Prosthodontic Maintenance of Maxillary Implant Overdentures: A Systematic Literature Review

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Purpose: The aim of this article is to systematically review the literature on prosthodontic maintenance requirements of maxillary implant overdentures with different prosthodontic designs. ***Materials and Methods:*** A standard approach of searching MEDLINE, PubMed, and Google Scholar databases as well as early online journal articles was followed. Hand-searching identified other relevant articles from the reference lists of the articles found. Selection criteria were details of prosthodontic maintenance related to different prosthodontic designs of maxillary implant overdentures, regardless of the dentition of the opposing arch or prosthesis. ***Results:*** From a total of 58 relevant studies identified, only 18 met the criteria. Several categories were used to document the prosthodontic maintenance of maxillary implant overdentures, usually with four or more splinted or unsplinted implants using different attachment systems. Aspects of patrix and matrix maintenance were primarily reported, although soft tissue complications were described frequently. Subjective information on relines and the rationale for minimizing overdenture fractures was found. ***Conclusions:*** Prosthodontic maintenance requirements of maxillary overdentures are a direct consequence of the attachment system, together with differing numbers and distributions of implants. The reviewed literature does not provide a clear controlled indication of prosthodontic maintenance requirements of maxillary overdentures for different prosthodontic designs and attachment systems. Future standardization of maxillary implant overdenture design is recommended, and universally accepted criteria for reporting maxillary implant overdenture maintenance should be implemented to establish accurate comparative data analysis. *Int J Prosthodont 2012;25:381–391.*

Rehabilitation of the edentulous maxilla with implant overdentures, irrespective of the opposing dentition or prosthesis, commits patients to future prosthodontic maintenance.[1] The key to prosthodontic success of maxillary implant overdentures is minimizing the future burden of postinsertion maintenance. Mechanical complications of the attachment systems selected along with mucosal problems are considered to be the most relevant in terms of maintenance requirements encountered.[1–4] Differences in maintenance requirements are related to the plethora of overdenture designs with various patrix and matrix components, independent of the implant systems used.[1,5,6] The number of implants and their positions and degrees of parallelism influence maxillary overdenture design and subjective selection of the attachment system.[7] These factors are essential in relation to the required mucosal support and palatal coverage from the primary and secondary stress-bearing areas.[8,9] Stable maxillary overdenture design is facilitated by implant alignment that limits micromovement during function and wear of attachment systems and decreases maintenance requirements.[10–14] Connecting bars as opposed to free-standing single ball, stud, or magnetic attachment systems have dominated the literature on maxillary overdentures.[10,11,15–19] Controversy exists in the literature regarding the use of ball abutments to retain maxillary implant overdentures, since some authors[17,20] have expressed concerns while others[21–23] have reported favorable outcomes with such designs.

Few studies have specifically evaluated the influence of prosthodontic design on the long-term maintenance requirements of these prostheses.[1,24] Lack of a standardized prosthodontic design and small participant numbers have resulted in data that are often inconclusive.[1,7,25–27] Nonetheless, there appears to be a uniform consensus that the maintenance requirements peak during the first year of service and

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decrease over subsequent years to reach a balanced level.[28,29] A clear distinction between maintenance requirements of maxillary and mandibular overdentures has not been presented in the literature. This is relevant in view of the differences in the minimum number of implants required to support a prosthesis, degree of residual ridge resorption, residual ridge anatomy, and the denture stress-bearing areas.[1,30–32] These aspects, combined with the weighted advantage of mandibular overdentures in the literature, may disguise the complexity of prosthodontic maintenance requirements for maxillary implant overdentures.

The aim of this review is to critically evaluate the literature on prosthodontic maintenance requirements for maxillary implant overdentures using different prosthodontic designs.

Materials and Methods

Specific inclusion and exclusion criteria were used during the literature search. Inclusion criteria consisted of randomized controlled trials and prospective and retrospective studies on completely edentulous maxillae rehabilitated with an implant overdenture, studies reporting prosthodontic maintenance on maxillary implant overdentures only and free of combined data with fixed prostheses or mandibular overdentures, and studies in the English language only. No restrictions were placed on the status of the mandible in terms of opposing prostheses, status of the natural dentition, or the minimum observation period. Exclusion criteria consisted of any studies on maxillary implant overdentures used to rehabilitate maxillofacial defects and studies reporting on combined maintenance requirements of maxillary and mandibular implant overdentures.

