Chapter 3

Implant Overdentures

Nikolaos Polychronakis, Stefanos Kourtis*

National and Kapodistrian University of Athens, Greece

***Corresponding Author:** Stefanos Kourtis, Plaza Chrys. Smyrnis14, 17121, Athens, Greece, Email: stefkour@dent.uoa.gr

First Published **November 10, 2016**

Summary

Implant overdentures have been used for decades for the restoration of completely edentulous patients. Various types of implant overdentures have been presented and used in the clinical practice, supported by a reduced or increased number of implants and with a variety of retentive mechanisms. The purpose of this chapter is to categorize the implant overdentures, to present and compare the various retention elements that are currently used and to discuss the advantages and disadvantages of the different clinical options based on the literature data. The points of attention for the selection and fabrication of each type of overdentures is also discussed and presented with clinical examples.

Introduction

Complete dentures have been the traditional standard of care in the rehabilitation of edentulous patients for more than a century [1]. Although the majority of patients using maxillary dentures are satisfied, as far as speech, esthetic, mastication and retention are concerned [2,3], in many cases retention of mandibular dentures is not adequate, since more than 20% of patients report none or little satisfaction [4] and decreased quality of life [5].

Furthermore, as expectations and demands have been rising in recent decades, patients are now seeking comfort and improved function at a higher standard than that offered by conventional mandibular dentures [2].

In order to overcome the problems of mandibular dentures, implant-retained overdentures have been proposed [6] because of their significantly improved retention, stability [7] and patient satisfaction [8].

Definition

An implant overdenture is defined as any removable dental prosthesis that covers and rests on dental implants, or a dental prosthesis that covers and is partially supported by dental implants [9].

Indications

An implant overdenture can be used for the treatment of edentulous jaws, mainly in mandibles, for patients who have problems with complete dentures [10], and in cases when alveolar bone preservation is desired [11]. The major indication for implant overdentures is the reduced number of implants, 2 for the mandible and 4 for the maxilla. There are also cases where an overdenture has advantages compared to a fixed restoration, even if multiple implants have been placed. These cases include the need for maintaining effective oral hygiene, support of the soft peri-oral tissues or implants with doubtful prognosis.

Classification

Implant overdentures are classified as tissue-supported/implant-retained, tissue-and-implant supported and solely implant- supported.

a) Tissue-supported overdentures are based on two implants and designed following the same principles as conventional dentures, but are retained on implants using a retentive mechanism (attachment) as, for example, ball, locators or magnets [1]. Tissue-supported overdentures are mainly used for the treatment of edentulous mandibles, as it is difficult to achieve retention from only 2 implants and also support the tissue of the maxilla, due to the soft tissue thickness.

b) Tissue and implant-supported overdentures are retained by a superstructure secured with two implants, usually positioned in the anterior area of the mandible or maxilla [1]. This type of restoration is supported both from soft tissues and implants. The supporting and retentive mechanism is usually a bar connecting the implants with clips integrated in the base of the restoration. Alternatively, other types of retentive mechanism (ball attachments or locators) can be used, if splinting of the implants is not considered necessary [12].

It must be underlined however that the support of implant overdentures is not dependent only on the number of implants but is also significantly affected by the retention system. Resilient attachments allow micro-movement towards the mucosa as also bars that have been constructed with a spacer underneath the clip.

c) Implant-supported overdentures are supported only by the implants, either via a superstructure rigidly

connected to them [1] or directly with telescoping crowns [13,14]. The minimum number of needed implants for the mandible is 4 while for the maxilla 4-6 implants are necessary [2]. The number of implants is also influenced by the width of the edentulous arch and the extension of the occlusal table that is planned [12]. Occlusal forces during mastication are mainly absorbed by the implants, so the mucosa is minimally loaded [1].

Treatment Strategy

The selection of the type of restoration in each case depends on various parameters, such as the number of implants, the pain or discomfort caused by the existing denture, the quality and quantity of the alveolar bone, the patient's demands and expectations, the interarch relationship, the ability of the patient to maintain effective oral hygiene and cost [1].

Number of Implants

When designing an implant overdenture, the clinician has to decide on the number of implants necessary to construct a long-lasting prosthesis that can fulfill the patient's demands.

Edentulous Mandible

According to the McGill consensus statement on overdentures, a 2-implant overdenture should be the treatment of choice for this case[15]. Additionally, in accordance to Hobkirk et al [11], two implants provide sufficient stabil-

ity, but support is also shared with the underlying tissue. A literature review [16] also stated that long-term success and survival of the highest level, as well as patient satisfaction and oral functions, can be achieved with 2-implants overdentures. Although such a restoration is the most popular clinical choice, even a single implant in the midline of the mandible can improve function, if cost is a pressing factor [16]. Furthermore, according to another literature [17], this type of overdenture seems a sound and more affordable treatment. Nevertheless, what should also be investigated are clinical variables, e.g. efficient mastication, bite force, retention and stability. Bhat et al [18] in an *in vivo* study revealed that the masticatory efficiency of a single midline implant mandibular overdenture is better than that of a conventional denture. Another systematic review by Kern et al [19] compared implant failure between one-implant and two-implant overdentures in the mandible and showed higher implant loss rates for the former rather than the latter type.

Edentulous Maxilla

For the construction of an implant maxillary overdenture a minimum 4 implants are necessary. More specifically, according to Hobkirk et al [11], 4 implants evenly distributed can provide most of the support and a maxillary overdenture can be converted to a horseshoe, exposing the palatal mucosa. In a systematic review [20] the annual survival rate of implants was compared in cases of 6 implants and a bar overdenture, 4 implants and a bar overdenture and 4 implants and a ball overdenture. Ac-

cording to the results, a maxillary overdenture supported by 6 implants connected with a bar provides the treatment affording the highest satisfaction, as far as survival of implants and overdentures is concerned. The second best was the 4-implant bar overdenture. The lowest success rate was reported for 4 or fewer implants and a ball attachment system.

According to Carlsson's literature review [16], 4-6 implant bar-splinted overdentures present sound results in regards to function. As Raghoebar et al [21] reported in 2014, high survival rates both for the implants and the overdentures were noted in cases of implant-supported maxillary overdentures (all studies ≥ 4 implants) with splinted anchorage. Another finding was that the risk of implant loss rose in cases of fewer than 4 implants with non-splinted anchorage. These results are confirmed by the systematic review by Kern et al [19] reporting that the rates of implant loss for maxillary overdentures supported by fewer than 4 implants by far exceeded those of four implant cases.

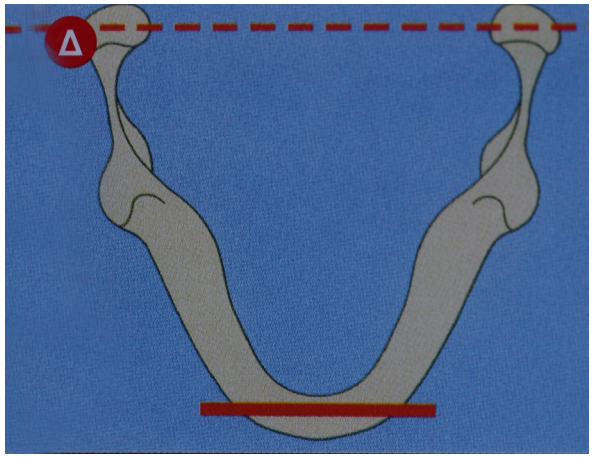
In an *in vivo* study [22] it was concluded that 6-implant supported maxillary overdentures retained by a bar offer higher satisfaction among patients than those of the same type supported by four implants. On the other hand, it is not possible to evaluate patients' satisfaction for 4 or 6 implants in the same subjects because, in most studies, each patient receives and uses one of the two types, making it impossible to compare it with the other one.

Guidelines for Mandibular Overdentures

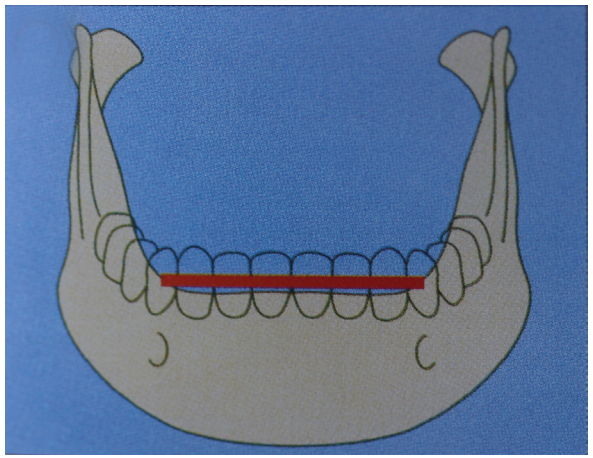
The basic prerequisite for a mandibular implant overdenture are 2 interforaminal implants, at least 8mm long, 15 to 25mm apart [1], so as to allow enough space for the retentive components [23]. The implants may be single with attachments or splinted by a bar.

The bar should be parallel to the horizontal level and to the arbitrary hinge axis of the patient [24]. The bar can be round-shaped in cross-section or "egg- shaped" (Dolder bar) to allow rotation of the overdenture (resilient retention) in cases of tissue-supported or implant-and-tissue supported overdentures. U-shaped bars (rigid retention) should be avoided if an implant-tissue supported overdenture is planned, as they allow no rotational freedom for the overdenture, thus transmitting all created torque on the implants [24] (Figure 1 and Figure 2). They can though be used in cases where multiple implants are splinted for an overdenture supported only by implants.

The bar should connect the implants with straight parts avoiding any curve. The space underneath the bar should and allow effective oral hygiene with interproximal brushes or special toothbrushes (Figure 3 and Figure 4). Adequate space should remain around the fixtures of the bar on the implants to avoid any interference or contact of the denture base on the implants.

