Implant-Supported Mandibular Overdentures Retained with Ball or Telescopic Crown Attachments: A 3-Year Prospective Study

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Purpose: The aim of the present study was to evaluate implant survival, peri-implant conditions, and prosthodontic maintenance requirements for implant-supported mandibular overdentures in atrophic mandibles retained with ball or resilient telescopic crown attachments during a 3-year period. ***Materials and Methods:*** Twenty-five patients with edentulous mandibles each received 2 Camlog root-form dental implants in the mandibular interforaminal (canine) region. The denture attachment system was chosen randomly; 13 patients received ball attachments and 12 patients received resilient telescopic crowns. Implant survival, implant mobility (Periotest values), and peri-implant conditions such as bone resorption, pocket depth, Plaque Index, Gingiva Index, Bleeding Index, and Calculus Index values were assessed for each implant. In addition, detailed prosthodontic maintenance was evaluated during the follow-up period and the 2 retention modalities were compared. ***Results:*** There were no differences in implant survival, implant mobility (Periotest values), and peri-implant conditions between the 2 retention modalities. During the 3-year period significantly more complications/interventions for maintenance purposes were registered in the ball group (62 interventions) than in the telescopic crown group (26 interventions; $P < .01$). ***Conclusion:*** The results indicate that both ball attachments and resilient telescopic crowns used on isolated implants in the edentulous mandible are viable treatment options. Implant success and peri-implant conditions did not differ between ball attachments and telescopic crowns used as retention modalities for implant overdentures, but the frequency of technical complications was significantly higher with ball attachments than with resilient telescopic crowns. *Int J Prosthodont 2006;19:164–170.*

Implant-supported overdentures (IOD) have been shown to provide a successful long-term outcome, particularly when used to restore edentulous mandibles.[1–5] Numerous studies have reported 5-year implant survival rates between 94% and 100% and high rates of patient satisfaction.[4–8] Although there are a wide variety of implant-supported prosthodontic rehabilitation options for the edentulous mandible, standard treatment with IOD for achieving good long-term results is recommended using only 2 interforaminal implants.[9–11]

The commonly used abutment types connecting overdentures and interforaminal implants include bars of different designs, balls, and magnets.[5,6,12–14] Although there is no significant difference in patient satisfaction with IOD stabilization between splinted and unsplinted attachments,[12–16] differences have been described in the extent of prosthodontic maintenance during the follow-up period.[14–18] The anatomic situa-

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tion in the mandible must be considered when choosing the appropriate type of attachments.[19,20] With advanced atrophy of the mandible, the prosthesis must be primarily stabilized with regard to horizontal forces, which is best achieved by a bar-type architecture.[20] As a result of the presenting anatomy of the jaw or because of implants placed in excessively distal locations, the tongue space may be restricted when using splinted bar constructions. Thus, single attachments would be preferred in such cases to avoid the problems outlined above.[19,20] In addition, single attachments facilitate hygiene procedures and frequently require less technical effort than bar constructions.[12,13,19–21] For selection of appropriate attachments, the oral status and the financial situation of the patient, cost effectiveness, and the patient's expectations of the new dentures must also be considered.[22]

For unsplinted implants, the most common attachment used is the ball attachment, while magnets are used only rarely.[11–16] Naert and colleagues[12,13] used 3 different attachment types (bar, ball, and magnets) and reported that the bar attachment was technically the most demanding one compared to both types of unlinked attachments. Numerous studies have investigated the incidence and extent of maintenance work for several attachment types used for stabilization of mandibular IODs, and ball attachments have been reported to require significantly more postoperative care during the follow-up period than bar attachments.[14–18,21–23]

An alternative method for unsplinted attachments is the resilient (nonrigid) telescopic crown as described by Heckmann et al in experimental and clinical studies.[20,24,25] In the experimental study, the denture-bearing areas were assessed with 5 different retention modalities; the data showed that resilient (nonrigid) telescopic crowns had similar results as bars, balls, and magnets.[24,25]

Overall, there are few reports on the use of double crowns for IOD abutments; however, recent clinical publications of implant outcomes using resilient telescopic crowns have confirmed successful long-term use as an alternate retention modality.[20] Without the knowledge of the recent results published by Heckmann et al, special interest was focused on evaluating and comparing the performance of nonrigid resilient telescopic crowns over a certain time period.[26,27]

The aim of the present study was to evaluate implant success, peri-implant conditions, and prosthodontic maintenance requirements for IOD retained with resilient telescopic crowns in comparison with traditional ball attachments over a 3-year period. The null hypothesis of the study was that there would be no differences in biologic and technical complications of IOD supported by either of the two retention modalities evaluated.