Search Strategy

MEDLINE (1988 to April 2010), PubMed (using medical subject headings), and Google Scholar databases were searched using the following key words: "maxilla ± implant ± overdenture(s)," "oral ± dental ± implant(s)," "prosthodontic design(s)," and "prosthodontic ± maintenance ± complication," with the restriction of articles in English only. Other articles were identified from the reference lists of the articles found using the aforementioned databases, supplemented by manual hand-searching of the following dental journals: *British Dental Journal, Clinical Implant Dentistry and Related Research*, *Clinical Oral Implants Research, Implant Dentistry, International Journal of Oral and Maxillofacial Implants, International Journal of Oral and Maxillofacial Surgery, International Journal of Periodontics & Restorative Dentistry, International Journal of Prosthodontics, Journal of the American Dental Association, Journal of Clinical Periodontology, Journal of Dental Research, Journal of Oral Implantology, Journal of Oral and Maxillofacial Surgery, Journal of Prosthodontics, Journal of Prosthetic Dentistry,* and *Journal of Periodontology.* The titles and abstracts (when available) of all reports identified through the electronic search were scanned independently by the authors. For studies appearing to meet the inclusion criteria or for which there were insufficient data in the title and abstract to make a clear decision, the full text was obtained. All information was assessed independently by the authors to establish whether the studies met the inclusion criteria. Unanimous agreement between the reviewers regarding the included studies was achieved.

Results

A total of 58 relevant studies on maxillary implant overdentures were identified, of which 28 reported on maintenance requirements.[2,3,9–11,14–18,21,24,28,29,33–46] On reviewing the abstracts of these articles, 18 studies fulfilled the inclusion criteria,[2,3,10,11,14,16,18,21,24,29,33,34,36,39–43] while 10 articles were excluded since the data reported were mixed with that of either implant fixed partial dentures[28,44] or mandibular overdentures,[9,15,17,35,37,38,45,46] which prevented analysis of data focused on maxillary overdenture maintenance requirements only (Table 1). The included articles consisted of 8 prospective[2,3,14,16,24,33,34,36] and 10 retrospective studies.[10,11,18,21,29,39–43] The definition of prosthodontic maintenance of a maxillary overdenture has been historically broadly classified into mechanical complications, prosthesis-related adjustments, and soft tissue problems,[3,41] with subjective complaints such as phonetics, esthetics, and aspects of the opposing prosthesis maintenance.[17,41] The patrix designs and number and size of the matrices were often not specified. Prosthodontic maintenance of patrices and matrices represented the cardinal aspects of the studies reviewed. Adjustment and contouring of denture flanges and relining were usually performed following wear and activation or replacement of matrices. The longest follow-up within the included studies was 10 years, and the shortest was 3 months.

Maintenance of Matrices

Adjustment or repair of loosened/fractured matrices of attachment systems dominated the identified studies.[11,18,24,33,39,40,42,43] A prospective multicenter overdenture study involving 133 participants using a

different number of implants noted clip fracture in 6 participants, while 8 maxillary implant overdentures required bar-clip activations on one or more occasions during the first year of function.[33] Jemt et al[39] investigated 91 maxillary overdentures and reported bar-clip retention problems (17%) and bar-clip fracture (22%) during the first year of function. This resulted in the recommendation of the inclusion of a spacer to allow vertical resiliency and to reduce loading on the acrylic resin of the clip and its surroundings, which would reduce fracture of the denture base. Kiener et al[42] reported a mean of 2.1 adjustments/repairs of matrices per splinted/unsplinted design for maxillary overdentures over a mean observation period of 3.2 years. They also noted that 50% of maintenance requirements were recorded for only 20% of participants.[17]

Studies using a specific planned approach for maxillary implant overdentures supported by milled bars and metal reinforcements showed a reduced incidence of prosthodontic maintenance requirements of bar-clip activation or renewal of the attachment system.[10,40] One group[10] also found increased maintenance required for overdentures with six to eight implants placed in the grafted maxillary molar regions as compared to four implants placed in the anterior maxillary regions. Others[24] reported minor adjustments of attachments (Ceka, Preat) and oral hygiene measures to be the only aftercare needed for maxillary implant overdentures during the 10-year follow-up. Naert et al[16] reported that the most frequent prosthodontic complication with hinging overdenture designs was wear of the attachments, which necessitated activation or replacement of the attachment systems.

