INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY ADVANCED RESEARCH TRENDS
ISSN : 2349-7408
VOLUME 2, ISSUE 2, MARCH 2015

COMPLICATIONS WITH IMPLANT SUPPORTED OVERDENTURES: A PROSTHODONTIC REVIEW

Dr.LAKSHMAIAH.P, Dr.TEJASHWAR REDDY.B Dr.M.PRADEEP.
Department of Prosthodontics,
C K S Theja Dental Sciences and Research, Tirupathi.

ABSTRACT

Implant-supported or implant-retained overdentures in the mandible provide predictable results with improved stability, retention, and patient satisfaction. Scientific evidence shows a lower rate of implant survival and a higher frequency of prosthetic complications for maxillary implant-retained or implant- supported overdentures. Although the literature presents considerable information on complications of implant prostheses, variations in study design preclude proper analysis of certain complications. Well-designed longitudinal studies are required to establish evidence-based treatment planning principle.

Introduction:

Edentulous patients with a severely resorbed mandible or maxilla often experience problems with conventional dentures, such as insufficient stability and retention, together with a decrease in chewing ability. Because of the good prognosis of dental implants, these patients can be successfully treated with implant-retained or implant-supported overdentures. Several studies reported the following benefits of overdenture in comparison to complete denture treatment in the mandible: better chewing ability, better fit and retention, improved function, and improved quality of life. Controversially, very few studies have evaluated patient satisfaction with maxillary overdentures. Data show that there is no significant improvement of the above parameters for overdenture wearers when good bony support exists for the fabrication of maxillary conventional prostheses. However, since many patients have problems with the retention of their mandibular prosthesis and do not desire implant- supported fixed prostheses, mainly because of financial reasons, the removable implant-retained or implant-supported overdenture has become a reliable treatment alternative, offering the same masticatory efficacy as a fixed prosthesis.

The lack of systematic terminology for implant prostheses requires the need for standardization of the terms used. According to “The Glossary of Prosthodontic Terms,” an overdenture is defined as “a removable partial or complete denture that covers and rests on one or more remaining natural

teeth, roots, and/or dental implants; a prosthesis that covers and is partially supported by natural teeth, tooth roots, and/or dental implants." An implant-supported overdenture is defined as a prosthesis that obtains its entire support from dental implants, while an implant-retained overdenture gains its support from a combination of intraoral tissues and dental implants. Studies have been carried out over the last 2 decades to evaluate the benefits of implant-supported or implant-retained overdenture therapy. Various treatment concepts involving different numbers and types of implants, as well as different retention mechanisms, have been proposed. Bars, magnets, ball attachments, and rigid and nonrigid telescopic copings have been used to retain overdentures. The clinical outcomes of different attachment systems were evaluated in a limited number of randomized controlled clinical trials (RCTs). In addition, most prospective studies with a follow-up period of at least 5 years focused exclusively on implant survival, while few studies evaluated the surgical and prosthetic complications in a 10-year observation period. It is obvious that there is a critical gap in the general understanding of the types and rates of prosthetic complications associated with a particular retention system or overdenture design. An evaluation of the long-term outcome of implant over- dentures and complications associated with different attachment systems may provide useful guidelines for the clinician in selecting the type of attachment system and overdenture design.

The purpose of this review was to provide information on the types of prosthodontic complications associated with implant-retained or implant-supported overdentures.

Implant Survival/Success and Type of Attachment:

The current literature revealed only 14 prospective studies and 4 RCTs addressing the prosthetic complications and implant survival/success rates of patients treated with implant-supported or implant-retained overdentures after a period of at least 5 years. Information regarding implant-supported or implant- retained overdentures in the maxilla was found in only four studies, none of which were RCTs. Maxillary overdentures generally involved an implant-splinted bar on a maximum of four to six implants. The implant success rate ranged between 72.4% and 84%, and the implant survival rate was 75.4%. The study of Attard and Zarb reported a cumulative survival rate of all implants (maxilla and mandible) of 96% and a cumulative success rate of 93%. According to the systematic review of Bryant et al, the pooled implant survival estimate was 76.6% at 5 years. Data regarding survival rates of implants after observation periods of more than 10 years were in short supply. As for the outcomes of mandibular implant- supported