Materials and Methods

Patient Selection and Treatment

The study included 25 participants (16 women, 9 men; mean age: 62.4 ± 9.1 years) with edentulous mandible showing moderate to severe mandibular resorption. The patients' maxillae were either edentulous with conventional maxillary dentures ($n = 22$) or retained a partial anterior dentition and posterior partial dentures ($n = 3$). Between March 2000 and February 2002 the included patients ($n = 25$) each received 2 root-form implants (Camlog, Altatec) in the canine region. Following implant placement and a healing period of 3 months, the implants were uncovered and healing abutments were inserted. For prosthodontic rehabilitation, definitive abutments were inserted and the patients were randomly selected to receive either ball attachments or resilient telescopic crowns for retaining an implant-supported metal-reinforced overdenture. All patients received new maxillary complete or partial dentures. The ball attachment group consisted of 13 patients (8 women, 5 men; 58.1 ± 9.2 years); the ball attachments (Camlog, Altatec) were inserted directly into the implants to connect the prefabricated matrix of the IOD (Fig 1). The resilient telescopic crown group included 12 patients (8 women, 4 men; 63.2 ± 8.4 years) who received nonrigid telescopic crowns as abutments for IOD connection (Fig 2). Table 1 summarizes the clinical variables of the two attachment groups.

The nonrigid telescopic crowns were made using a method similar to that described by Heckmann et al,[20] with parallel walls and a tiny amount of circumferential play between the primary and secondary copings (0.3 to 0.5 mm) as well as an occlusal space. To achieve sufficient retention or to improve the retention between inner and outer telescope, the authors used the TC-SNAP (Si-Tec) in a manner similar to that described by Wenz et al,[26,27] situated in the outer telescopic crown (Marburg double crown). The rotational stability of the abutments for the Camlog implant system allowed a universal abutment (Camlog, Altatec) to be directly ground as the inner telescopic crown. Thus, no additional technical effort was required for the fabrication of the inner telescopic crown, and only the outer telescopic crown had to be prepared in the fashion described above.

Clinical Analysis

Follow-up visits were part of a regular recall program and were scheduled initially as control visits (during the first 3 months), and thereafter at annual recall visits. Recalls were not always regularly attended by all pa-

Fig 1 Ball attachments retaining a mandibular overdenture.

Fig 2 Resilient telescopic crowns used to stabilize the mandibular overdenture.

Table 1 Characteristics of Patients in the Study

Characteristic	Ball-attachment group (n = 13)	Telescopic crown group (n = 12)
Age (y)	58.1 ± 9.2	63.2 ± 8.4
Gender (F/M)	8/5	8/4
Edentulous period (y)	12.9 ± 4.8	14.2 ± 6.1
Mandibular bone height (mm)	17.1 ± 2.8	16.8 ± 3.1
Implant length (mm and range)	14.2 (13–16)	13.9 (13–16)

tients. Any additional visits were initiated by the patients when and if they experienced problems.

The annual recall program included investigations of implant survival, implant mobility, peri-implant conditions, and patients' subjective assessment of the IOD. Implant mobility was measured with the Periotest instrument (Siemens) at the abutment close to the implant edge.[28] Examination of the peri-implant conditions included evaluation of peri-implant marginal bone loss (mm) and probing (pocket) depth (mm), as well as Plaque Index, Bleeding Index, Gingival Index, and the presence of calculus. Plaque and Bleeding indices were assessed according to Mombelli et al[29] (score 0 = no plaque/bleeding, score 1 = plaque/bleeding detected by running a probe across the smooth marginal surface of the implant, score 2 = plaque/bleeding seen by visual inspection, score 3 = lots of plaque, spontaneous bleeding). To assess potential peri-implant inflammation, the Gingival Index was used according to the modified Löe and Silness Index[30] (score 0 = normal mucosa, score 1 = mild inflammation, score 2 = moderate inflammation, score 3 = severe inflammation). Probing (pocket) depth was measured at 4 sites (mesial, distal, lingual, buccal) around each implant using a calibrated periodontal probe (Hu-Friedy). The presence (score 1) or absence (score 0) of calculus was also recorded.[29,30]

Radiographic Analysis

Marginal bone loss (mm) for the implants was assessed radiographically using the method of Gomez et al,[31] and radiographic evaluation included an orthopantomogram and/or single periapical radiographs based on the paralleling technique. The initial postoperative radiograph after implant placement (baseline radiography) was compared with a prosthodontic postinsertion radiograph—especially with the annual follow-up radiographs.

