Abstract: The recent literature on maxillary implant overdenture (IOD) was reviewed in order to clarify its predictability and establish treatment guidelines. Electronic searches were performed using PubMed, and articles about maxillary IOD written after 1990 were reviewed, focusing on the following items: I. implant survival rate, II. maxillary IOD 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 61-100% and an overdenture survival rate of 72.4-100%. 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 IOD ranged from 2 to 8. At present, there is no strong evidence to indicate that maxillary IOD is clearly superior for all the items examined. However, the existing data indicate that maxillary IOD 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.

Keywords: attachment type, dental implant, maxillary overdenture

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 prosthetic 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 (IOD) should be applied. As indicated previously by the McGill consensus, IOD may be considered the first choice of prosthetic prosthesis for edentulous patients [15]. Among IODs, the mandible IOD is a treatment that has been sufficiently studied both clinically and in literature reviews [16-18], and in recent years, retaining the IOD 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 IOD [21]. IOD ensures stability of the prosthesis, and patients are able to reproduce a determined centric occlusion. Patients with IODs show better chewing ability than complete denture wearers, and moreover, the maximum occlusal force of a denture wearer may be improved with an IOD [22].

In fact, there are still no established treatment guidelines for maxillary IODs, 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 IOD 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 IOD, 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 IODs 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 IOD 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 IOD?”

Study selection

Electronic searches were performed using PubMed, and articles about maxillary IOD 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 IOD survival rate, III. number of implants, IV. attachment type, V. follow-up period, VI. implant system, and VII. opposing dentition.

Results

Forty one papers published between 1992 and 2014 were included. The following items were described below: I. implant survival rate, II. Maxillary IOD 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 IOD, the success rate was found to be lower than that of fixed prostheses for partial edentulism and mandible IOD 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 IOD (especially when stud attachments were used) receives lateral force, which affects the survival rate of the IOD in the maxilla. From these results, maxillary IOD 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.
Maxillary IOD survival rate
The survival rate of maxillary IOD was also very high, similar to that of the implant itself [27-38,40-43,46-50,52-56,58-67]. When the number of implants placed was 4 or more, the IOD was maintained even if the implant was lost. However, if fewer than four implants were used as abutments, it appeared difficult to maintain the IOD 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 IOD can be maintained, it may be considered as a treatment that allows subsequent complications to be easily dealt with.

Number of implants
Table 1 shows data on the number of implants used [28-32,34-38,40-42,46-67]. Very few studies involved placement of two implants. It was common to insert four or more implants, and six were included 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 IOD more strongly than the fixed upper structure in the upper jaw. Based on these facts, the choice of whether an implant superstructure can be firmly connected using a bar attachment when the IOD is used as the superstructure. This may be more resistant to lateral stress. Attachments can be firmly connected using a bar attachment when the IOD is used as the superstructure 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.

Attachment type
The types of attachment are shown in Table 1 [27-29,31-38,40-67]. Bars, locators, and balls were used in common with the existing lower jaw IOD. In recent years, research using locator attachments, which are expected to exert loose pressure on the implant body, seems to have been increasing. If the superstructure is IOD, 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.

Follow-up period
Table 1 also shows data for the follow-up period [27-67]. 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 IOD. Since some studies documented a high survival rate during an observation period of 10 years or more, there is a good possibility that maxillary IOD would function in the oral cavity in the long term if properly treated.