or implant-retained overdentures, it seems that there is more evidence available than that with maxillary overdentures. Of the 17 studies identified, only 4 were RCTs, and 4 of the prospective studies had an observation period of at least 10 years. The majority of studies employed bars, balls, or magnets as attachment systems. Only one additional study evaluated soft and hard tis- sue conditions as well as the function of telescopic copings for implant overdentures. In most studies, overdentures were supported by two implants, but there were also studies with one, three, four, or more implants. Implant survival did not appear to vary by splinting, rotational characteristics, or the number of implants and ranged from 93% to 100% at 10 years. Bryant et al showed that the pooled implant survival rate in the mandible after 10 years was 95.4%. The statistical finding that implant survival in the mandible exceeds the outcomes in the maxilla rein- forces the long-established evidence of a somewhat elevated vulnerability of the edentulous maxilla for implant failure.[33] Although no clear evidence is avail- able, several studies demonstrated that failures in the maxilla are related to short implants, poor bone quality or quantity, and a small number of implants. However, the recent development in the field of new implant surfaces could lead to higher integration rates in the maxilla.

Definition of Clinical Complications:

There are two categories of complications that occur in implant therapy: biologic and technical (mechanical). The present review focused on the technical complications that were related to implant-supported or implant-retained overdentures. “Technical complications” served as a collective term for mechanical damage to the implant and implant components and superstructures. Such complications included implant fracture, wear or corrosion of the retention elements, fracture of the retention elements or superstructure, abutment fracture, abutment screw loosening or fracture, attachment screw loosening or fracture, activation or changing of the clip, matrix activation (change of rubber ring) or replacement (change of O-ring housing), changing of the magnet, rebasing or relining of the overdenture, and overdenture fracture.[35].

Prosthetic Success and Incidence of Technical Complications:

In contrast to implant survival/success rates, the percentage of prosthetic survival/success ranged widely between the studies and prosthetic types and was generally not calculated cumulatively. The data obtained showed that prosthetic maintenance is inconsistent between different studies. Variable definitions of events, visits, and occasions were used with or without accounting for prosthetic maintenance conducted at routine

reassessment visits. Bryant et al could not calculate an overall complication incidence for implant overdentures because there were no multiple clinical studies with a similar study design that simultaneously evaluated all or most of the categories of complications. On the other hand, Berglundh et al, in a systematic review, observed that a 4- to 10-times higher incidence of prosthetic complications was associated with implant-supported or implant-retained overdentures in comparison to implant fixed prostheses.[36]Goodacre et al combined raw data from multiple studies and calculated means in an attempt to identify trends noted in the incidence of complications. For a specific complication to be included, three or more studies must have reported data related to the incidence of that particular complication. The authors clarified that the mean percentages presented in their study suggested trends rather than absolute incidence values and should be interpreted cautiously due to the large variation in numbers of implants and prostheses evaluated and the lack of statistical analysis. The following complications were reported (listed in order of frequency): overdenture loss of retention or adjustment (30%), overdenture rebasing or relining (19%), clip or attachment fracture (17%), overdenture fracture (12%), opposing prosthesis fracture (12%), acrylic resin base fracture (7%), prosthesis screw loosening (7%), abutment screw loosening (4%), abutment screw fracture (2%), and implant fracture (1%).35 Irrespective of the anchorage system used, adjustments to the overdenture attachment system were the most common mechanical problem in implant prosthodontics. In an RCT, Naert et al compared the prosthetic aspects of three different attachment types (ball, bar, and magnets) in two implant-retained mandibular overdentures. In the ball group, renewal of the O-ring housing and rubber ring and abutment screw loosening were the most common mechanical complications after an observation period of 10 years. In the magnet and bar groups, the most frequent complications were wear and corrosion and the need for clip activation, respectively. Compared to the bar group, the magnet and ball groups presented the highest incidence of prosthetic complications.

