dent* 123, 269-276.
5. Brånemark PI, Hansson BO, Adell R, Breine U, Lindström J, Hallén O et al. (1977) Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10-year period. *Scand J Plast Reconstr Surg Suppl* 16, 1-132.
6. Breine U, Brånemark PI (1980) Reconstruction of alveolar jaw bone. An experimental and clinical study of immediate and preformed autologous bone grafts in combination with osseointegrated implants. *Scand J Plast Reconstr Surg* 14, 23-48.
7. Adell R, Lekholm U, Rockler B, Brånemark PI (1981) A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. *Int J Oral Surg* 10, 387-416.
8. Jung RE, Pjetursson BE, Glauser R, Zembic A, Zwahlen M, Lang NP (2008) A systematic review of the 5-year survival and complication rates of implant-supported single crowns. *Clin Oral Implants Res* 19, 119-130.
9. Fischer K, Stenberg T (2013) Prospective 10-year cohort study based on a randomized, controlled trial (RCT) on implant-supported full-arch maxillary prostheses. part II: prosthetic outcomes and maintenance. *Clin Implant Dent Relat Res* 15, 498-508.
10. Papaspyridakos P, Mokti M, Chen CJ, Benic GI, Gallucci GO, Chronopoulos V (2014) Implant and prosthodontic survival rates with implant fixed complete dental prostheses in the edentulous mandible after at least 5 years: a systematic review. *Clin Implant Dent Relat Res* 16, 705-717.
11. Wittneben JG, Buser D, Salvi GE, Bürgin W, Hicklin S, Brägger U (2014) Complication and failure rates with implant-supported fixed dental prostheses and single crowns: a 10-year retrospective study. *Clin Implant Dent Relat Res* 16, 356-364.
12. Goodacre BJ, Goodacre SE, Goodacre CJ (2018) Prosthetic complications with implant prostheses (2001-2017). *Eur J Oral Implantol Suppl* 1, S27-S36.

- 13.Korsch M, Baum A, Bartols A (2020) Postoperative discomfort after implant placement according to the All-on-4 concept with or without Zygoma implants: a prospective clinical study. *Clin Oral Implants Res* 31, 133-143.
- 14.Chrcanovic BR, Kisch J, Albrektsson T, Wennerberg A (2016) Factors influencing early dental implant failures. *J Dent Res* 95, 995-1002.
- 15.Feine JS, Carlsson GE, Awad MA, Chehade A, Duncan WJ, Gizani S et al. (2002) The McGill consensus statement on overdentures. Mandibular two-implant overdentures as first choice standard of care for edentulous patients. *Gerodontology* 19, 3-4.
- 16.Chen KW, Lin TM, Liu PR, Ramp LC, Lin HJ, Wu CT et al. (2013) An analysis of the implant-supported overdenture in the edentulous mandible. *J Oral Rehabil* 40, 43-50.
- 17.Raghoobar GM, Meijer HJ, Slot W, Slater JJ, Vissink A (2014) A systematic review of implant-supported overdentures in the edentulous maxilla, compared to the mandible: how many implants? *Eur J Oral Implantol Suppl* 2, S191-201.
- 18.Bakker MH, Vissink A, Meijer HJA, Raghoobar GM, Visser A (2019) Mandibular implant- supported overdentures in (frail) elderly: a prospective study with 20-year follow-up. *Clin Implant Dent Relat Res* 21, 586-592.
- 19.Padmanabhan H, Kumar SM, Kumar VA (2020) Single implant retained overdenture treatment protocol: a systematic review and meta-analysis. *J Prosthodont* 29, 287-297.
- 20.Kutkut A, Rezk M, Zephyr D, Dawson D, Frazer R, Al-Sabbagh M (2019) Immediate loading of unsplinted implant retained mandibular overdenture: a randomized controlled clinical study. *J Oral Implantol* 45, 378-389.