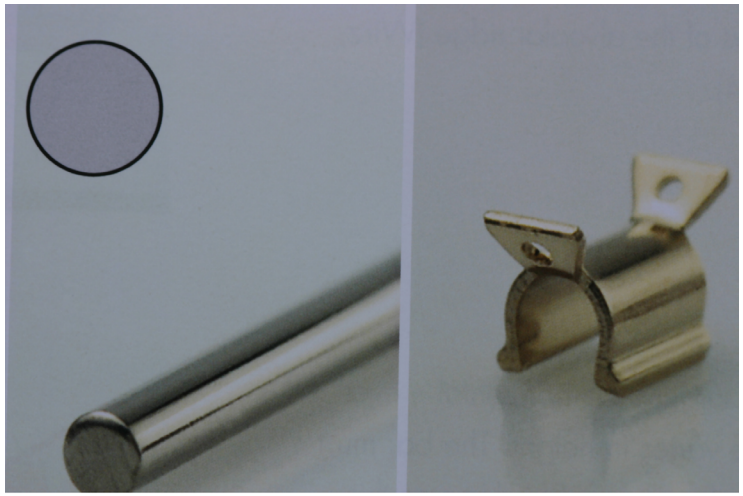


1(a)

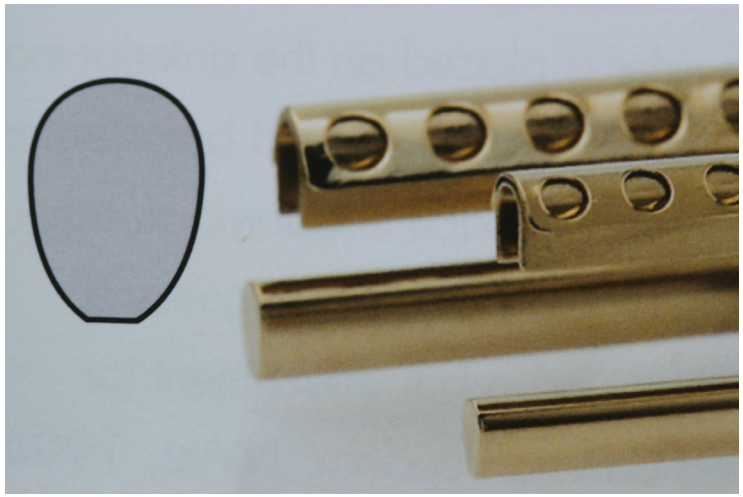


1(b)

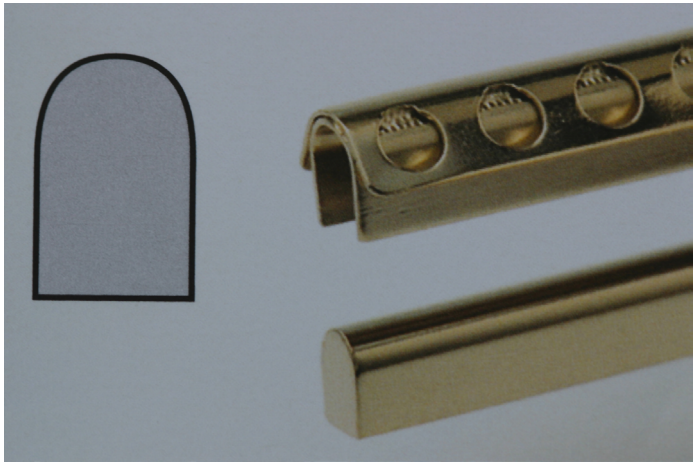
Figures 1a and 1b: The bar should be parallel to the hinge axis of the patient nd to the horizontal level (from Preci-Line Laboratory manual, Alphadent Co., Belgium).



2 (a)



2 (b)



2 (c)

Figure 2: Various types of bars in cross-section (left to right): a) round bar , b) egg-shaped bar, c) U-shaped bar (from Implant-borne hybrid dentures manual, Straumann Co., Switzerland)

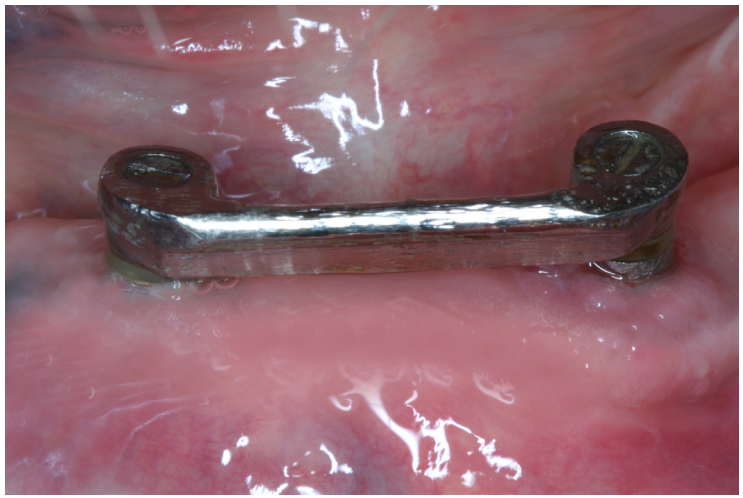


Figure 3

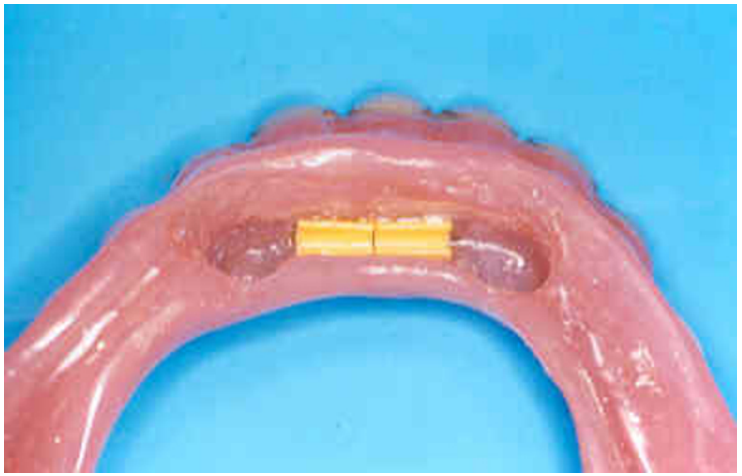


Figure 4

Figures 3 and 4: Dolder bar and the corresponding prefabricated plastic retaining clips in the base of the denture.

The bar can be fabricated by casting from gold or base metal alloys. Alternatively, it may be constructed by soldering of prefabricated metal parts, usually from gold alloys. The retaining clips are made of gold alloy or plastic and are embedded directly in the base of the denture or are fitted in a prefabricated "housing" fixed in the base material.

Single retentive elements - as ball attachments or Locators - may also be used without splinting the implants (Figures 4-8). Their use is however restricted if the implants have intense diversion [25].

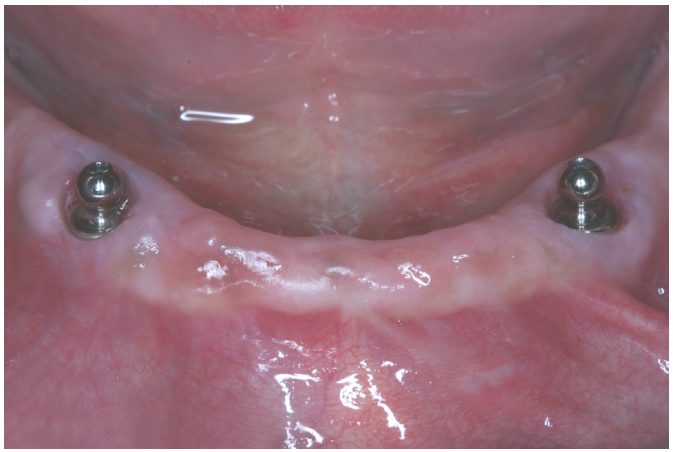


Figure 5

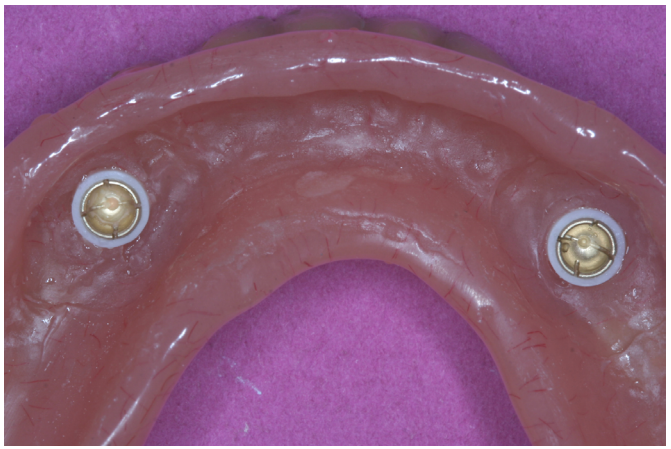


Figure 6

Figures 5 and 6: Ball-attachments on two implants and the corresponding female parts in the base of the denture. The male parts are fabricated from titanium and the retaining parts from gold alloy.

Figure 7

Figure 8

Figures 7 and 8: Locator attachments and the corresponding retaining female parts in the base of the denture. The plastic retaining parts in the housing are available in different retention forces and color coded.

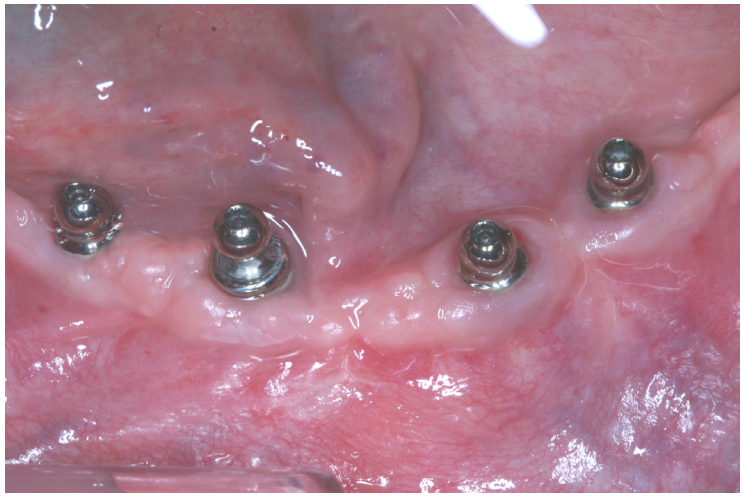


Figure 9

Figure 10

Figures 9 and 10: Mandibular overdenture on 4 ball attachments.