Conversely, significantly more complications and re- pairs were reported in the bar group compared to the ball group during the first year of function. However, no significant differences between the different attachment systems were observed in the following years. Another point of concern is the distinction between resilient (Dolder) and rigid (milled) bars regarding their prosthodontic maintenance. In contrast to well- established clinical use and the numerous publications regarding hinged overdentures, very few data exist comparing the use of resilient or rigid bar stabilization. In a recent study, Krennmairet al[30]reported that when four interforaminal

implants were used to anchor mandibular overdentures, the design of the anchorage system significantly influenced the need for prosthodontic aftercare. Rigid anchorage using milled bars and a metal-reinforced denture framework required less prosthodontic maintenance than resilient denture stabilization with multiple round bars and dentures with- out frameworks. Similarly, Dudic and Mericske-Stern found a significant superiority of the mandibular rigid bar design versus the resilient bar configuration after 2 and 5 years of follow-up but not after a period of 15 years. A change from a resilient retention device to a rigid bar was performed more often than vice versa, but not at a statistically significant level. Concerning the telescopic crowns as an anchorage system for implant overdentures, there are very limited long-term data in the literature. In the only longitudinal prospective study included, Heckmannet al investigated the clinical function of nonrigid telescopic crowns over an observation period of 10 years. Out of a total of 46 telescopic crowns (16 cemented and 30 screw- retained), 4 primary copings had to be recemented during the follow-up period (25%), while loosening of the occlusal screw occurred in 5 implants (16.6%). Relining of the overdentures occurred with an incidence of 21.7%. In general, a higher incidence of mechanical problems was reported with implant-supported or implant- retained overdentures in the maxilla compared to those in the mandible, especially for maxillary overdentures without palatal coverage. Limitations in vertical space for the prosthetic components and matrix were more common in the maxilla, which resulted in compromises in design and material failure. After a 5-year follow-up, Watson et al[25]reported a threefold increase in fractures of overdentures in the maxilla compared to those in the mandible. However, a cast chromium-cobalt frame- work reinforcement was reported to eliminate this complication. Regardless of the anchorage system, the predominant complication in maxillary overdenture therapy involved a change in the retention system resulting from loosening or fracture of the prosthetic components.

Comparison of the Four Anchorage Systems Used Parameters compared

Type of anchorage	Retention	Space requirement	Cleansibility	Costs and technique sensitive	Aftercare	Patient satisf-action
Bar	3	3	1	3	2	2
Ball attachments	2-3	1	3	1	3	2
Telescopic crowns	2	2	3	2	1	2
Magnets	1	1	2	1	3	1

1 = least effective; 3 = most effective

Discussion:

In the present review, a number of longitudinal cohort studies were analyzed with respect to prosthodontic complications related to implant-retained or implant- supported overdentures. The main approach in the search was to identify studies of prospective design with follow-up periods of at least 5 years. Although the gold standard for systematic reviews is to study RCTs, which have the most robust design, most of the studies included in this review were prospective clinical trials. A retrospective study design and duration of < 5 years were the main reasons for exclusion. Several retention systems for implant overdentures have been described in the literature. Differences be- tween studies in regards to methods and lack of standardization of prosthetic procedures, as well as insufficient sample size, have prevented an objective assessment of the preferred retention system for implant-retained or implant-supported overdentures. The choice of a specific system seems to be based more on the clinician's preference than on scientific evidence. Several clinical longitudinal studies have shown that there are no differences in implant survival and peri-implant variables between bar and unsplinted retention systems.

Comparison of the Four Anchorage Systems:

Although there is no significant difference in patient satisfaction with overdenture stabilization between the different attachments (both implant-supported and implant-retained), differences have been described regarding prosthetic maintenance during the follow-up period (Table 1). For selection of the appropriate type of attachments, the oral status, the financial situation of the patient, cost-effectiveness, and the patient's expectations of the new overdentures must be considered. The anatomical situation in the mandible or maxilla is a critical factor. Advanced atrophy of the alveolar crest calls for prosthetic stabilization, especially with regard to horizontal forces, which can be achieved predominantly with bars and telescopic crowns. As a result of the presenting anatomy of the mandible or because the implants are placed in excessively distal locations, the tongue space may be restricted when using bars. More common limitations in the maxilla are in vertical space for the prosthetic components and matrix due to contour and phonetic considerations. In the vertical axis, a minimum distance of 13 to 14 mm from the implant platform to the incisal edge of the overdenture is necessary for the bar attachment, allowing 4 mm for the bar and 1 mm between the bar and gingiva for hygiene, as well as space for the clip and the acrylic/tooth housing.[44]Solitary anchors require only 10 to 11 mm of vertical space above the implant platform and therefore offer more flexibility. It also has been demonstrated that solitary attachments are less costly and less technique