- 21.Nogueira TE, Dias DR, Leles CR (2017) Mandibular complete denture versus single- implant overdenture: a systematic review of patient-reported outcomes. *J Oral Rehabil* 44, 1004-1016.
- 22.Emami E, Heydecke G, Rompré PH, de Grandmont P, Feine JS (2009) Impact of implant support for mandibular dentures on satisfaction, oral and general health-related quality of life: a meta-analysis of randomized-controlled trials. *Clin Oral Implants Res* 20, 533-544.
- 23.De Bruyn H, Raes S, Matthys C, Cosyn J (2015) The current use of patient-centered/ reported outcomes in implant dentistry: a systematic review. *Clin Oral Implants Res Suppl* 11, 45-56.
- 24.Trbakovic A, Toljanic JA, Kumar VV, Thor A (2020) Eight to eleven-year follow-up of immediately loaded implants placed in edentulous maxillae with compromised bone volume and poor bone quality: a prospective cohort study. *Clin Implant Dent Relat Res* 22, 69-76.
- 25.Wright SP, Hayden J, Lynd JA, Walker-Finch K, Willett J, Ucer C et al. (2016) Factors affecting the complexity of dental implant restoration - what is the current evidence and guidance? *Br Dent J* 221, 615-622.
- 26.Pignatton TB, Wenzel A, Ferreira CEA, Borges Martinelli C, Oliveira GJPL, Marcantonio E Jr et al. (2019) Influence of residual bone height and sinus width on the outcome of maxillary sinus bone augmentation using anorganic bovine bone. *Clin Oral Implants Res* 30, 315-323.
- 27.Johns RB, Jemt T, Heath MR, Hutton JE, McKenna S, McNamara DC et al. (1992) A multicenter study of overdentures supported by Brånemark implants. *Int J Oral Maxillofac Implants* 7, 513-522.
- 28.Krämer A, Weber H, Benzing U (1992) Implant and prosthetic treatment of the edentulous maxilla using a bar-supported prosthesis. *Int J Oral Maxillofac Implants* 7, 251-255.

- 29.Smedberg JI, Lothigius E, Bodin I, Frykholm A, Nilner K (1993) A clinical and radiological two-year follow-up study of maxillary overdentures on osseointegrated implants. *Clin Oral Implants Res* 4, 39-46.
- 30.Jemt T, Book K, Lie A, Börjesson T (1994) Mucosal topography around implants in edentulous upper jaws. Photogrammetric three-dimensional measurements of the effect of replacement of a removable prosthesis with a fixed prosthesis. *Clin Oral Implants Res* 5, 220-228.
- 31.Palmqvist S, Sondell K, Swartz B (1994) Implant-supported maxillary overdentures: outcome in planned and emergency cases. *Int J Oral Maxillofac Implants* 9, 184-190.
- 32.Hutton JE, Heath MR, Chai JY, Harnett J, Jemt T, Johns RB et al. (1995) Factors related to success and failure rates at 3-year follow-up in a multicenter study of overdentures supported by Brånemark implants. *Int J Oral Maxillofac Implants* 10, 33-42.
- 33.Jemt T, Lekholm U (1995) Implant treatment in edentulous maxillae: a 5-year follow-up report on patients with different degrees of jaw resorption. *Int J Oral Maxillofac Implants* 10, 303-311.
- 34.Jemt T, Chai J, Harnett J, Heath MR, Hutton JE, Johns RB et al. (1996) A 5-year prospective multicenter follow-up report on overdentures supported by osseointegrated implants. *Int J Oral Maxillofac Implants* 11, 291-298.
- 35.Watson RM, Jemt T, Chai J, Harnett J, Heath MR, Hutton JE et al. (1997) Prosthodontic treatment, patient response, and the need for maintenance of complete implant-supported overdentures: an appraisal of 5 years of prospective study. *Int J Prosthodont* 10, 345-354.
- 36.Ekfeldt A, Johansson LA, Isaksson S (1997) Implant-supported overdenture therapy: a retrospective study. *Int J Prosthodont* 10, 366-374.