Postinsertion Maintenance

Any prosthodontic complications and repairs during the 3-year follow-up were registered and calculated according to following events: attachment (abutment) loosening (ball/telescopic crown loosening), abutment worn/fractured (ball or telescopic crown worn/fractured), matrix activation/replaced (ball-matrix), outer telescopic crown activation/renewed (Si-Tec[26,27]), overdenture fracture/remade, overdenture relined/rebased, and opposing prosthesis rebased/remade.

Statistical Analysis

The parameters were recorded in descriptive statistical manner, tabulated, and evaluated. Categoric variables for nonparametric data were compared using the chi-square test; continuous variables were tested with the Wilcoxon rank test. $P < .05$ was taken as the statistical significance level.

Results

All 50 implants showed satisfactory osseointegration and could be used for prosthodontic rehabilitation (25 overdentures), with 26 implants in 13 patients pro-

Table 2 Peri-implant Parameters (Means and SDs) at all Recall Examinations

	1 y		2 y		3 y	
Parameter	Ball (n = 13)	RTC (n = 12)	Ball (n = 12)	RTC (n = 12)	Ball (n = 12)	RTC (n = 11)
Bone loss (mm)	1.6 (0.8)	1.5 (0.8)	1.8 (0.6)	1.8 (0.7)	1.9 (0.6)	1.8 (0.8)
Probing depth (mm)	3.6 (1.8)	3.3 (2.0)	3.2 (1.8)	3.1 (1.9)	3.3 (1.9)	3.2 (2.1)
Periotest values	–3.4 (–1.2)	–3.5 (–1.4)	–3.5 (–1.5)	–3.2 (–1.6)	–3.2 (–1.8)	–3.4 (–1.5)
Plaque Index (0–3)	0.4 (0.6)	0.4 (0.6)	0.6 (0.7)	0.6 (0.7)	0.6 (0.6)	0.5 (0.5)
Gingival Index (0–3)	0.3 (0.4)	0.3 (0.5)	0.3 (0.5)	0.3 (0.6)	0.3 (0.5)	0.4 (0.6)
Bleeding Index (0–3)	0.4 (0.5)	0.5 (0.5)	0.6 (0.5)	0.5 (0.6)	0.6 (0.5)	0.6 (0.6)
Presence of calculus (0–1)	0.2 (0.4)	0.3 (0.4)	0.2 (0.4)	0.3 (0.5)	0.3 (0.5)	0.4 (0.6)

RTC = resilient telescopic crown.

Table 3 Prosthodontic Maintenance Needed During the 3-Year Period

Maintenance performed	1 y	2 y	3 y	Total
Ball group				
Attachment (ball) loosening	1	2	0	3
Ball worn/fracture	0	1	0	1
Matrix activation	3	9	13	25
Matrix replaced	0	2	5	7
Overdenture repair	1	0	3	4
Overdenture relined/rebased	4	3	5	15
Opposite denture remade/rebased	2	3	2	7
Total	11	22	28	62
Telescopic crown group				
Attachment (inner telescope) loosening	1	0	2	3
Inner telescope worn/fracture	0	0	0	0
Outer telescope activation (Si-Tec)	0	1	3	4
Outer telescope renewed	0	0	0	0
Overdenture repair	0	2	2	4
Overdenture relined/rebased	3	1	5	9
Opposite denture remade/rebased	2	1	3	6
Total	6	5	15	26

vided with ball attachments (Fig 1) and 24 implants in 12 patients with nonrigid telescopic crown crowns (Fig 2). All patients presented for implant uncovering and for the first annual recall examination. At the 2-year follow-up, 1 patient (ball-attachment group) did not attend the evaluation because of illness (cerebral stroke). At the 36-month (3-year) recall examination, 2 patients (1 in each group) failed to present for examination; one had moved away from the area and the other had suffered a cerebral stroke, which made attendance for the examination impossible. Thus, it was assumed that failure to present for follow-up was independent of clinical and/or radiographic status. With no implant losses, the survival rate in this 3-year prospective study was 100%. The implant survival rate did not differ between the 2 retention modalities used.