sensitive, while clinical experience shows that secondarily blocked constructions ease oral hygiene procedures considerably for elderly patients compared with bars. In a comparative study, the bar group revealed more mucositis and gingival hyperplasia, whereas the solitary attachment group displayed more decubitus ulcers. Several longitudinal prospective studies have shown that there is no significant difference in the implant survival rate and marginal bone loss between subjects with overdentures retained with splinted or unsplinted anchorage systems. Van Kampen et al demonstrated that bars provide more retention than solitary anchors when subjected to both vertical and oblique forces. Implant angulation may compromise the retention of solitary anchors. However, Chung et al[48] showed that in cases of parallel- placed implants, solitary attachments such as Locators may match or exceed the Hader bar and metal clip retention. Naertet al demonstrated that the ball group presented the highest vertical retention capacity of the implant-retained overdenture and a remarkable in- crease in this retention capacity over time, whereas a decrease occurred in the magnet and bar groups. Magnets have been shown to be the least retentive of all attachment systems but may be appropriate for patients with bruxism or dexterity problems.[10]Finally, the extent of prosthetic maintenance using different attachment systems should be considered. Whencomparing bars with single anchors, controversy exists as to whether the bar or ball design requires more maintenance.[12,26,49] Several studies have shown that there is no correlation between attachments and prosthetic complications, except for bars with distal extensions, which were more prone to fracture. It has also been shown that rigid bars retaining overdentures on four implants demonstrate a significantly lower incidence rate of prosthodontic maintenance than a resilient anchorage system with round bars. In the study by Dudic and Mericske-Stern, fracture of bars or ex- tensions and retightening of female parts was higher in the rigid group, whereas broken, loose, or lost retainers required significantly more repairs in the resilient group. Other studies demonstrated an increased amount of prosthetic maintenance for ball attachments and mag- nets because of wear or fracture of the ball head or need for activation of the ball matrix and corrosion or wear of the magnets. In terms of maintenance, the bar and the Locator attachment systems have been rec- ommended when restoring implants with a divergence between 10 and 40 degrees.[51]However, clinical studies comparing prosthetic maintenance of Locators with other attachment systems are in short supply.

Etiology of Technical Complications:

To minimize potential problems during and after the restorative phase, attention must be paid to various factors that can lead to mechanical

complications. A common problem associated with the prosthetic restoration of dental implants is loosening or fracturing of the attachment screws. This complication occurs mainly because of the magnitude and direction of the oral forces and the strength limitations of the compo- nents. Other factors such as operator error, torsion relaxation, and thermal changes may also contribute to screw loosening. Moreover, the amount of ridge resorption, the length and number of implants, the opposing dentition, the angulation of the implants, and parafunctionalhabits may increase the susceptibility for such complications. In the severely resorbed mandible, implants supporting or retaining an over- denture may be subjected to excessive masticatory forces by the mesial and distal cantilever and also from the occlusogingival lever arm. These forces include off-axis centric contacts, excursive contacts, cantilevered loading, and internal stresses created by both component and framework misfit.[52]In the case of angulated implants, the occlusal forces may generate more strain than the screw can bear. In addition to implant fracture, prosthesis fracture or acrylic resin failure or wear may occur. Such complications are observed when the applied loads exceed the material's proportional limit or fracture strength.

Other technical failures, such as material contamination, casting porosities, and poor alloy surface preparation, may also lead to prosthetic complications.[54] Misfit of the framework has also been suggested as an important factor as far as prosthetic failures are concerned. It should be considered that an absolute passive fit of a framework is almost impossible. However, studies designed to assess the effects of the degree of misfit of an implant-supported or implant- retained restoration on the implant bone-phase boundary have been unable to demonstrate a negative effect of misfit on this area.[54] Within the limits of this review, treatment recommendations have been posited given the available evidence. Therefore, cantilever lengths should be minimized, nonworking contacts should be eliminated, centric occlusion contacts should be centralized, and components should be torqued in accordance with manufacturer recommendations. Much effort should be taken to improve the fit of the prostheses. As the etiologies of many technical complications are not fully clear, the clinician is left to weigh the costs and complexity of treatment. According to the principles of evidence-based dentistry, it is agreed that an RCT is the most scientifically sound method to establish reliable conclusions regarding the effectiveness of therapeutic alternatives.[61] The proportion of RCTs in the prosthodontic literature is, however, very small and further re- search is needed to provide better answers to the "how" and "why" of successful implant-supported or implant-retained restorations. The effects of design variables such as anchorage

system used, maintenance, costs, patient satisfaction, and success of the reconstruction require better quantification and documentation so that basic guidelines can be established.