The frequency of matrix replacements varied, and it was unclear whether replacement was determined subjectively by the patient or objectively by the clinician. In a retrospective study, 50% of patients did not request any matrix replacement for more than 5 years, whereas the other half required replacement of the resilient matrices bimonthly owing to unsatisfactory retention.[11] The mean time in service reported before matrix replacement was 21.5 months.[11]

Maintenance of Patrices

The wear and fracture or failure of patrices was notably less frequent than that of matrices in the selected studies. For splinted implant overdenture designs, evidence of low failure rates of interabutment connecting bars but higher failure rates of distal cantilever extensions were clearly identified.[42] Kiener et al[42] reported 2 fractured interabutment U-shaped Dolder bars compared to 8 fractured distal bar extensions in 33 maxillary implant overdentures during 2 years of service. However, reasons for these fractures and the specific fracture sites were not reported. A low incidence of bar fractures at the bar-abutment junction was noted in several studies,[2,3,39] attributed to inadequate soldering or casting at the junction between the abutment cylinder and bars.

Visser et al[24] modified their attachment design from a milled gold alloy bar with Ceka attachments to a thick egg-shaped milled solid titanium bar to avoid complications and technical difficulties associated with the Ceka attachment and bar superstructure. Only one study reported wear of ball abutments on top of a bar superstructure in more than 33% of participants despite using resilient matrices.[11] The authors attributed this wear to the overdenture design with partial palatal coverage and the material used for fabrication of the bar and ball attachments.

Studies reported abutment screw loosening with implant overdentures.[10,16,18,39,40,42,43] Smedberg et al[40] noted that 5 of 8 patients with maxillary overdentures needed tightening of implant abutment screws after 2 years of function. Others[42] also reported retightening of abutment screws to be the most frequent mechanical complication encountered with maxillary implant overdentures supported by bars. They detected 6 of 41 and 5 of 34 overdentures with screw loosening in the first and second years of service, respectively. Krennmair et al[10] reported an abutment screw loosening incidence of 5% after a mean observation period of 5 years.

Interabutment Distance

The interabutment distance and its influence on maxillary overdenture patrix and matrix maintenance was not addressed in the majority of studies. Naert et al[43] used an interabutment distance of 24 to 39 mm along the ridge when using two or three unsplinted implants. Närhi et al[21] speculated that with the splinted design, an increased interabutment distance would cause loss of connecting bar rigidity, more complex stress distribution, and higher incidence of abutment screw loosening. However, they still did not recommend an ideal interabutment distance.

Relines

Jemt et al[39] found relining to be necessary for 24% of maxillary implant overdentures in the first year of function to compensate for residual ridge resorption under the distal extension areas, and improve the adaptation of prostheses to the underlying tissues. Other reports noted that 40% of maxillary implant overdentures required relining within 3 years.[41]

Table 1 Studies Involving Maxillary Implant Overdentures and Prosthodontic Maintenance

Study	Type of study	Maximum observation period (mo)	No. of participants	Total no. of implants	No. of implants in maxilla	Attachment system
Naert et al[43]	Retrospective	28	6	12	2 (canine to premolar region)	Splinted: round curved bar (n = 1) Unsplinted: O-rings (n = 4), magnets (n = 1)
Johns et al[33]	Prospective	12	25	117	Maximum number	Splinted: cast bar, soldered wrought wire, round/oval, curved/straight
Jemt et al[39]	Retrospective	12	92	430	Unplanned	Splinted: bar (n = 90) Unsplinted: ball (n = 1), magnet (n = 1)
Jemt[29]	Retrospective	36	70	336	Unplanned	Splinted: bars
Smedberg et al[41]	Retrospective	32	18	86	4 to 6	Splinted: tapered milled bar
Palmqvist et al[18]	Retrospective	36	25	93	4 to 8	Splinted: wrought round bar (without extension [n = 5], with extension [n = 16]), Dolder bar (without extension [n = 2], with extension [n = 1]) Unsplinted (n = 1)
Watson et al[3]	Prospective	60	29	117	Not mentioned	Splinted: cast/wrought bars (round/oval/U-shaped), straight/curved/angular bars
Toljanic et al[34]	Prospective	19	25	162	Not mentioned	Splinted: primary milled framework, positive locking with parallel friction pin and swivel latch attachments
Naert et al[16]	Prospective	48	13	53	Minimum = 4	Rigid cast bar and two attachments placed distal to abutment
Smedberg et al[40]	Retrospective	72	28	154	6	Splinted: tapered cast and milled gold alloy bar
Zitzmann and Marinello[14]	Prospective	27	10	71	5 to 10	Splinted: milled bar (soft tissue contact [n = 7], no soft tissue contact [n = 3])
Kiener et al[42]	Retrospective	108	41	173	4 to 6	Splinted: U-shaped Dolder bar with bilateral distal extension (n = 24) (mesial extension [n = 1], without extension [n = 8]) Unsplinted (n = 8): ball, telescopic coping
Närhi et al[21]	Retrospective	54	16	88	Not mentioned	Splinted: bar (n = 11) Unsplinted: 2 to 6 balls (n = 5)
Widbom et al[11]	Retrospective	60	27	145	Not mentioned	Splinted: rigid cast gold alloy bar with 2 ball attachments (OT cap, Rein 83)