The mean scores for the indices of plaque, gingiva, and bleeding as well as for calculus were low for each evaluation period (1, 2, 3 years) and did not differ between the groups (Table 2). Peri-implant pocket depth (probing depth), marginal bone loss, and implant mobility (Periotest values) also did not differ between the 2 retention modalities at the first-, second-, and third-year recall examinations. The most obvious marginal bone loss was noticed between the baseline radiograph (implant placement) and initial prosthesis incorporation (1.4 ± 0.5 mm) for all abutments after consolidation of the biologic width.

A great variety of prosthodontic or technical complications and maintenance requirements was noted during this 3-year study (Table 3). The most frequent complication was the activation or replacement of the ball matrix into the prosthesis. In general, significantly more matrix repairs (activation + repairs) were required in the ball-attachment group than in the telescopic crown group (32 matrix repairs, versus 4 interventions for outer telescopic crown activation). In total, 62 maintenance procedures were required in the ball-attachment group (13 patients) and 26 interventions were needed in the telescopic crown group (12 patients) over 3 years. Annually, a mean of 1.6 complications/repairs were needed for the ball-attachment group, versus 0.7 interventions/repairs for the telescopic crown group ($P < .05$). The most frequent intervention in the resilient telescopic crown group was rebasing/relining of the dentures (9 interventions). Outer telescopic crown (matrix) activation (Si-Tec renewal, Si-Tec activation) was significantly less frequent in the telescopic crown group, compared to matrix activation in the ball-attachment group (25 in the ball-attachment group versus 4 interventions in the telescopic crown group). The incidence and amount of prosthodontic maintenance in the maxilla did not differ between the 2 groups (7 versus 6 interventions; Table 3).

Discussion

The success rate of implants in this prospective study was 100% in those patients taking part in the follow-up program and was comparable to that in other prospective studies, which reported high survival rates for implant-supported mandibular overdentures.[2,4,15,16] On account of the low dropout rate in both groups, a comparison between the 2 attachment modalities for retention can be made. The clinical results seen in this study are consistent with those in other comparative studies; no differences were seen in implant survival rates, implant mobility, and peri-implant soft and hard tissue conditions after 3 years with either the ball or the resilient telescopic crown system as the retention mode for mandibular overdentures.[15,16,32–34] In both groups investigated, only minor changes in peri-implant marginal bone loss level were observed from baseline to the 3-year recall.[32–34] However, the observed drop in mean marginal bone level after implant placement and prosthesis incorporation may be explained by the surgical trauma when placing implants and by bone remodelling and consolidation of the biologic width.[34–36]

However, assessment of peri-implant structures showed slight increased scores for plaque and bleeding indices in both the ball-attachment and the telescopic crown groups. This is consistent with the studies of Naert et al,[5,12] who also described increased plaque scores for ball and magnet attachments, although the scores also did not differ between the 2 study groups. In obvious contrast, Davis and Packer[16] reported that magnets showed a higher extent of plaque accumulation than ball attachments, obviously a result of the higher age of the patients and their lack of manual dexterity in dental cleaning. Although telescopic crowns are larger than ball attachments, no significant differences in indices of the peri-implant soft tissue structures were noted in the present study. Compliance with regular recall appointments and appropriate hygiene may provide for appropriate remedy and reduce this problem.[5,12,21,33]

The most commonly used abutment types for connections between overdentures and interforaminal implants are bars, ball attachments, magnets, and—although used much more rarely—telescopic crowns.[5,6,11–16,20] Although there is no significant difference in patient satisfaction with IOD stabilization between splinted and unsplinted attachments,[12–16] differences have been described in the extent of prosthodontic maintenance needed during the follow-up period.[14–18,21–23]

In addition, the various attachment systems exhibit different biomechanical features regarding stress upon the implants and the mucosa.[24,25] Because the appropriate choice of attachment should be made based on the anatomic state of the mandible, advanced atrophy of the alveolar crest calls for prosthetic stabilization, especially with regard to horizontal forces, which can be achieved predominantly with bars and double crowns.[19,20] In geriatric patients with marked mandibular atrophy, anchorage with resilient double crowns—eg, telescopic crowns—constitutes a feasible alternative for retention.[20,26,27] Heckmann et al[20] have described excellent long-term results with resilient telescopic crowns for anchoring overdentures on implants.