When the size (diameter and length) of implants is reduced, more than 2 implants are preferred to allow a more even distribution of occlusal forces [1,10,11]. A bar can be useful when the implants diverge from each other [26].

In cases of V-shaped alveolar ridges in the anterior part-where the direct connection with a bar might restrict the space available for the tongue-single retentive mechanisms are preferred or more than 2 implants should be placed [27] (Figure 9 and Figure 10).

The use of telescoping crowns may combine the advantages of both retaining types (bar and ball attachments) and offer a clinical solution to certain clinical cases. Primary crowns are formed by milling compact titanium abutments fixed on the implants. Secondary crowns are fabricated by casting with precious or non-precious alloys, rigidly connected to the metal framework of the superstructure. Telescoping crowns can compensate divergent implants that are splinted, not directly through a bar but through the superstructure.

All types of mandibular implant overdentures should be reinforced either with a cast metal framework or at least with a lingual bar within the denture to reduce the risk of fracture. For geriatric patients, particularly those with retentive anchors, this may not be necessary [10].

Guidelines for Maxillary Overdentures

At least 4 implants evenly distributed along the anterior region are desired [1]. If connection with a bar is

planned, the segmented straight parts between the implants may follow the curve of the alveolar ridge without restricting palatal space (Figure 11 and Figure 12). Each implant should be at least 10mm long and, if the host bone sites are resorbed and do not allow placement of long fixtures, several shorter ones should be inserted [27].

Labial inclination of the maxillary alveolar region-especially in the anterior region-often leads to the need for a bar to allow a single insertion path for the overdenture. Single retentive mechanisms may also be used, but the thick mucosa and the intense inclination of implants often restrict their clinical application and efficacy (Figure 13 and Figure 14). Telescopic crowns are another attractive clinical solution facilitating insertion and ensuring indirect splinting of implants (Figures 15-17). In the maxilla, where most implants show intense diversion and labial inclination, telescoping crowns may compensate the divergent axes without reducing the retention force. In these cases, the overdenture is similar to a removable bridge. Reinforcement of the denture base is mandatory and should include a cast metal framework supporting the restoration in all extent [1].

As reported in a 5-to 8-year retrospective study [28] maxillary implant-supported telescopic crown or bar overdentures are a sound and predictable treatment option for patients with edentulous maxillae.

Reinforcement of the denture base is mandatory and should include a cast metal framework supporting the restoration throughout its extent [1].

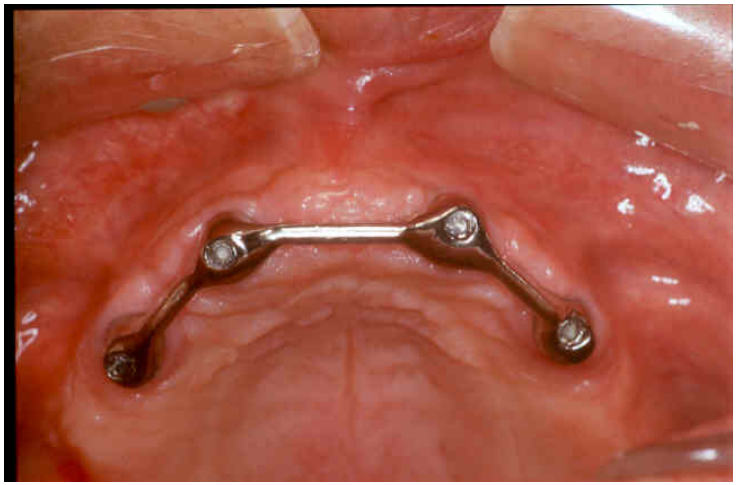


Figure 11

Figure 12

Figures 11 and 12: Maxillary overdenture with cast bar and the corresponding retaining clips fixed in the metal framework.

Figure 13

Figure 14

Figures 13 and 14: Maxillary overdenture on 4 ball attachments at the 1-year recall. Although the patient performs oral hygiene both on implants and the overdenture, hyperplasia of the soft peri-implant tissues is evident reducing the retention.

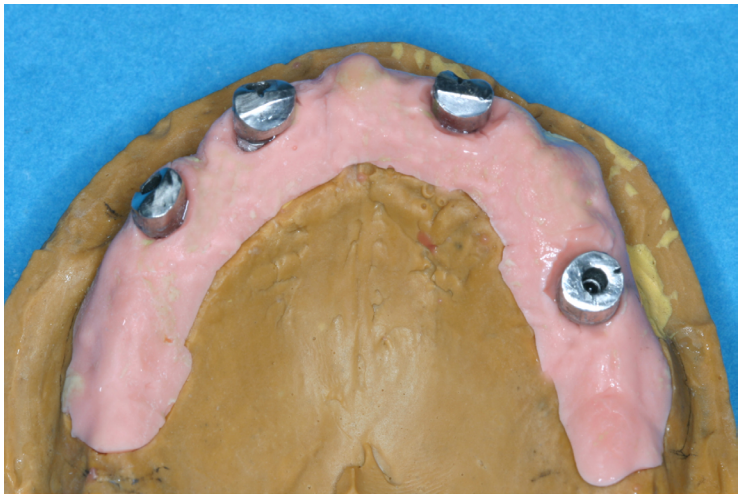


Figure 15

Figure 16

Figures 15 and 16: Primary titanium copings on 4 milled prefabricated titanium abutments for a maxillary overdenture.

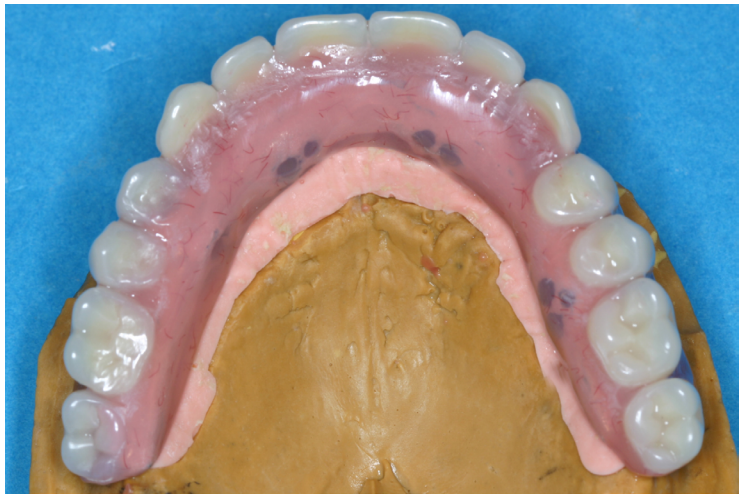


Figure 17: The corresponding maxillary overdenture without palatal coverage.

Advantages of Implant Overdentures

Patients accept the prosthesis more readily and underlying tissue sore spots are less frequent as compared to conventional dentures. Furthermore, increased retention and stability ensure improved function of the whole stomatognathic system in every aspect. Improved aesthetics can also be achieved due to better support of facial soft tissues, while the remaining alveolar bone is also effectively preserved. In addition, soft tissue coverage may be reduced when an implant overdenture is used [29].

Implant overdentures can significantly improve the aesthetic result, as they can offer support to lips and peri-

oral tissues, while prosthetic teeth length is not influenced by alveolar crest resorption, as this is compensated by the polymer material of the flange.

Regarding oral hygiene, a removable prosthesis requires less time and effort to maintain a proper level of plaque control. This is an important factor for elderly patients with reduced visual capacity and dexterity.

According to a 5-year study by Hemmings et al [30], overdentures needed more frequent post-insertion adjustment than fixed prostheses in the first year of use. At a later time, fixed restorations showed more severe technical complications and needed higher maintenance than overdentures. On the other hand, the results of a systematic review by Berglundh et al [31]revealed that incidence rates for technical complications due to implant components and superstructures were higher among overdentures than among fixed reconstructions. It must be underlined, however, that prosthetic complications of overdentures may, in general, be more frequent, but in the majority of cases are of low severity and can be repaired with minimum effort and cost.

Disadvantages of Implant Overdentures

The main problem with implant overdentures arises from patients' demands and expectations, e.g. that the prosthesis should be fixed, which this type of restoration cannot fulfill. On the other side, if more implants are used

with the proper retention elements (as for example telescopic crowns), maximum stability and retention can be achieved and the overdenture should only be removed for purposes of oral hygiene.

Implant overdentures require increased care and cost, compared to conventional dentures. Retentive mechanisms are sometimes difficult for non-dexterous patients to manage, while there is also the likelihood of implant loss. Besides, prosthetic complications are more frequent than those of conventional dentures and a regular recall system should be in place [12,29].

Retention Systems

A variety of retention systems have been used in order to retain implant overdentures, which are mainly classified into single attachments, splinted anchorage systems (bars) and telescopic crowns [32]. Single anchorage system and telescopic crowns are attached independently to each implant [33] i.e. ball, magnets, locators [34,35]. Splinted anchorage systems are clips fitting on a bar that may be round, egg-shaped (Dolder Bar) or U-shaped. Round and egg-shaped bars allow rotation of the superstructure and provide a relative stress breaking effect. U-shaped bars offer increased retention, require more accurate fit and result in rigid fixation of the superstructure [27].