× = no. of occasions.

Palatal coverage	Status of opposing arch	Prosthodontic maintenance
Not mentioned	Not mentioned	Mechanical: corrosion, wear, and loss of retention of magnets; fractured O-ring housing twice (n = 8); loose abutment screws
Not mentioned	Natural teeth with fixed partial prostheses or removable partial denture, fixed implant prostheses, completely edentulous	Soft tissue: soreness, ulceration, denture stomatitis, hyperplasia Mechanical: clip fracture (n = 6), overdenture fracture (n = 3), clip activation (n = 8) Denture adjustments: relining (n = 8)
Not mentioned	Not mentioned	Soft tissue: ulceration (33%), hyperplasia (7%) Mechanical: clip fracture (22%), clip activation (10%, 1×; 4%, 2×; 3%, 3×), overdenture fracture (3%), denture tooth fracture (2%), bar fracture (1%), acrylic resin fracture around clips (11%), loose abutment screws (3%) Denture adjustments: occlusal adjustment, relining (24%)
Not mentioned	Not mentioned	Soft tissue: hyperplasia (6/37), decubitus ulcer (4/37) Mechanical: clip fracture (3/37), clip activation (3/37) Denture adjustments: denture resin fracture (10/37), relining (3/37)
Horseshoe (Co-Cr reinforced)	Not mentioned	Soft tissue: denture stomatitis (n = 1) Mechanical: attachment activation (n = 10), attachment replacement (n = 6) Denture adjustments: relining (n = 3), replacement overdenture (n = 1), esthetic problems
Complete: acrylic resin (n = 8), metal base (n = 3) Horseshoe: acrylic resin base with metal framework (n = 10), metal base (n = 4)	Natural dentition, conventional fixed partial denture, fixed implant prostheses, removable partial denture	Soft tissue: hyperplasia (12/25), denture stomatitis (7/25) Mechanical: loose abutment screws (3/19), loose/fractured matrices (6/25), overdenture fracture (3/25), denture teeth fracture (1/6) Denture adjustments: relining (2/25), denture adjustment (2/25), replacement overdenture (4/25)
Complete (acrylic resin)	Natural dentition, overdenture	Soft tissue: hyperplasia, denture stomatitis, soreness, ulceration Mechanical: overdenture fracture (8, 17×), clip fracture (10, 17×), bar fracture (n = 1), dislodged clip (8, 17×), clip activation (11, 33×) Denture adjustment: relining and rebasing (8, 16×)
Ag/Pl framework and acrylic resin base	Not mentioned	Mechanical: fracture of overdenture and/or denture teeth (n = 7), nonfunctional swivel latch (n = 1), difficult manipulation of swivel latch (n = 2)
Various	Full or partial dentition (n = 8), implant overdenture on two implants (n = 1), fixed implant prosthesis (n = 2), complete denture (n = 2)	Soft tissue: mucositis, hyperplasia, soreness, ulceration Mechanical: attachment wear and replacement (n = 17), attachment activation (n = 10), loose abutment screws (n = 1) Denture adjustment: replacement overdentures (n = 1)
Horseshoe (Co-Cr framework)	Not mentioned	Soft tissue: hyperplasia (2×), denture stomatitis (14×) Mechanical: matrix activation (14, 33×), patrix replacement (14, 32×), loose abutment screws (18, 12×) Denture adjustment: relining (18, 8×), occlusal adjustment (14, 3×), denture teeth fracture (14, 6×), esthetic problems (18, 3×)
Various (depending on speech)	Not mentioned	Soft tissue: hyperplasia (n = 2) Mechanical: abutment screw fracture (n = 1), lost attachment, discolored denture teeth
No coverage (reinforced with cast framework)	Natural teeth (n = 16), natural teeth with fixed implant prostheses (n = 4), full-arch fixed implant prosthesis (n = 1), removable partial denture (n = 9), implant overdenture (n = 12)	Soft tissue: hyperplasia (n = 4), irritation, sore spots Mechanical: loose abutment screws (n = 15); fractured, loose, or lost retainers (n = 9); fractured bar (n = 2); fractured cantilever bar (n = 8) Denture adjustment: relining (n = 2), occlusal adjustment (n = 11), denture teeth fracture (n = 6), overdenture fracture (n = 1)
Complete coverage (n = 9), no coverage (n = 7)	Natural dentition with/without removable partial denture, tooth-supported overdenture, implant-supported/retained overdenture, complete denture	Soft tissue (more with bars): hyperplasia (n = 9), inflammation (n = 8) Mechanical: loose abutment screws (n = 12)
Complete: acrylic resin Palatal strap, horseshoe: Co-Cr framework	Not mentioned	Soft tissue: hyperplasia (40%–67%) Mechanical: matrix replacement (167×), patrix replacement (10×), loose abutment screw (3×) Denture adjustment: overdenture fracture (17×), denture teeth fracture (5×), denture base adjustment (11×), relining (31×)