Conclusions:

There is scientific evidence that a lower rate of implant survival and a higher frequency of prosthetic complications exist for maxillary implant-retained or implant- supported overdentures. The heterogeneity of studies dealing with prosthetic aftercare and maintenance does not allow an estimation of an overall complication rate. Further well-designed RCTs are required to establish evidence-based treatment planning principles for implant overdenture patients

References

1. Bergman B, Carlsson GE. Clinical long-term study of complete denture wearers. J Prosthet Dent 1985; 53:56–61.
2. Van Waas MA. The influence of clinical variables on patients' satisfaction with complete dentures. J Prosthet Dent 1990; 63:307–310.
3. Attard NJ, Zarb GA. Long-term treatment outcomes in edentulous patients with implant overdentures: The Toronto study. Int J Prosthodont 2004; 17:425–433.
4. Fueki K, Kimoto K, Ogawa T, Garrett NR. Effect of implant-supported or retained dentures on masticatory performance: A systematic review. J Prosthet Dent 2007; 98:470–477.
5. de Albuquerque Júnior RF, Lund JP, Tang L, et al. Within-subject comparison of maxillary long-bar implant-retained prostheses with and without palatal coverage: Patient-based outcomes. Clin Oral Implants Res 2000; 11:555–565.
6. Cune MS, de Putter C, Hoogstraten J. Treatment outcome with implant-retained overdentures: Part I—Clinical findings and predictability of clinical treatment outcome. J Prosthet Dent 1994; 72:144–151.
7. de Grandmont P, Feine JS, Taché R, et al. Within-subject comparisons of implant-supported mandibular prostheses: Psychometric evaluation. J Dent Res 1994; 73:1096–1104.
8. The glossary of prosthodontic terms. J Prosthet Dent 2005; 94:10–92.

9. Simon H, Yanase RT. Terminology for implant prostheses. Int J Oral Maxillofac Implants 2003; 18:539–543.
10. Trakas T, Michalakis K, Kang K, Hirayama H. Attachment systems for implant retained overdentures: A literature review. Implant Dent 2006; 15:24–34.
11. Davis DM, Packer ME. Mandibular overdentures stabilized by Astra Tech implants with either ball attachments or magnets: 5-year results. Int J Prosthodont 1999; 12:222–229.
12. Gotfredsen K, Holm B. Implant-supported mandibular overdentures retained with ball or bar attachments: A randomized prospective 5-year study. Int J Prosthodont 2000; 13:125–130.
13. Naert I, Alsaadi G, Quirynen M. Prosthetic aspects and patient satisfaction with two-implant-retained mandibular overdentures: A 10-year randomized clinical study. Int J Prosthodont 2004; 17: 401–410.
14. Heckmann SM, Schrott A, Graef F, Wichmann MG, Weber HP. Mandibular two-implant telescopic overdentures. Clin Oral Implants Res 2004; 15:560–569.
15. Meijer HJ, Raghoebar GM, Van't Hof MA, Visser A. A controlled clinical trial of implant-retained mandibular overdentures: 10 years' results of clinical aspects and aftercare of IMZ implants and Brånemark implants. Clin Oral Implants Res 2004; 15:421–427.
16. Naert I, Alsaadi G, van Steenberghe D, Quirynen M. A 10-year randomized clinical trial on the influence of splinted and unsplinted oral implants retaining mandibular overdentures: Peri-implant outcome. Int J Oral Maxillofac Implants 2004; 19:695–702.
17. Dudic A, Mericske-Stern R. Retention mechanisms and prosthetic complications of implant-supported mandibular overdentures: Long-term results. Clin Implant Dent Relat Res 2002; 4:212–219.
18. Sutherland SE. The building blocks of evidence-based dentistry. J Can Dent Assoc 2000; 66:241–244.
19. Esposito M, Grusovin MG, Coulthard P, Thomsen P, Worthington HV. A 5-year follow-up comparative analysis of the efficacy of various osseointegrated dental implant systems: A systematic review of randomized controlled clinical trials. Int J Oral Maxillofac Implants 2005; 20:557–568.