Indications for Single Attachments

Single attachments are easier to use, require no additional laboratory steps (ex casting), and entail lower cost when compared to clips on bars. They are often preferred when the patient's existing overdenture is to be transformed to an implant overdenture. This clinical option facilitates elderly denture-wearing patients-usually with limited dexterity-to use and maintain their existing dentures more easily. These overdentures can also be used as interim prostheses during the post-surgical healing phase, prior to the insertion of the definite prosthetic restoration which is demanding in regard to time and laboratory stages [27].

Single attachments are also an attractive solution in cases of limited vertical space, as they require shorter height within the base of the dentures than the bar and the retaining clip with its housing [23]. Single retention elements are also used in cases of unfavorable distribution of the implants, where the space between them may not allow adequate length of the bar (Figure 18 and Figure 19). Another indication for attachments is in cases where an implant may be lost during osseointegration and the patient denies re-implantation (Figure 20 and Figure 21).

Figure 18

Figure 19

Figures 18 and 19: Mandibular implant overdenture on four implants. Ball-attachments were selected as the distribution of the implants was not favorable for the construction of a bar.

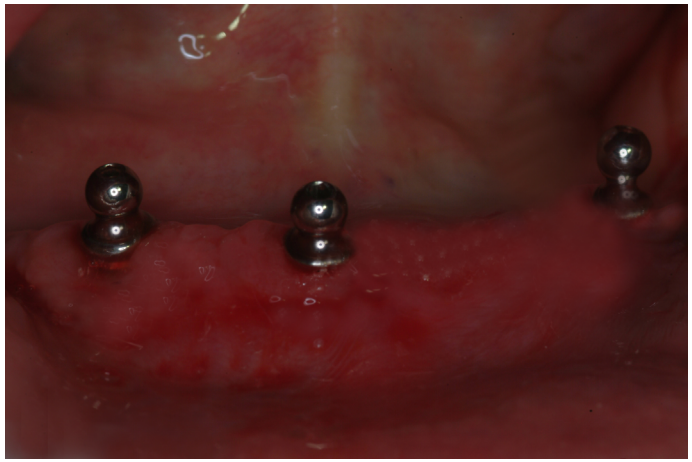


Figure 20

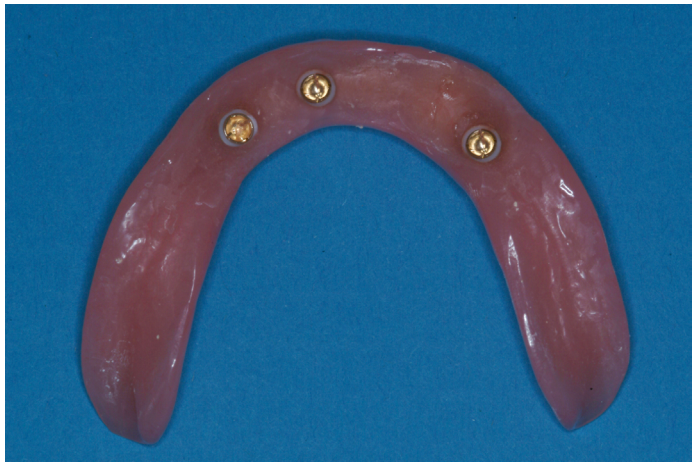


Figure 21

Figure 20 and 21: Mandibular implant overdenture on three implants. Ball attachments were selected due to the distribution of the implants. The patient had received four implants but one failed during osseointegration and the patient denied re-implantation.

Indications for Splinted Attachments (Bars)

When single attachments are used, patients often complain of inadequate retention. Bar and clips provide increased retention when compared to single attachments, if proper fit of the clips can be ensured. Bars can also compensate unfavourable inclination of implants and diverted axes. In cases of short implants, splinting by a bar may contribute to increased stability and more even distribution of occlusal forces to the implants and the surrounding bone [36].

The prefabricated retentive clip for the bar can be either metallic or plastic. Metallic clips (usually gold alloy) offer increased longevity as they are more wear-resistant than plastic. On the other hand, the thin "wings" of metal clips may be easily deformed, if the overdenture is not carefully inserted by the patient. In these cases, replacement of the retaining clips is mandatory.

The bar may be cast individually from gold or base metal alloy. Some manufacturers also offer the possibility to avoid casting and construct the bar by soldering of prefabricated pieces. As the use of gold alloys increases cost, there is a tendency for the use of base metal alloys. The prefabricated metal retaining clips are usually made from gold alloy, as they show reduced wear resistance compared to other alloys. The main reason is that the expected wear during the clinical use should be mainly done on the retaining clips that are more easily replaced, leaving the bar intact. The clips are usually available in predetermined length and can be adjusted to the clinical dimensions by cutting. If the length between the implants is adequate, a single clip is preferred. If the length is limited, two shorter separate clips may be used (Figures 22-24).The integration of the clip in the base of the denture can be done either in the laboratory or chairside by using auto-polymerizing resin. When using a single long clip, procession in the laboratory is preferred. Chairside integration of the clips prerequisite extreme caution, as no resin should flow underneath the bar, which would result in difficulty to remove the denture after polymerization. In case of two short clips the procedure can be accomplished in the dental officethrough a "window" in the lingual side of the denture, but isolation of the space under the bar is mandatory.

Plastic clips are an attractive clinical solution to metal clips. They have lower cost but they should be replaced more often as their retention decreases by clinical use. They are available in different hardness according to the intended retention force and are usually color coded. The plastic clip is easily inserted by slight pressure of a special tool in a metal housing, solidly integrated in the denture base. In this way their replacement is easy and time effective (Figure 25 and Figure 26).

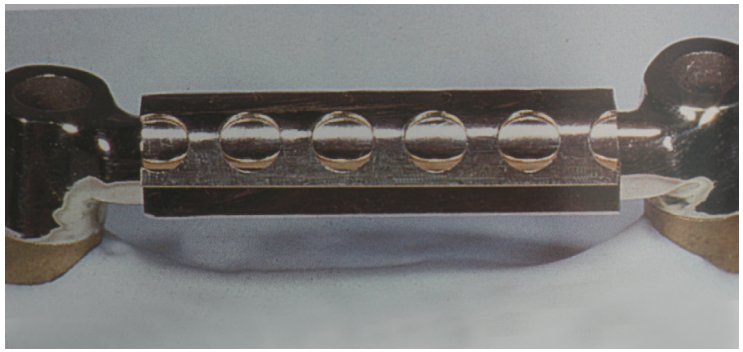


Figure 22: A gold bar with a single retaining clip on the working cast. Before integration in the denture base, the space underneath should be isolated (from Preci-Line Laboratory manual, Alphadent Co., Belgium).

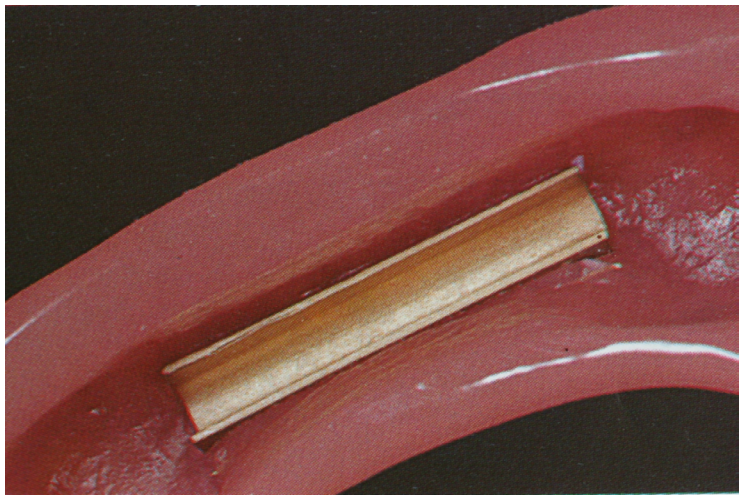


Figure 23: The overdenture base with a single long clip (from Preci-Line Laboratory manual, Alphadent Co., Belgium).

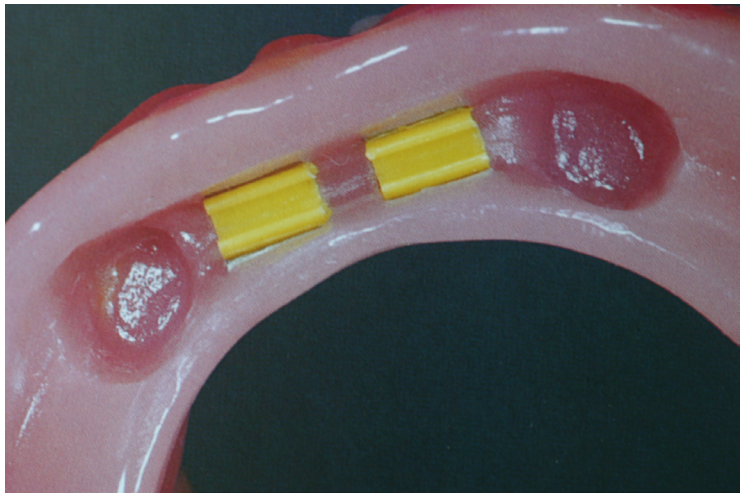


Figure 24: The overdenture base with two shorter clips (from Preci-Line Laboratory manual, Alphadent Co., Belgium).

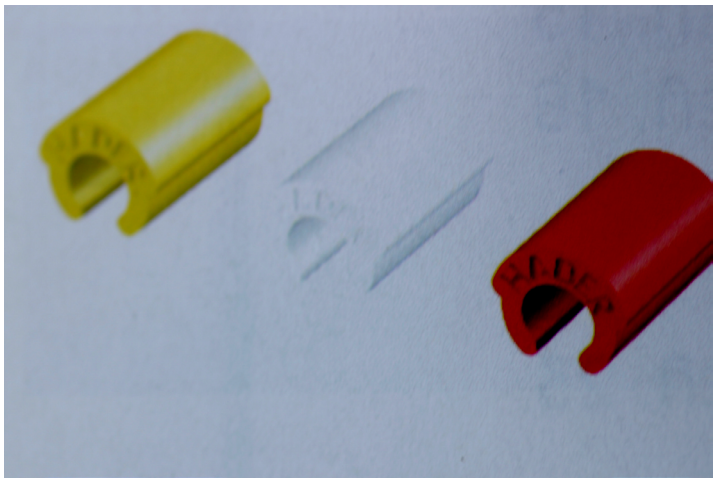


Figure 25: Color-coded plastic clips for bar with different retention force (from Preci-Line Laboratory manual, Alphadent Co., Belgium).