Table 1 Studies Involving Maxillary Implant Overdentures and Prosthodontic Maintenance (cont)

Study	Type of study	Maximum observation period (mo)	No. of participants	Total no. of implants	No. of implants in maxilla	Attachment system
Ahlgren et al[36]	Prospective	49	9	25 zygomatic, 30 conventional	2 zygomatic, 2 to 3 conventional	Splinted: standard cast gold bar, rigid cast gold bars with Ceka attachment
Krennmair et al[10]	Retrospective	42.1 ± 20.1	34	179	4 to 8	Splinted: anterior milled bars with cantilevers or two bilateral posterior milled bars
Visser et al[24]	Prospective	120	39	234	6	Splinted: milled bar with Ceka attachments
Akça et al[2]	Prospective	48.5	11	44	4	Splinted: egg-shaped prefabricated gold Dolder bar with cantilever (n = 1), egg-shaped cast gold Dolder bar with cantilever (n = 10)

× = no. of occasions.

Fracture of Overdenture Bases

A higher incidence of denture base fracture of maxillary prostheses relative to the mandibular counterpart has been demonstrated, especially in cases of reduced palatal coverage and absence of metal reinforcement.[3,11] Jemt et al[39] reported 14% of participants with acrylic resin fracture around clips, and another study[34] showed acrylic resin base and tooth fracture to be the most frequently encountered complications with spark erosion maxillary overdentures over 5 years.

Mucosal Complications

The most common mucosal complications reported with maxillary implant overdentures were hyperplasia, irritations, and denture stomatitis, independent of the type of attachment system.[3,11,14,16,18,21,24,33,39,41–43] Denture stomatitis was reported in 31% of overdentures.[3] A retrospective study involving bars revealed a high incidence of hyperplasia in 64% to 67% of participants over a 5-year observation period.[11] Zitzmann and Marinello[14] noted hyperplasia in 2 of 10 participants with a splinted design at 6 months and stressed the importance of a longer observation period to minimize further complications related to mucosal hyperplasia.

Planned vs Emergency Maxillary Overdentures

Two studies reported on the maintenance requirements of maxillary overdentures in two different situations: when planned as a first line of treatment and when indicated as a rescue replacement for fixed prostheses. No difference was found in mechanical complications between the two groups. The reported mean time in service of nylon attachments was 21.5 and 18 months for the two groups, respectively.[11] However, regarding soft tissue complications, Widbom et al[11] found that hyperplasia was more common among subjects originally planned for overdentures (67%) compared with those receiving emergency overdenture treatment (40%). On the other hand, Palmqvist et al[18] reported no difference in soft tissue complications between both groups.