20. Tinsley D, Watson CJ, Russell JL. A comparison of hydroxylapatite coated implant retained fixed and removable mandibular prostheses over 4 to 6 years. Clin Oral Implants Res 2001; 12:159–166.

21. 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.

22. Wismeyer D, van Waas MA, Vermeeren JI. Overdentures supported by ITI implants: A 6.5-year evaluation of patient satisfaction and prosthetic aftercare. Int J Oral Maxillofac Implants 1995; 10:744–749.

23. Makkonen TA, Holmberg S, Niemi L, Olsson C, Tammisalo T, Peltola J. A 5-year prospective clinical study of Astra Tech dental implants supporting fixed bridges or overdentures in the edentu- lous mandible. Clin Oral Implants Res 1997; 8:469–475.

24. Walmsley AD, Frame JW. Implant supported overdentures—The Birmingham experience. J Dent 1997; 25(suppl 1):S43–S47.

25. Watson RM, Jemt T, Chai J, et al. Prosthodontic treatment, patient response, and the need for maintenance of complete implant-supported overdentures: An appraisal of 5 years of prospective study. Int J Prosthodont 1997; 10:345–354.

26. Bergendal T, Engquist B. Implant-supported overdentures: A longitudinal prospective study. Int J Oral Maxillofac Implants 1998; 13:253–262. 27.

27. Smedberg JI, Nilner K, Frykholm A. A six-year follow-up study of maxillary overdentures on osseointegrated implants. Eur J ProsthodontRestor Dent 1999; 7:51–56.

28. Behneke A, Behneke N, d'Hoedt B. A 5-year longitudinal study of the clinical effectiveness of ITI solid-screw implants in the treatment of mandibular edentulism. Int J Oral Maxillofac Implants 2002; 17:799–810.

29. Visser A, Raghoebar GM, Meijer HJ, Batenburg RH, Vissink A. Mandibular overdentures supported by two or four endosseous implants. A 5-year prospective study. Clin Oral Implants Res 2005; 16:19–25.

30. Krennmair G, Krainhöfner M, Piehslinger E. The influence of bar design (round versus milled bar) on prosthodontic maintenance of mandibular overdentures supported by 4 implants: A 5-year prospective study. Int J Prosthodont 2008; 21:514–520.

31. Needleman IG. A guide to systematic reviews. J ClinPeriodontol 2002; 29(suppl 3):6–9.

32. 32. Bryant SR, MacDonald-Jankowski D, Kim K. Does the type of implant prosthesis affect outcomes for the completely edentulous arch? Int J Oral Maxillofac Implants 2007; 22(suppl):117–139 [erratum 2008; 23:56].

33. Jaffin RA, Berman CL. The excessive loss of Brånemark fixtures in type IV bone: A 5-year analysis. J Periodontol 1991; 62:2–4.

34. Chan MF, Närhi TO, de Baat C, Kalk W. Treatment of the atrophic edentulous maxilla with implant-supported overdentures: A review of the literature. Int J Prosthodont 1998; 11:7–15.

35. Goodacre CJ, Bernal G, Rungcharassaeng K, Kan JY. Clinical complications with implants and implant prostheses. J Prosthet Dent 2003; 90:121–132.

36. 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 ClinPeriodontol 2002; 29(suppl 3):197–212.

37. Sadowsky SJ. Treatment considerations for maxillary implant over-dentures: A systematic review. J Prosthet Dent 2007; 97:340–348.

38. 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.

39. Payne AG, Solomons YF. Mandibular implant-supported over-dentures: A prospective evaluation of the burden of prosthodontic maintenance with 3 different attachment systems. Int J Prosthodont 2000; 13:246–253.

40. Krennmair G, Weinländer M, Krainhöfner M, Piehslinger E. Implant-supported mandibular overdentures retained with ball or telescopic crown attachments: A 3-year prospective study. Int J Prosthodont 2006; 19:164–170.