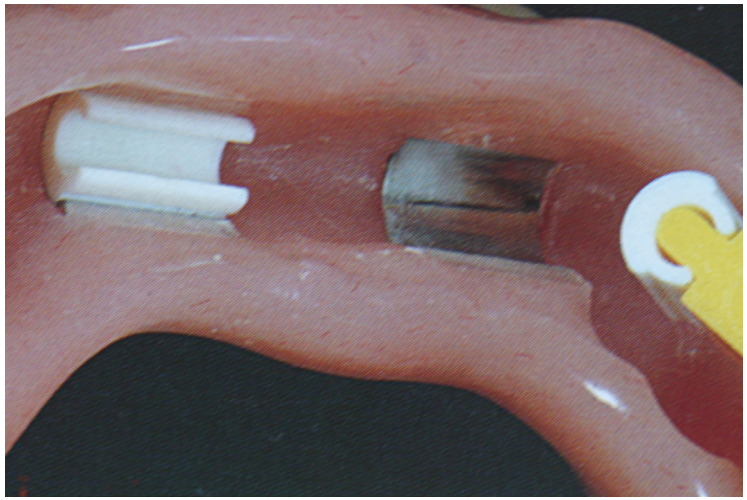


Figure 26: Insertion of the plastic clip in the metal housing by a special instrument (from Preci-Line Laboratory manual, Alphadent Co, Belgium).

If the horizontal space available between implants is too short to allow construction of a bar with adequate length, additional stability may be contributed by integrating precision attachments into the bar. Alternatively, short distal extensions may be added to the bar to allow placement of additional retaining clips [37,38]. In these cases the overdenture is implant-supported (Figure 27 and Figure 28).

White et al [39] and Elsyad et al [40] reported increased loading of most distal implants, when distal cantilevers were used, resulting in bone absorption, but these findings have not been confirmed by other *in-vitro* and *in-vivo* studies [41,42].

Figure 27: A cast bar on four implants with distal extensions.

Figure 28: The corresponding overdenture with metal framework and five retaining clips.

Furthermore, neither the length of the cantilever can be predictably determined [43], nor can extensions (cantilevers) be used without considering the restrictions they impose on rotational freedom [10].

Bars connecting three implants have also been suggested, but angulation of the two connective parts also prohibits denture rotation, probably leading to unfavourable loading of implants. In these cases, it is impossible to form the bar parallel to the hinge axis of the patient. Although such a design has been described and presented, there is not sufficient clinical documentation on the longevity of these restorations [44].

Bars have been generally considered as a standard for maxillary overdentures in cases where mostly 4 implants were inserted [45]. Main reasons for preferring a bar for the maxillary overdenture are the curve of the alveolar ridge, the palatal inclination of implants with-usually- divergent axes and the increased thickness of the mucosa. Ball attachments or locators may also be used, but maximum divergence between implants should be 10° and 40°, respectively [2,46]. For this reason, the use of telescopic copings as retentive and supporting elements also shows clinical advantages [10].

Single retentive mechanisms facilitate oral hygiene due to their shape and should be preferred for patients that do not have the visual or manual capacity to effectively clean implants. Bars may predispose for hyperplasia of the underlying soft tissues [28,47]. This phenomenon

has been attributed both to insufficient oral hygiene and to the negative pressure created underneath the overdenture. For this reason the bar should be at a distance from the gingival crest to allow the use of interdental brushes; furthermore, specific instructions should be given to patients and a proper recall system should be in place.

Indications for Telescopic Copings

Telescopic copings provide stable and accurate retention and support to overdentures though friction of the primary coping and the secondary crown. The primary coping is formed by milling of a prefabricated massive titanium abutment retained by screw directly on the implant. The inclination of the axial walls varies from 20-60, depending on the number of implants, and the friction planned. The secondary crown is cast-as in conventional telescopic crowns on natural teeth-and is connected to the frame of the overdenture. Gold alloys are most suitable for the casting of secondary crowns, as they offer biocompatibility, accurate casting and the friction needed, but they entail increased cost. Base metal alloys can also be used for this purpose, but they should be cast with extreme caution to achieve the necessary friction.

CAD/CAM systems for fabrication of telescopic crowns on implants have recently been introduced, but there is not yet sufficient clinical data to compare the conventional casting procedure with the newly introduced technology [48].

Telescopic copings offer excellent stability, allow for easy oral hygiene and can be used even in severely divergent implants. They also offer a solution in cases of limited vertical space where a bar cannot be properly formed. Another indication for telescopic copings is to support overdentures on natural teeth and implants (Figure 29 and Figure 30). In these cases remaining teeth with good or doubtful prognosis can serve as supporting elements along with implants placed in strategical positions. If a tooth fails and has to be extracted, the overdenture can remain in function with minimum repair on the by the rest of the teeth or implants.

On the other hand, a technique-sensitive procedure must be followed, which requires a skilled and experienced dental laboratory. Cost is also increased, due to technical complexity, the need for prefabricated abutments (requiring precision milling) and the casting of secondary crowns.

Prefabricated titanium abutments of different inclinations (40-60) and various gingival heights are also available for some implant systems, as for example Syncone Abutments for Ankylos implants (Dentsply Implants, Mannheim, Germany). These abutments can be parallelized and fixed intraorally, ensuring a single insertion path for the overdenture. They are combined with prefabricated telescoping gold copings that fit accurately on the abutments. The whole procedure of integrating the copings to the base of the overdenture can be accomplished chairside, eliminating the need for laboratory procedures.

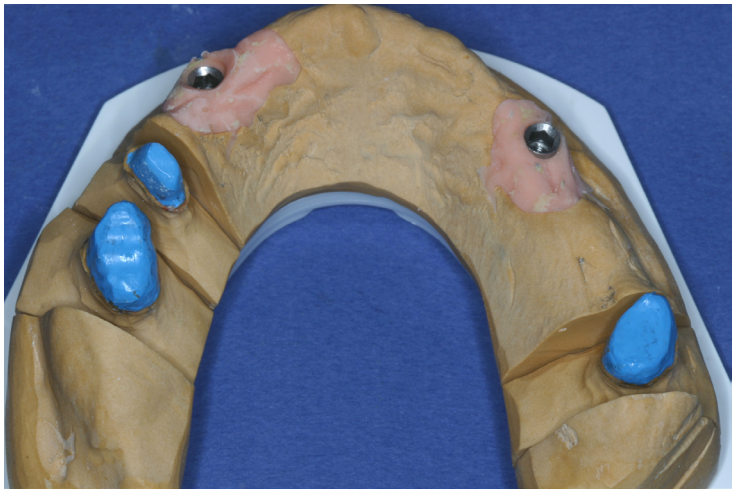


Figure 29

Figure 30

Figures 29 and 30: A clinical case for an overdenture supported by telescoping crowns on natural teeth and implants inserted in strategical positions.

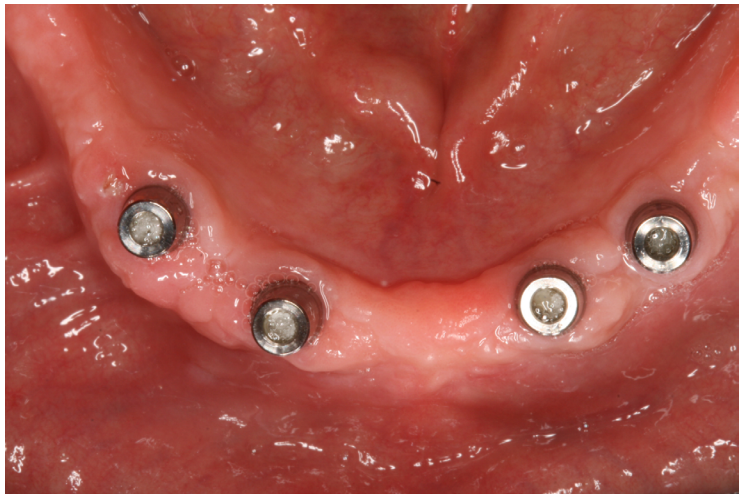


Figure 31

Figure 32

Figures 31 and 32: A clinical case restored with refabricated titanium primary telescopic copings (Ankylos Syncone Abutments) in the mandible at the 1-year recall.

Figure 33: Prefabricated gold secondary telescopic copings welded to the metal framework of the overdenture at the 1-year recall.

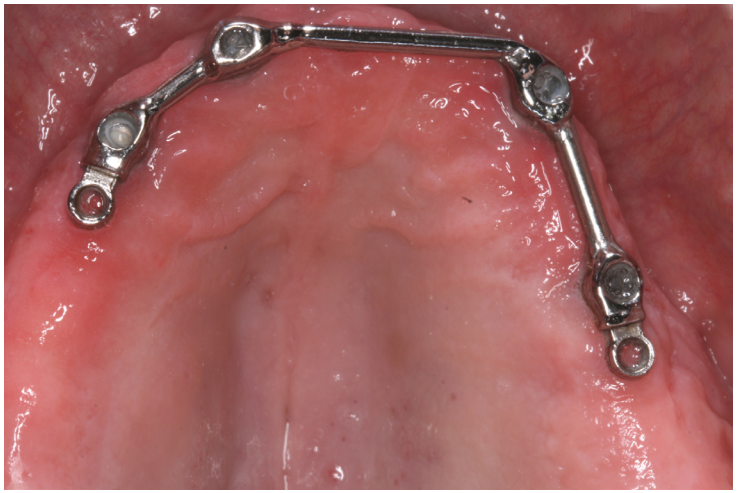


Figure 34: The same patient as in Fig 31-33 restored with a bar-retained maxillary overdenture at the 1-year recall.