Time and Cost

With the exception of two studies discussing the time involved in prosthodontic aftercare of maxillary implant overdentures, time and cost implications were scarce in the literature. No studies could be identified describing the cost involved with long-term maintenance of maxillary overdentures.[29] Visser et al[24] reported a mean aftercare per patient of 443 minutes starting at 2 months after overdenture insertion until the end of the 10-year follow-up. This included only the dental chair time. Another study compared the number of clinical appointments between patients receiving maxillary overdentures as a final treatment as opposed to patients with a provisional overdenture that was later replaced with a fixed implant prosthesis. The authors identified that fewer appointments were needed for the provisional group during the first year of function, while the situation was reversed for the second and third years of follow-up.

Palatal coverage	Status of opposing arch	Prosthodontic maintenance
Not mentioned	Not mentioned	Soft tissue: hyperplasia Mechanical: cast gold bar and Ceka attachment adjustment, bulky palate (zygomatic)
Horseshoe (reinforced with cast framework)	Not mentioned	Mechanical: loose abutment screw (5%), matrix activation and renewal (6.6%) Denture adjustment: denture adjustment (n =11), denture teeth fracture/ renewal (n = 6), occlusal adjustment (n = 3), rebasing (n = 2)
Partial	Implant overdenture on 4 implants (n = 17), natural dentition (n = 15), implant overdenture on 2 implants (n = 4), conventional complete denture (n = 3)	Soft tissue: sore spots Mechanical: attachment activation (50%), attachment repair (25%) Denture adjustment: replacement overdenture (23%)
Not mentioned	Implant overdentures (n = 4), fixed implant prosthesis (n = 1), removable partial denture (n = 1), fixed prostheses (natural dentition) (n = 4), dentate (n = 1)	Soft tissue: hyperplasia (n = 3), sore spots Denture adjustment: relining (n = 1)

Discussion

This literature review was conducted to examine studies specifically related to prosthodontic maintenance requirements of maxillary implant overdentures with different designs. To the authors' knowledge, this review is the first to evaluate maxillary overdenture maintenance requirements as a separate entity, not mixed with those of mandibular counterparts or full-arch implant fixed partial dentures. This identifies a cornerstone on a topic that is relatively deficient in the literature. On the other hand, limitations with this review also need to be addressed. The bias toward English language literature is acknowledged. This could result in omission of some relevant data related to the topic at hand. Another limitation addressed is the insufficient data available for comparative analysis because of the limited number of studies included with their small sample sizes. Furthermore, the lack of standardization in the assessment of prosthodontic outcomes among studies resulted in drawing general recommendations rather than coming up with definite conclusions.

This review finds that prosthodontic maintenance requirements of maxillary implant overdentures are a direct consequence of the attachment system and the number and distribution of implants. Uncertainty exists as to what constitutes acceptable maintenance or repair and whether either of these categories should be considered as retreatment.[37] Various definitions of adjustment have been proposed ranging from any treatment of the denture that did not involve the addition of new material or the replacement of broken or missing components.[47,48] Walton and MacEntee,[48] although principally addressing mandibular implant overdentures, categorized adjustments as those events needed to adjust the denture contour, correct the occlusion, or tighten the components, whereas repair events were related to lost, loose, or fractured retentive clips and relines. On the other hand, others[42] have quantitatively differentiated between maintenance and complications depending on the number of appointments needed; in such a way, an excessive amount of maintenance needed would be categorized as a complication and failure of the prosthesis. Another classification based its prosthodontic complications on the severity: major nonretrievable, major retrievable, and minor retrievable.[44] Major nonretrievable complications included implant fracture and failure of osseointegration; major retrievable complications involved acrylic resin and tooth wear, retentive matrix fracture, overdenture fracture, or detachment; and minor retrievable complications comprised retentive bar-clip loosening and acrylic resin tooth fracture. This range of categorization makes comparison between different studies difficult and attests to the need for more universally accepted evaluation criteria for data reporting. The wide range of terminology used to describe postinsertion maintenance events and lack of strict categorization made it difficult to establish success of maxillary implant overdentures in terms of maintenance requirements and complications.[1,2,5,27] Furthermore, the authors recommend that prosthodontic complications of maxillary implant overdentures should be reported separately from mandibular implant overdentures to

distinguish their unique maintenance issues from the fixed counterparts.[9,17,49] A detailed categorization for prosthodontic maintenance of implant overdentures was proposed by Payne et al[50] in which an existing classification for fixed full-arch implant prostheses using six objectively defined fields of success, survival, unknown, dead, and retreatment (repair or replace) was adapted. This protocol would allow a detailed description of prosthodontic maintenance requirements and time to retreatment regardless of design, type of attachment, or implant system used.