- 37.Naert I, Gizani S, van Steenberghe D (1998) Rigidly splinted implants in the resorbed maxilla to retain a hinging overdenture: a series of clinical reports for up to 4 years. *J Prosthet Dent* 79, 156-164.
- 38.Watzek G, Weber R, Bernhart T, Ulm C, Haas R (1998) Treatment of patients with extreme maxillary atrophy using sinus floor augmentation and implants: preliminary results. *Int J Oral Maxillofac Surg* 27, 428-434.
- 39.Kaptein ML, Hoogstraten J, de Putter C, de Lange GL, Blijdorp PA (1998) Dental implants in the atrophic maxilla: measurements of patients' satisfaction and treatment experience. *Clin Oral Implants Res* 9, 321-326.
- 40.Bergendal T, Engquist B (1998) Implant-supported overdentures: a longitudinal prospective study. *Int J Oral Maxillofac Implants* 13, 253-262.
- 41.Smedberg JI, Nilner K, Frykholm A (1999) A six-year follow-up study of maxillary overdentures on osseointegrated implants. *Eur J Prosthodont Restor Dent* 7, 51-56.
- 42.Keller EE, Tolman DE, Eckert S (1999) Surgical-prosthodontic reconstruction of advanced maxillary bone compromise with autogenous onlay block bone grafts and osseointegrated endosseous implants: a 12-year study of 32 consecutive patients. *Int J Oral Maxillofac Implants* 14, 197-209.
- 43.Zitzmann NU, Marinello CP (2000) Treatment outcomes of fixed or removable implant-supported prostheses in the edentulous maxilla. Part I: patients' assessments. *J Prosthet Dent* 83, 424-433.
- 44.Rodriguez AM, Orenstein IH, Morris HF, Ochi S (2000) Survival of various implant-supported prosthesis designs following 36 months of clinical function. *Ann Periodontol* 5, 101-108.

- 45.Närhi TO, Hevinga M, Voorsmit RA, Kalk W (2001) Maxillary overdentures retained by splinted and unsplinted implants: a retrospective study. *Int J Oral Maxillofac Implants* 16, 259-266.
- 46.Kiener P, Oetterli M, Mericske E, Mericske-Stern R (2001) Effectiveness of maxillary overdentures supported by implants: maintenance and prosthetic complications. *Int J Prosthodont* 14, 133-140.
- 47.Mericske-Stern R, Oetterli M, Kiener P, Mericske E (2002) A follow-up study of maxillary implants supporting an overdenture: clinical and radiographic results. *Int J Oral Maxillofac Implants* 17, 678-686.
- 48.Fortin Y, Sullivan RM, Rangert BR (2002) The Marius implant bridge: surgical and prosthetic rehabilitation for the completely edentulous upper jaw with moderate to severe resorption: a 5-year retrospective clinical study. *Clin Implant Dent Relat Res* 4, 69-77.
- 49.Ferrigno N, Laureti M, Fanali S, Grippaudo G (2002) A long-term follow-up study of non- submerged ITI implants in the treatment of totally edentulous jaws. Part I: ten-year life table analysis of a prospective multicenter study with 1286 implants. *Clin Oral Implants Res* 13, 260-273.
- 50.Raghoobar GM, Schoen P, Meijer HJ, Stellingsma K, Vissink A (2003) Early loading of endosseous implants in the augmented maxilla: a 1-year prospective study. *Clin Oral Implants Res* 14, 697-702.
- 51.Payne AG, Tawse-Smith A, Thomson WM, Duncan WD, Kumara R (2004) One-stage surgery and early loading of three implants for maxillary overdentures: a 1-year report. *Clin Implant Dent Relat Res* 6, 61-74.
- 52.Widbom C, Söderfeldt B, Kronström M (2005) A retrospective evaluation of treatments with implant-supported maxillary overdentures. *Clin Implant Dent Relat Res* 7, 166-172.