This treatment option combines increased stability and retention, reduced laboratory cost and minimal maintenance care (Figures 31-33). The same patient was restored in the maxilla with a bar-retained overdenture with additional precision attachments to increase stability and retention (Figure 34).

Compared to bars, telescoping crowns have also a major advantage concerning the peri-implant soft tissues, as they allow an easier and more effective oral hygiene. In Figures 35-38 the same patient as in Figures 31-33 is presented at the 7-year recall. As it can be noted, there is inflammation on the peri-implant tissue surrounding the bar anchors and a light hyperplasia underneath the bar. In contrast, the condition of the soft tissues around the telescopic copings is significantly healthier. The ability of the patient to maintain efficient oral hygiene is also reflected on the base of the two types of overdenture of the same patient (Figure 39).

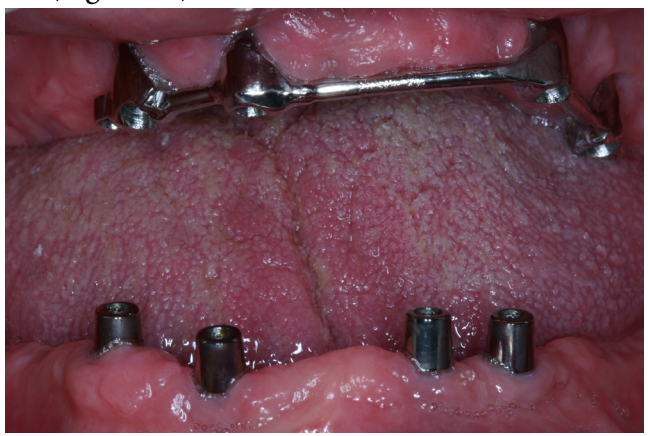


Figure 35: The same patient as in Fig 27-29 at the 7-year recall.

Figure 36: Soft tissue condition around the mandibular telescopic copings at the 7-years recall.

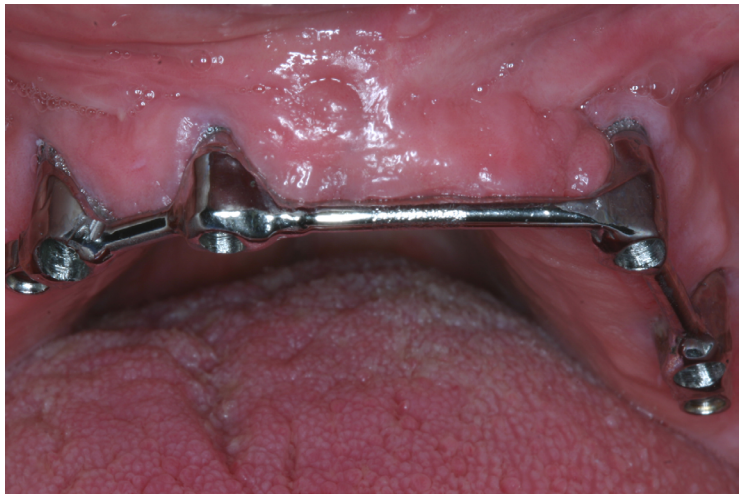


Figure 37

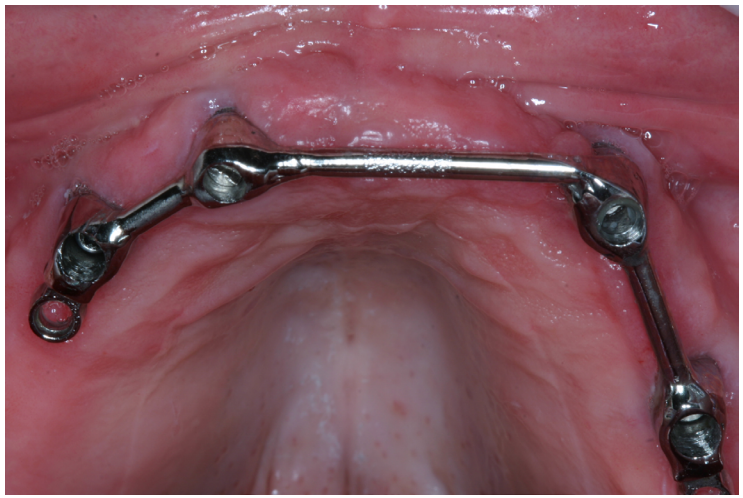


Figure 38

Figures 37 and 38: Soft tissue condition around the maxillary bar copings at the 7-year recall.

Figure 39: The maxillary and mandibular overdentures at the 7-years recall.

Selection of Retention Elements

The selection of a retention element depends on the following: type of overdenture, condition and shape of residual alveolar ridge, implant length and distribution on the ridge, patient's dexterity and demands from the final prosthesis and, last but not least, the cost entailed [1,12]. Another factor impacting this choice is, of course, the clinician's personal preference depending on their experience and training [49].

In cases of extended bone resorption, the retention elements should ensure horizontal stability, like bars and telescopic copings [50]. On the other hand, when alveolar bone resorption is minimal, magnets may be considered as an alternative solution, despite their inherent disadvantages. Ball attachments are suitable for patients with a narrow alveolar crest, as bars may require space (vertical and horizontal) and reducing tongue comfort [50]. Telescopic copings offer excellent retention and stability to the overdenture, but require a technique-sensitive laboratory and clinical procedure. As in these cases the splinting of implants is achieved only indirectly, high stresses may be transferred on single implants, which can lead to marginal bone resorption or mechanical complications.

Cost and time are two more important factors to be taken under consideration. Telescopic copings are the most expensive retention system followed by cast bars. Magnets, ball-attachments and locators need minimum additional laboratory stages and even their maintenance is simpler and easier to accomplish chairside.

Comparison of Retention Elements

When comparing retaining mechanisms, the following factors should be taken under consideration: longevity, retention, patient satisfaction, quality of life and technical complications.

Longevity

A randomized prospective study [51] revealed a 100% survival rate over 5 years for implant-supported mandibular overdentures ov 2 implants with a bar or ball-attachment. In addition, a retrospective study [52] evaluated the cumulative survival rate for implant-supported, bar-retained and ball-retained overdentures over a period of 72 months; the authors reported an overall survival rate of 90%. Another clinical trial with a 3-year follow up [53] reported survival rates of 90%, 88% and 75% for the Locator group, the Southern plastic attachment (Southern Implants, South Africa), and the Straumann (Straumann Co, Switzerland) gold attachment, respectively.

According to another 5-8 year retrospective study [28] no differences were found between telescopic crown and bar overdenture groups, during follow up, regarding survival and success rates of implants, average bone resorption and patients' subjective satisfaction scores. Therefore, implant-supported overdentures seem to be a safe and predictable treatment option with any type of retentive element.

Retention

A 5-year follow-up clinical trial [47] studied comparative prosthetic outcomes and patients' satisfaction when ball, bar and magnet overdentures were used. Results revealed higher retention capacity in the bar group than in magnet and ball-attachments. Patients reported they would choose the same treatment again, but most of those in the magnet group would choose a better retentive solution to improve their denture stability.

According to the conclusions of a systematic review [54], in 2-implant overdentures most attachment systems lose their retentive force after clinical use. The cause for retention loss was definitely wear, but there has been insufficient research into the specific mechanisms involved in this technical problem. Relevant literature implicates various parameters influencing both the retention force produced by the attachment system used and the characteristics of its wear. There are still, however, no conclusive data confirming the precise role of the process of wear.

Türk et al [55] compared *in-vitro* the retentive force between ball and locator attachments. They reported decreased retention for both systems after 5,000 insertion-separation cycles. It should be noted, however, that Locators showed higher retention as compared to ball-attachments at the end of the fatigue test. Contrary results were reported in a later study [56], where locators showed a lower retentive force than ball and bar and clip attachment systems.

Patient Satisfaction

Following an observation period of 5 years, Naert et al [47]reported that despite the lower retention forces noted in the magnet group-as compared to bar and ball groups-all patients reported similar levels of satisfaction from their restorations. On the other hand, a clinical trial by Ellis et al [57] concluded that the overall satisfaction of patients treated with ball-retained overdentures exceeded that of patients with magnets. Patients' satisfaction level with either implant overdenture type was significantly higher as compared to conventional dentures. This study indicated that most patients showed preference for ball-attachments, despite the fact that one-third of them actively chose the magnetic attachment.

The long-term follow-up study by Kuoppala et al [58] presented excellent treatment results for implant-supported mandibular overdentures with a bar or a ball connection. Whichever type of attachment was used led to patients' satisfaction. Practical aspects that have to be considered are the following: removable overdentures are easier to clean outside the oral cavity, while fixed-implant full-arch dentures in an edentulous mandible demand significantly more time, effort and dexterity for proper oral hygiene. For this reason, implant overdentures should be preferred for geriatric patients, due to their limited capacity for maintaining proper hygiene.

The 5-year prospective study conducted by Krennmair et al [59] reported that, when the mandible is atrophic, either ball attachments or telescopic crowns on single implants can be a viable treatment for implant-supported overdentures, as there were no implant failures, and peri-implant conditions and overall patient satisfaction were good.

A crossover clinical trial by Krennmair et al [60] demonstrated improved satisfaction among patients with ball or locator attachment as compared to patients' baseline (i.e. their old dentures) for all parameters. Nevertheless, there was no significant preference among patients or differences concerning ball or locator attachments in regard to any of the satisfaction criteria evaluated.

As the systematic literature review by Boven et al [61] revealed, the treatment of patients already using complete dentures with implant(s) support enhances their mastication capacity and increases bite force providing a definite improvement of their overall satisfaction.