Maintenance of attachment systems and denture adjustments were the most frequently encountered postoperative maintenance requirements.[3,15,34,44,48] The ability to differentiate between the extent of maintenance required among different unsplinted attachment systems has been limited by the lack of standardization in recording criterion, varying lengths of observation periods, and a small number of participants in most studies.[15–18,37] Moreover, a repeated frequency of maintenance events reported for a particular group of participants[33,42] indicated the subjective nature of these prosthodontic complications. Nonetheless, the findings reported in some early studies should be viewed cautiously because of the rapid ongoing developments of the attachment systems, which had a bearing on the number of maintenance events encountered.

Mechanical complications, though minor or reversible, can be time-consuming and financially burdening for patients. These complications may indicate that the design concept is inappropriate, the mechanical or material components are incompatible, or the occlusal scheme and masticatory function are not in harmony.[48]

When comparing rigid and resilient overdenture designs, the reduced amount of maintenance requirements for the rigid design may be attributed to the prosthesis design, which had a frictional overcasting that did not allow prosthesis rotation, thus reducing the wear on the clips.[10] This was corroborated by another study[16] that reported increased incidence of wear of attachments with a hinging overdenture design. Moreover, rigid overdenture designs tend to be implant-supported with an increased number of implants rather than solely mucosa-supported, which reduces the need for the relief of sore spots and denture relines.[24] Differences in maintenance reported between milled gold alloy bars with Ceka attachments and solid titanium bars[24] could be attributed to the physical properties of the materials used. This is supported by the findings of Widbom et al,[11] who recommended a harder and more resistant metal alloy for superstructure construction than the gold alloy used in their study to reduce the need for maintenance.

Controversy still exists in terms of prosthodontic maintenance requirements when comparing splinted and unsplinted designs. A lack of standardized superstructure design within a study and between different studies, combined with a small number of participants, did not allow any definite conclusion regarding the most effective mode of attachment system.[6,21] However, studies reporting on maintenance requirements for maxillary and mandibular overdentures combined described a higher incidence of prosthodontic complications for ball attachments compared to bars (77.5% vs 42.9%).[51] The number of maintenance events per prosthesis was 1.5 for ball attachments compared to 0.9 for bar-retained overdentures.[51] Corrosion, wear, and rapid loss of retention have frequently been reported with magnet attachment systems.[43]

Controlled trials comparing plastic and metal clips in terms of prosthodontic maintenance requirements are lacking and should be encouraged. An in vitro study[52] comparing metal and plastic clips revealed no complications after 3 years of simulated function. The authors suggested that in clinical situations, the malfunction of clips may be a result of heavy functional and parafunctional loading, improper fit of denture bases, nonparallel/misaligned implants, and changes in the supporting tissues. On the other hand, some clinical reports found a lower frequency of technical complications with metal clips compared to other types of resilient retention systems.[3,17,39] This could be explained by the fact that metal clips can be easily adjusted to improve retention. Nonetheless, resilient attachment systems are more cost-effective, easily replaced, and may produce less wear of their respective patrices than metal clips.[11,52,53]

Relines and remakes, although subjective in clinical assessment, are long-term clinical maintenance events for maxillary implant overdentures. In an attempt to facilitate the objective assessment that indicates the need for relines, Payne et al[50] proposed criteria that aid in decision making rather than relying solely on patients' subjective evaluations,[37] thus allowing a more valid comparison between studies. Remake of overdentures should also largely be dependent on professional judgment and experience, corresponding to similar objective measures developed for assessing conventional complete denture treatment.[54]

Maxillary implant overdenture base fracture has been reported frequently because of the reduced bulk of acrylic resin to accommodate attachment systems, which imparts greater load on the prosthesis base.[3,29] Several techniques and materials such as cast metal reinforcement of the denture base have been adopted,[10,16,27,40,55,56] albeit with contradicting

reports on its efficacy and possibility of implant overloading.[42,43,47,57] Fiber-reinforced denture bases have also been recommended to improve the mechanical strength of the prosthesis.[58–60] However, further research is still required to show the clinical effectiveness of this technique.