- 53.Raghoobar GM, Schortinghuis J, Liem RS, Ruben JL, van der Wal JE, Vissink A (2005) Does platelet-rich plasma promote remodeling of autologous bone grafts used for augmentation of the maxillary sinus floor? *Clin Oral Implants Res* 16, 349-356.
- 54.Raghoobar GM, Liem RS, Bos RR, van der Wal JE, Vissink A (2006) Resorbable screws for fixation of autologous bone grafts. *Clin Oral Implants Res* 17, 288-293.
- 55.Pieri F, Aldini NN, Fini M, Marchetti C, Corinaldesi G (2009) Immediate functional loading of dental implants supporting a bar-retained maxillary overdenture: preliminary 12-month results. *J Periodontol* 80, 1883-1893.
- 56.Visser A, Raghoobar GM, Meijer HJ, Vissink A (2009) Implant-retained maxillary overdentures on milled bar suprastructures: a 10-year follow-up of surgical and prosthetic care and aftercare. *Int J Prosthodont* 22, 181-192.
- 57.Sanna A, Nuytens P, Naert I, Quirynen M (2009) Successful outcome of splinted implants supporting a 'planned' maxillary overdenture: a retrospective evaluation and comparison with fixed full dental prostheses. *Clin Oral Implants Res* 20, 406-413.
- 58.Akca K, Cehreli MC, Uysal S (2010) Marginal bone loss and prosthetic maintenance of bar-retained implant-supported overdentures: a prospective study. *Int J Oral Maxillofac Implants* 25, 137-145.
- 59.Mangano C, Mangano F, Shibli JA, Ricci M, Sammons RL, Figliuzzi M (2011) Morse taper connection implants supporting "planned" maxillary and mandibular bar-retained overdentures: a 5-year prospective multicenter study. *Clin Oral Implants Res* 22, 1117-1124.
- 60.Katsoulis J, Brunner A, Mericske-Stern R (2011) Maintenance of implant-supported maxillary prostheses: a 2-year controlled clinical trial. *Int J Oral Maxillofac Implants* 26, 648-656.

61. Van Assche N, Michels S, Quirynen M, Naert I (2012) Extra short dental implants supporting an overdenture in the edentulous maxilla: a proof of concept. *Clin Oral Implants Res* 23, 567-576.
62. El-Ghareeb M, Pi-Anfruns J, Khosousi M, Aghaloo T, Moy P (2012) Nasal floor augmentation for the reconstruction of the atrophic maxilla: a case series. *J Oral Maxillofac Surg* 70, e235-241.
63. Slot W, Raghoobar GM, Vissink A, Meijer HJ (2013) Maxillary overdentures supported by four or six implants in the anterior region; 1-year results from a randomized controlled trial. *J Clin Periodontol* 40, 303-310.
64. Zou D, Wu Y, Huang W, Wang F, Wang S, Zhang Z et al. (2013) A 3-year prospective clinical study of telescopic crown, bar, and locator attachments for removable four implant-supported maxillary overdentures. *Int J Prosthodont* 26, 566-573.
65. Zou D, Wu Y, Huang W, Zhang Z, Zhang Z (2013) A 5- to 8-year retrospective study comparing the clinical results of implant-supported telescopic crown versus bar overdentures in patients with edentulous maxillae. *Int J Oral Maxillofac Implants* 28, 1322-1330.
66. Slot W, Raghoobar GM, Vissink A, Meijer HJ (2014) A comparison between 4 and 6 implants in the maxillary posterior region to support an overdenture; 1-year results from a randomized controlled trial. *Clin Oral Implants Res* 25, 560-566.
67. Slot W, Raghoobar GM, Vissink A, Meijer HJ (2014) Maxillary overdentures supported by anteriorly or posteriorly placed implants opposed by a natural dentition in the mandible: a 1-year prospective case series study. *Clin Implant Dent Relat Res* 16, 51-61.