Implant system
Table 1 also shows the implant systems employed [27-43,45-67]. 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
Table 1 also gives details of the implant systems used [27,31,32,34,35, 37,38,40,42,45-47,50,51,55-58,60-63,66,67]. There were various cases involving opposite dentition such as an implant-fixed superstructure, natural dentition, IOD, 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.
| Author, (year) | Study type | Number of implants | Attachment type | Implant system | Implant survival rate (%) | IOD survival rate (%) | Follow-up period | Opposing dentition |
|---------------|------------|-------------------|----------------|---------------|--------------------------|----------------------|------------------|-------------------|
| Slot, (2014), [67] | clinical | 6 | bar | Astra | 98 | 100 | 12 | natural teeth |
| Slot, (2014), [66] | clinical | 4 | bar | Straumann TL SLA | 100 | 100 | 12 | IOD |
| Zou, (2013), [64,65] | clinical | 4 | locator telescopic crown | Straumann TLSLA | 100 | 100 | 36 | |
| Slot, (2013), [63] | clinical | 4 | bar | Astra | 100 | 100 | 12 | IOD |
| El-Ghareeb, (2012), [62] | clinical | 4 | bar | Straumann TL SLA | 100 | 100 | 12 | all kinds |
| Van Assche, (2012), [61] | clinical | 4 | bar | Straumann TL SLA | 98.6 | 100 | 24 | all kinds |
| Katsoulis, (2011), [60] | clinical | 4 | bar | Replace select tapered | 98.9 | 100 | 24 | all |
| Mangano, (2011), [59] | clinical | 4 | bar | Leone | 97.4 | 100 | 60 | |
| Akca, (2010), [58] | clinical | 4 | bar | Straumann | 97.7 | 88 | 59 | all |
| Sanna, (2009), [57] | clinical | 4 to 6 | bar | Bmk | 99.2 | 73.5 | 84 | all |
| Visser, (2009), [56] | clinical | 6 | ball | Bmk | 86.1 | 74.4 | 120 | CD, IOD, natural teeth |
| Pieri, (2009), [55] | clinical | 4 | bar | Prima Connex | 96.4 | 97.3 | 12 | all |
| Raghoebar, (2006), [54] | clinical | 6 to 8 | bar | Bmk | 100 | 100 | 22 | |
| Raghoebar, (2005), [53] | clinical | 6 | bar | Bmk | 96.7 | 100 | 20 | |
| Widbom, (2005), [52] | clinical | 4 | bar | Bmk | 77 | 100 | 60 | |
| Payne, (2004), [51] | clinical | 3 | ball | Bmk | 92 | 82 | 12 | IOD |
| Raghoebar, (2003), [50] | clinical | 6 to 8 | bar | ITI | 95.6 | 96.9 | 12 | all |
| Ferrigno, (2002), [49] | clinical | 4 to 6 | bar | ITI | 92.2 | 94.7 | 120 | |
| Forin, (2002), [48] | clinical | 3 to 7 | bar | Bmk | 97 | 60 | |
| Mericske-Stern, (2002), [47] | clinical | π | bar | ITI | 94.2 | 97.6 | 49 | all |
| Kiener, (2001), [46] | clinical | 4 to 6 | bar and ball | ITI | 95.5 | 95 | 38 | all |
| Närhi, (2001), [45] | clinical | 2 to 6 | bar and ball | Bmk and IMZ | 90 | 81.8 to 94.6 | 36 | |
| Rodriguez, (2000), [44] | clinical | 6 to 8 | bar and ball | Bmk | 94.4 | 100 | 27 | |
| Zitzmann, (2000), [43] | clinical | 3 to 6 | bar and ball | Bmk | 76 | 77 | 81 | all |
| Keller, (1999), [42] | clinical | 3 | ball | Bmk | 83.7 | 85.3 | 100 | 35 | |
| Smedberg, (1999), [41] | clinical | π | bar | Bmk | 85.3 | 85.3 | 35 | |
| Bergendal, (1998), [40] | clinical | 2 to 5 | bar | Bmk | 79 | 80 | 60 | all |
| Kaptein, (1998), [39] | clinical | π | # | IMZ | 82.1 | 82.1 | 70 | |
| Watzek, (1998), [38] | clinical | 6 to 8 | bar | Frialen and IMZ | 95 | 90 | 39 | |
| Naert, (1998), [37] | clinical | 4 | bar | Bmk | 88.6 | 85 | 48 | all |
| Elmfeldt, (1997), [36] | clinical | 1 to 4 | bar and ball | Bmk | 84.3 | 85.7 | 30 | |
| Watson, (1997), [35] | clinical | 3 to 4 | bar | Bmk | 72.4 | 77.9 | 60 | natural teeth or implant prosthesis |
| Jemt, (1996), [34] | clinical | 3 to 4 | bar | Bmk | 72.4 | 77.9 | 60 | all |
| Jemt, (1995), [33] | clinical | π | bar | Bmk | 71.6 | 81.2 | 60 | |
| Hurtton, (1995), [32] | clinical | π | bar | Bmk | 72.4 | 72.4 | 36 | all |
| Palmqvist, (1994), [31] | clinical | 2 to 4 | bar | Bmk | 93.2 | 100 | 40 | all |
| Jemt, (1994), [30] | clinical | 4 to 6 | # | Bmk | 100 | 100 | 12 | |
| Smedberg, (1993), [29] | clinical | 2 to 6 | bar | Bmk | 86 | 90 | 24 | |
| Krämer, (1992), [28] | clinical | 4 | locator telescopic crown | Straumann TL SLA | 94 | 100 | 19 | |
| Johns, (1992), [27] | clinical | π | bar | Bmk | 82.2 | 86.3 | 12 | all |

π, Not available
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. Future studies related to dental implant treatment of the edentulous maxilla should focus on long-term prospective cohort clinical trials with specific follow-up involving clinical and radiographic evaluation, superstructure function, and patient satisfaction score. Current randomized controlled trials (RCTs) still analyze only short-term follow-up data. In addition to difficulty of using maxillary IOD of overdentures, 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 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.

In conclusion, the author’s PICO question “What is the clinical outcome of maxillary IOD?” cannot be answered adequately based on the present results alone. At present, there is no strong evidence to show that maxillary IOD is clearly superior in terms of all the parameters examined. However, maxillary IOD 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.

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