41. Stoker GT, Wismeijer D, van Waas MA. An eight-year follow-up to a randomized clinical trial of aftercare and cost-analysis with three types of mandibular implant-retained overdentures. J Dent Res 2007; 86:276–280.

42. Eitner S, Schlegel A, Emeka N, Holst S, Will J, Hamel J. Comparing bar and double-crown attachments in implant-retained prosthetic reconstruction: A follow-up investigation. Clin Oral Implants Res 2008; 19:530–537.

43. Timmerman R, Stoker GT, Wismeijer D, Oosterveld P, Vermeeren JI, van Waas MA. An eight-year follow-up to a randomized clinical trial of participant satisfaction with three types of mandibular implant-retained overdentures. J Dent Res 2004; 83:630–633.

44. Phillips K, Wong KM. Space requirements for implant-retained bar-and-clip overdentures. CompendContinEduc Dent 2001; 22: 516–518, 520, 522.

45. Sadowsky SJ. Mandibular implant-retained overdentures: A literature review. J Prosthet Dent 2001; 86:468–473.

46. Wismeijer D, van Waas MA, Mulder J, Vermeeren JI, Kalk W. Clinical and radiological results of patients treated with three treatment modalities for overdentures on implants of the ITI Dental Implant System. A randomized controlled clinical trial. Clin Oral Implants Res 1999; 10:297–306.

47. Van Kampen F, Cune M, van der Bilt A, Bosman F. Retention and postinsertion maintenance of bar-clip, ball and magnet attach- ments in mandibular implant overdenture treatment: An in vivo comparison after 3 months of function. Clin Oral Implants Res 2003; 14:720–726.

48. Chung KH, Chung CY, Cagna DR, Cronin RJ Jr. Retention characteristics of attachment systems for implant overdentures. J Prosthodont 2004; 13:221–226.

49. 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.

50. Mericske-Stern RD, Taylor TD, Belser U. Management of the edentulous patient. Clin Oral Implants Res 2000; 11(suppl 1): 108–125.

51. Walton JN, Huizinga SC, Peck CC. Implant angulation: A measurement technique, implant overdenture maintenance, and the influence of surgical experience. Int J Prosthodont 2001; 14: 523–530.

52. Binon PP. Implants and components: Entering the new millennium. Int J Oral Maxillofac Implants 2000; 15:76–94.

53. Brunski JB, Puleo DA, Nanci A. Biomaterials and biomechanics of oral and maxillofacial implants: Current status and future developments. Int J Oral Maxillofac Implants 2000; 15:15–46.

54. Sones AD. Complications with osseointegrated implants. J Prosthet Dent 1989; 62:581–585.

55. Rangert B, Krogh PH, Langer B, Van Roekel N. Bending overload and implant fracture: A retrospective clinical analysis. Int J Oral Maxillofac Implants 1995; 10:326–334 [erratum 1996;11:575].

56. Baran G, Boberick K, McCool J. Fatigue of restorative materials. Crit Rev Oral Biol Med 2001; 12:350–360.

57. Sahin S, Cehreli MC. The significance of passive framework fit in implant prosthodontics: Current status. Implant Dent 2001; 10:85–92.

58. Wood MR, Vermilyea SG. A review of selected dental literature on evidence-based treatment planning for dental implants: Report of the Committee on Research in Fixed Prosthodontics of the Academy of Fixed Prosthodontics. J Prosthet Dent 2004; 92:447–462.

59. Siamos G, Winkler S, Boberick KG. Relationship between implant preload and screw loosening on implant-supported prostheses. J Oral Implantol 2002; 28:67–73.

60. Kim Y, Oh TJ, Misch CE, Wang HL. Occlusal considerations in implant therapy: Clinical guidelines with biomechanical rationale. Clin Oral Implants Res 2005; 16:26–35.

61. Anderson JD. Need for evidence-based practice in prosthodontics. J Prosthet Dent 2000; 83:58–65.

62. Dumbrigue HB, Jones JS, Esquivel JF. Developing a register for randomized controlled trials in prosthodontics: Results of a search from prosthodontic journals published in the United States. J Prosthet Dent 1999; 82:699–703.