Oral Health-Related Quality of Life (OHRQoL)

Oral health-related quality of life (OHRQoL) and satisfaction are used to assess some treatment modalities implemented to restore partial or complete edentulism [62].

The influence of an implant overdenture on the oral health-related quality of life has been studied by many

researchers. A systematic review by Thomason et al [62], which compared quality of life between complete denture wearers and maxillary implant overdenture users, found that there were no significant higher overall ratings for maxillary implant prostheses compared to new conventional maxillary prostheses.

A meta-analysis of randomized-clinical trials, conducted by Emamai et al [63] revealed that mandibular implant overdentures increase the quality of life compared to new conventional complete dentures. Yunus et al [64] in a prospective study comparing OHRQoL of patients wearing complete dentures and of the same patients after the insertion of implant mandibular overdenture reported increased OHRQoL following the placement of the implant mandibular overdenture. Furthermore, a systematic review and meta-analysis of randomized controlled studies comparing implant supported mandibular overdentures and conventional dentures in regard to quality of life showed that the former perform better than the latter in improving various domains of the quality of life of edentulous patients [65].

Technical Complications

Implant overdentures require a technique-sensitive procedure and both biological and technical complications are likely to occur. The term 'technical complications' covers any kind of mechanical damage caused to the implant, to implant components or to superstructures [31].

Therefore, technical complications that may arise during clinical use should be taken under consideration for the selection of a retention element. When bars with single anchors are compared, there is controversy as to which of the two systems requires less maintenance.

According to Naert et al [47], after a 5-year observation period magnets and ball groups presented the highest incidence of prosthetic complications as compared to the bar group. A report by Walton [66] presented the three-year follow up of bar-clip and ball attachment dentures and found that the latter needed to be repaired five times more frequently, namely there were 324 repairs as compared to 72 needed for the former.

In addition, according to MacEntee et al [67], after a 3-year follow up period, the ball-attachment system needed significantly more repairs as compared to the bar-and-clip system.

Furthermore, an in vivo study by Rentsch-Kollar et al [68] reported that ball anchors required significantly more prosthetic service and a higher average number of incidents than systems with bars. Retention device complications mainly entailed mounting new female retainers, bar repairing and ball anchor changing.

On the contrary, the results of a 5-year randomized, prospective, clinical study [51] focused on mandibular 2-implant overdentures showed that technical complications and repairs per patient were more frequent in bars than in ball attachments.

Locator and ball attachment systems were compared in a one-year report [34], which revealed that the former showed higher maintenance needs than the latter. Krennmair et al [60] also reported that locator attachment systems demanded higher post-insertion care (activation of retention) than ball anchors, despite the fact that overall prosthodontic maintenance incidence rates showed no significant difference between the two retention modalities.

Contrary to the above, Cakarer et al [69] reported lower frequency of mechanical complications with locators than with ball-attachments or bars.

Ball-attachments and telescopic crowns were compared in a 5-year prospective study by Krennmair et al [69]. They reported that frequency of technical complications was higher with the use of the former rather than the latter system in the first years of the study, but similar rates of maintenance could well be expected from both retention modalities. According to a 5-8 year retrospective study by Zou et al [28], despite higher plaque and calculus levels in the bar group and the higher maintenance required for the telescopic crown group, in both groups implants found a healthy peri-implant structure with overdentures. Telescoping crowns have also shown good survival rates with a minimum number of complications, as reported in an extended systematic review [70].

In a long term retrospective study [71] of more than 4000 implants and a follow-up of 19 years, the survival of implants under various types of restorations was investigated along with the prosthetic complications that appeared (Figure 40). Significantly more complications occurred under bars (23,4%) compared to the mean rate of complications with all types of restorations (7,7%) and to overdentures with single ball attachments (8,3%).

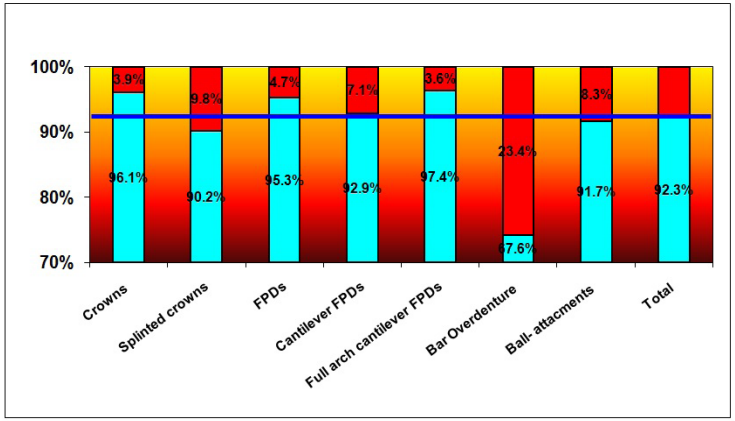


Figure 40: Prosthetic complications of implants in various types of restorations (from Kourtis 2010 [71]).

Concluding, implant overdentures can offer great comfort and satisfaction to edentulous patients using a reduced number of implants and at a lower cost, as compared to fixed restorations. There are limitations and points of attention that have to be evaluated prior to implant insertion. The number of implants and the type of retention significantly affect the final outcome and the treatment plan should be made according to the specific characteristics of each clinical case. The patient's demands and expectations should be taken into consideration along with the ability of the patient to maintain oral hygiene and adapt to the restoration planned.

References

1. Feine JS, Carlsson GE. Implant overdentures. The standard of care for edentulous patients. Chicago: Quintessence Publ. Co. 2003; 61-155.
2. Association of Dental Implantology. A dentist's guide to Implanology. England: ADI. 2012.
3. Thalji G, McGraw K, Cooper LF. Maxillary Complete Denture Outcomes: A Systematic Review of Patient-Based Outcomes. Int J Oral Maxillofac Implants. 2016; 31: s169-s181.
4. Celebić A, Knezović-Zlatarić D. A comparison of patient's satisfaction between complete and partial removable denture wearers. J Dent. 2003; 31: 445-451.
5. Redford M, Drury TF, Kingman A, Brown LJ. Denture use and the technical quality of dental prostheses among persons 18-74 years of age: United States, 1988-1991. J Dent Res. 1996; 75 Spec No: 714-725.
6. Feine JS, Carlsson GE, Awad MA, Chehade A, Duncan WJ, et al. The McGill consensus statement on overdentures. Mandibular two-implant overdentures as first choice standard of care for edentulous patients. Montreal, Quebec, May 24-25, 2002. Int J Oral Maxillofac Implants. 2002; 17: 601-602.

7. Burns DR, Unger JW, Elswick RK Jr, Beck DA. Prospective clinical evaluation of mandibular implant overdentures: Part I-Retention, stability, and tissue. J Prosthet Dent. 1995; 73: 354-363.
8. Burns DR, Unger JW, Elswick RK Jr, Giglio JA. Prospective clinical evaluation of mandibular implant overdentures: Part II-Patient satisfaction and preference. J Prosthet Dent. 1995; 73: 364-369.
9. The Academy of Prosthodontics. The glossary of prosthodontic terms (ed 8). J Prosthet Dent. 2005; 94: 10-92.
10. Mericske-Stern RD, Taylor TD, Belser U. Management of the edentulous patient. Clin Oral Implants Res. 2000; 11: 108-125.
11. Hobkirk JA, Watson RM, Searson LJJ. Introducing dental implants. London: Churchill Livingstone. 2003; 63-64.
12. Block MS, Kent JK, Guerra TR. Implants in dentistry: essentials of endosseous implants for maxillofacial reconstruction. Philadelphia: W.B. Saunders Co. 1997; 95-100.
13. Krennmair G, Sütö D, Seemann R, Piehslinger E. Removable four implant-supported mandibular overdentures rigidly retained with telescopic crowns or milled bars: a 3-year prospective study.

Clin Oral Implants Res. 2012; 23: 481-488.

14. Zou D, Wang F, Wu Y, Huang W, Zhang C, et al. Implant-Supported Telescopic Crown-Retained Overdentures for Oral Rehabilitation of Patients with Severe Bony Defects: A 5-Year Retrospective Study. Int J Oral Maxillofac Implants. 2015; 30: 937-944.

15. Thomason JM, Kelly SA, Bendkowski A, Ellis JS. Two implant retained overdentures-a review of the literature supporting the McGill and York consensus statements. J Dent. 2012; 40: 22-34.

16. Carlsson GE. Implant and root supported overdentures - a literature review and some data on bone loss in edentulous jaws. J Adv Prosthodont. 2014; 6: 245-252.

17. Mahoorkar S, Bhat S, Kant R. Single implant supported mandibular overdenture: A literature review. J Indian Prosthodont Soc. 2016; 16: 75-82.

18. Bhat S, Chowdhary R, Mahoorkar S. Comparison of masticatory efficiency, patient satisfaction for single, two, and three implants supported overdenture in the same patient: A pilot study. J Indian Prosthodont Soc. 2016; 16: 182-186.

19. Kern JS, Kern T, Wolfart S, Heussen N. A systematic review and meta-analysis of removable and fixed implant-supported prostheses in edentulous jaws: post-loading implant loss. Clin Oral Implants Res. 2016; 27: 174-195.

20. Slot W, Raghoebar GM, Vissink A, Huddleston Slater JJ, Meijer HJ. A systematic review of implant-supported maxillary overdentures after a mean observation period of at least 1 year. J Clin Periodontol. 2010; 37: 98-110.

21. Raghoebar GM, Meijer HJ, Slot W, Slater JJ, Vissink A.

22. A systematic review of implant-supported overdentures in the edentulous maxilla, compared to the mandible: how many implants? Eur J Oral Implantol. 2014; 7 2: S191-S201.

23. Listl S, Fischer L, Giannakopoulos NN. An economic evaluation of maxillary implant overdentures based on six vs. four implants. BMC Oral Health. 2014; 14: 105.