The higher incidence of mucosal hyperplasia associated with the maxillary splinted implant overdenture design can be attributed to design considerations.[16,33,39,53] Bar placement close to the mucosa and a negative pressure gradient in the dead space underneath the bar have been hypothesized to be the main reasons for the poor mucosal response.[33,38,39] Patient reluctance to remove their prostheses has also been claimed to be a contributing factor for increased hyperplasia.[43] Likewise, the higher percentage of hyperplasia reported for planned maxillary overdentures compared to emergency treatments could be explained by the fact that overdenture treatments are usually related to severe alveolar atrophy.[11] Such atrophy is frequently associated with more loosely attached mucosal tissues, resulting in higher incidence of hyperplastic tissue. However, owing to a small sample size and lack of statistical significance, this finding should be viewed cautiously.

A critical appraisal of the literature reveals a variety of terms used to describe changes in peri-implant mucosa, such as gingival hyperplasia,[16] mucosal proliferation,[41] and mucosal hyperplasia.[21,28] Although these terms have become a part of the evidence-based literature, there is no histologic evidence to support the descriptive terminology. The alternative term, mucosal enlargement, proposed by Payne et al,[61] is appropriate and more descriptive. Differences in methods used to record soft tissue parameters have tended to prevent correct interpretation of the outcomes. However, peri-implant soft tissue health was found to be independent of the type of attachment system.[1,21] Nonetheless, published evidence shows a higher Plaque Index associated with magnet attachments.[62] The more favorable soft tissue outcome shown with zirconia abutments in partially edentulous cases may be extrapolated for implant overdentures. This may be advantageous for the maintenance of peri-implant soft tissue health[63,64] and an area for future research, with application of standardized recording criterion and controlled prospective studies.

The impact of palatal coverage on prosthodontic maintenance events was not evaluated using comparative controlled trials and merits further investigation. Controversial reports on the extent of palatal coverage exist in the literature. Several authors advocated a superstructure design with reduced palatal coverage to avoid mucosal problems commonly found under maxillary overdentures and allow the preservation of oral sensations and improved patient satisfaction.[10,14,22,40,42,55] Contradicting opinions contend that complete palatal coverage is more advantageous since it reduces the wear of attachments and minimizes the risk of base fracture, which is frequently encountered with reduced palatal coverage.[3,11,26]

Similarly, the status of the opposing dentition and its potential influence on the maintenance requirements has been overlooked in most studies. Nevertheless, when described, no attempts were made to correlate it with the prosthodontic events encountered. This leaves a void in the literature that merits further investigation.

Abutment screw loosening remains a significant maintenance issue.[16,18,39,40,49] Promising and encouraging results achieved with single-piece ceramic implants in the rehabilitation of partially dentate arches[65–68] could represent an answer to this problem if ceramic implants prove to be a feasible option for implant overdentures.

Consensus is needed among prosthodontists to define what constitutes repair and maintenance for implant overdentures. There is a need to limit and redefine the wide range of terminology used so that outcomes of different studies can be more reliably compared. Future clinical trials designed to evaluate prosthodontic maintenance requirements should be more standardized with regard to the superstructure design, palatal contour, attachment system used, and status of the opposing arch to enable more definite conclusions to be drawn. Cost and time factors involved with prosthodontic aftercare of maxillary overdentures should be evaluated to allow a predictable comparison with full-arch fixed prostheses over the long term. The influence of the opposing arch on maintenance requirements of maxillary implant overdentures should also be evaluated within randomized controlled trials.

Conclusions

Prosthodontic maintenance requirements of maxillary overdentures are a direct consequence of the attachment system, together with differing numbers and distributions of implants. The reviewed literature does not provide a clear controlled indication of prosthodontic maintenance requirements of maxillary overdentures for different prosthodontic designs and attachment systems. Future standardization of maxillary implant overdenture designs is recommended, along with universally accepted criteria for reporting maxillary implant overdenture maintenance, to establish an accurate comparative data analysis.

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