24. Laurito D, Lamazza L, Spink MJ, De Biase A. Tissue-supported dental implant prosthesis (overdenture): the search for the ideal protocol. A literature review. Ann Stomatol (Roma). 2012; 3: 2-10.

25. Spiekermann H. Color Atlas of Dental Implantology. Stuttgart: Thieme Verlag. 1995; 143-202

26. Renouard F, Rangert B. Risk Factors in Implant Dentistry. Simplified clinical analysis for predictable treatment. Illinois: Quintessence Publ. Co. 1999; 139.

27. Burns D. The mandibular complete overdenture. Dent Clin N Am. 2004; 48: 603-623.

28. Zarb G, Bolender C, Eckert S, Jacob R, Fenton A, et al. Prosthodontic treatment for edentulous patients. 12th ed. St Louis: Mosby. 2004; 502-506.

29. Zou D, Wu Y, Huang W, Zhang Z, Zhang ZA. 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. 2013; 28: 1322-1330.

30. Mish C. Dental implant prosthetics. St. Louis: Elsevier Mosby. 2005; 207-210.

31. Hemmings KW, Schmitt A, Zarb GA. Complications and maintenance requirements for fixed prostheses and overdentures in the edentulous mandible: a 5-year report. Int J Oral Maxillofac Implants. 1994; 9: 191-196.

32. Berglundh T, Persson L, Klinge B. A systematic review of the incidence of biological and technical complications in implant dentistry reported in prospective longitudinal studies of at least 5 years. J Clin Periodontol. 2002; 29: 197-212.

33. Priescel HW. Overdentures made easy. Quintessence Publ. 1996; 81-138.

34. Stoumpis C, Kohal RJ. To splint or not to splint oral implants in the implant-supported overdenture therapy? A systematic literature review. J Oral Rehabil. 2011; 38: 857-869.

35. Kleis WK, Kämmerer PW, Hartmann S, Al-Nawas B, Wagner W. A comparison of three different attachment systems for mandibular two-implant overdentures: one-year report. Clin Implant Dent Relat Res. 2010; 12: 209-218.

36. Kim HY, Lee JY, Shin SW, Bryant SR. Attachment systems for mandibular implant overdentures: a systematic review. J Adv Prosthodont. 2012; 4: 197-203.

37. Hussein MO. Stress-strain distribution at bone-implant interface of two splinted overdenture systems using 3D finite element analysis. J Adv Prosthodont. 2013; 5: 333-340.

38. McCartney JW. Cantilever rests: An alternative to the unsupported distal cantilever of osseointegrated implant-supported prostheses for the edentulous mandible. J Prosthet Dent. 1992; 68: 817-819.

39. Mericske-Stern R. Force distribution on implants supporting overdentures: the effect of distal bar extensions. A 3-D in vivo study. Clin Oral Implants Res. 1997; 8: 142-151.

40. White SN, Caputo AA, Anderkvist T. Effect of cantilever length on stress transfer by implant-supported prostheses. J Prosthet Dent. 1994; 71:

493-499.

41. Elsyad MA, Al-Mahdy YF, Salloum MG, Elsaih EA. The effect of cantilevered bar length on strain around two implants supporting a mandibular overdenture. Int J Oral Maxillofac Implants. 2013; 28: e143-150.
42. Sadowsky SJ, Caputo AA. Stress transfer of four mandibular implant overdenture cantilever designs. J Prosthet Dent. 2004; 92: 328-336.
43. Semper W, Heberer S, Nelson K. Retrospective analysis of bar-retained dentures with cantilever extension: marginal bone level changes around dental implants over time. Int J Oral Maxillofac Implants. 2010; 25: 385-393.
44. Ebadian B, Mosharraf R, Khodaeian N. Effect of cantilever length on stress distribution around implants in mandibular overdentures supported by two and three implants. Eur J Dent. 2016; 10: 333-340.
45. Liu J, Pan S, Dong J, Mo Z, Fan Y, et al. Influence of implant number on the biomechanical behaviour of mandibular implant-retained/supported overdentures: a three-dimensional finite element analysis. J Dent. 2013; 41: 241-249.
46. Calvert G, Lamont T. Four implant bar-connected implants sufficient to support a maxillary overdenture. Evid Based Dent. 2013; 14: 49-50.
47. Finger IM, Markovits S, Raigrodski AJ. Salvaging a failed implant-supported fixed prosthesis in the completely edentulous patient. In: Zinner JS, Panno JM, Small A, Landa J. Implant dentistry. From failure to success. UK: Quintessence Publishing Co. 2004; 169.
48. Naert I, Gizani S, Vuylsteke M, Van Steenberghe D. A 5-year prospective randomized clinical trial on the influence of splinted and unsplinted oral implants retaining a mandibular overdenture: prosthetic aspects and patient satisfaction. J Oral Rehabil. 1999; 26: 195-202.
49. Bergler M, Holst S, Blatz MB, Eitner S, Wichmann M. CAD/CAM and telescopic technology: design options for implant-supported overdentures. Eur J Esthet Dent. 2008; 3: 66-88.
50. Kim HY, Shin SW, Lee JY. Standardizing the evaluation criteria on treatment outcomes of mandibular implant overdentures: a systematic review. J Adv Prosthodont. 2014; 6: 325-332.
51. Shafie HR. Clinical and laboratory manual of implant overdentures. Iowa: Blackwell Publ. Prof. 2007; 33.
52. Gotfredsen K, Holm B. Implant-supported mandibular overdentures retained with ball or bar

Dental Implants

attachments: a randomized prospective 5-year study. Int J Prosthodont. 2000; 13: 125-130.

53. Närhi TO, Hevinga M, Voorsmit RA, Kalk W. Maxillary overdentures retained by splinted and unsplinted implants: a retrospective study. Int J Oral Maxillofac Implants. 2001; 16: 259-266.

54. Mackie A, Lyons K, Thomson WM, Payne AG. Mandibular two-implant overdentures: three-year prosthodontic maintenance using the locator attachment system. Int J Prosthodont. 2011; 24: 328-331.

55. Alsabeeha NH, Payne AG, Swain MV. Attachment systems for mandibular two-implant overdentures: a review of *in vitro* investigations on retention and wear features. Int J Prosthodont. 2009; 22: 429-440.

56. Türk PE, Geckili O, Türk Y, Günay V, Bilgin T. *In vitro* comparison of the retentive properties of ball and locator attachments for implant overdentures. Int J Oral Maxillofac Implants. 2014; 29: 1106-1113.

57. Shastry T, Anupama NM, Shetty S, Nalinakshamma M. An *in vitro* comparative study to evaluate the retention of different attachment systems used in implant-retained overdentures. J Indian Prosthodont Soc. 2016; 16: 159-166.

58. Ellis JS, Burawi G, Walls A, Thomason JM. Patient satisfaction with two designs of implant supported removable overdentures; ball attachment and magnets. Clin Oral Implants Res. 2009; 20: 1293-1298.

59. Kuoppala R, Näpänkangas R, Raustia A. Outcome of implant-supported overdenture treatment--a survey of 58 patients. Gerodontology. 2012; 29: e577-584.

60. Krennmair G, Seemann R, Weinländer M, Piehslinger E. Comparison of ball and telescopic crown attachments in implant-retained mandibular overdentures: a 5-year prospective study. Int J Oral Maxillofac Implants. 2011; 26: 598-606.

61. Krennmair G, Seemann R, Fazekas A, Ewers R, Piehslinger E. Patient preference and satisfaction with implant-supported mandibular overdentures retained with ball or locator attachments: a cross-over clinical trial. Int J Oral Maxillofac Implants. 2012; 27: 1560-1568.

62. Boven GC, Raghoebar GM, Vissink A, Meijer HJ. Improving masticatory performance, bite force, nutritional state and patient's satisfaction with implant overdentures: a systematic review of the literature. J Oral Rehabil. 2015; 42: 220-233.

63. Thomason JM, Heydecke G, Feine JS, Ellis JS. How

do patients perceive the benefit of reconstructive dentistry with regard to oral health-related quality of life and patient satisfaction? A systematic review. Clin Oral Implants Res. 2007; 18: 168-188.

64. Emami E, Heydecke G, Rompré PH, de Grandmont P, Feine JS. 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. 2009; 20: 533-544.

65. Yunus N, Masood M, Saub R, Al-Hashedi AA, Taiyeb Ali TB, et al. Impact of mandibular implant prostheses on the oral health-related quality of life in partially and completely edentulous patients. Clin Oral Implants Res. 2016; 27: 904-909.

66. Sivaramakrishnan G, Sridharan K. Comparison of implant supported mandibular overdentures and conventional dentures on quality of life: A systematic review and meta-analysis of randomized controlled studies. Aust Dent J. 2016.

67. Walton JN. A randomized clinical trial comparing two mandibular implant overdenture designs: 3-year prosthetic outcomes using a six-field protocol. Int J Prosthodont. 2003; 16: 255-260.

68. MacEntee MI, Walton JN, Glick N. A clinical trial of patient satisfaction and prosthodontic needs with ball and bar attachments for implant-retained complete overdentures: three-year results. J Prosthet Dent. 2005; 93: 28-37.

69. Rentsch-Kollar A, Huber S, Mericske-Stern R. Mandibular implant overdentures followed for over 10 years: patient compliance and prosthetic maintenance. Int J Prosthodont. 2010; 23: 91-98.

70. Cakarer S, Can T, Yaltirik M, Keskin C. Complications associated with ball, bar and Locator attachments for implant-supported overdentures. Med Oral Patol Oral Cir Bucal. 2011; 16: 953-959.

71. Verma R, Joda T, Brägger U, Wittneben JG. A systematic review of the clinical performance of tooth-retained and implant-retained double crown prostheses with a follow-up of ≥ 3 years. J Prosthodont. 2013; 22: 2-12.

72. Kourtis S. Long term clinical results from the use of dental implants. A clinical research monography. Athens. 2010.