Although reports on the use of double crowns for overdenture stabilization have been scarce, the use of resilient telescopic crowns for prosthesis stabilization shows numerous benefits and advantages, which are primarily associated with the unsplinted property of the attachment.[5,8,15,16] Thus, implant placement in a defined location is shown to be less restricted than with splinted structures.[19,20] Splinted bar constructions connecting implants in the anterior mandible may restrict the tongue space and thus result in disturbing effects, while this will not be seen with single attachments.[11–13,19,32–34] Double crowns also provide horizontal stabilization as a result of the cone-shaped wall structure and thus also may stabilize prostheses against lateral dislocation forces.[20,25]

Another advantage is implied from the present results, which assessed the extent of prosthodontic maintenance in overdentures with different single implant attachments.[15–18] Especially with elderly patients, complications and repairs should be kept to a minimum. As shown by the results of this study, overdentures retained with ball attachments required significantly more maintenance than telescopic crown attachments. This is also consistent with the results of numerous other studies reporting on the extent of maintenance for overdentures retained with ball or magnet attachments as compared to bar-clip retention modalities.[11,14–18,23] The present study also showed the increased need for maintenance with ball attachments, as predominantly reflected by the activation of the ball matrix as compared with the required activation on resilient telescopic crowns. This data confirms previous findings of other studies demonstrating an increased amount of prosthodontic maintenance for ball attachments used for mandibular overdenture anchorage.[11,14,15,18]

Considering the technical requirements, it should be noted that the inner telescope can be easily fabricated when using an implant system with rotational stability.[37,38] With direct application and direct preparation of the abutment as the inner telescopic crown, fabrication is simplified to the extent that, following the grinding of the abutment as the inner telescope, fabrication of the outside telescope is the only demanding technical work remaining. In contrast to the previous technical requirements described by Heckmann et al,[20,25] where the primary crown consisted of solid abutments and cementable primary copings or of abutments cast to gold cylinders, the present fabrication method of the inner telescopic crown may reduce the technical requirements and the costs for both the clinician and the patient.[19,38] Since the abutment and the inner telescopic crown represent an integral unit, this type of retention is comparable with other single attachments, ie, one-piece abutments, as with a ball attachment, but it certainly provides general prosthetic, technical, and clinical benefits.

Overall the null hypothesis was partially abandoned. Implant survival, implant stability, and peri-implant conditions did not differ between ball attachments and telescopic crowns used as retention modalities for IOD in edentulous mandibles, but the frequency of technical complications was significantly higher with ball attachments than with resilient telescopic crowns. Therefore, telescopic crowns may provide a retention modality with reduced prosthodontic maintenance and may be a viable alternative treatment alternative when single attachments are used.

References

1. Mericske-Stern R, Zarb GA. Overdentures: An alternative implant methodology for edentulous patients. Int J Prosthodont 1993;6:203–208.
2. Jemt T, Chai J, Harnett J, et al. A 5-year prospective multicenter follow-up report on overdentures supported by osseointegrated implants. Int J Oral Maxillofac Implants 1996;11:291–298.
3. Bergendal T, Engquist B. Implant-supported overdentures: A longitudinal prospecticve study. Int J Oral Maxillofac Implants 1998;13:253–262.
4. Meijer HJ, Raghoebar GM,Van`t Hof MA. Comparison of implant-retained mandibular overdentures and conventional complete dentures: A 10-year prospective study of clinical aspects and patient satisfaction. Int J Oral Maxillofac Implants 2003;18:879–885.
5. Naert I, Alsaadi G, van Stehenberghe 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.
6. Wismeijer D, van Waas MA,Vermeeren JI, Mulder J, Kalk W. Patient satisfaction with implant-supported mandibular overdentures: A comparison of three treatment strategies with ITI dental implants. Int J Oral Maxillofac Surg 1997;26:263–267.
7. Mericske-Stern R. Treatment outcomes with implant-supported overdentures: Clinical considerations. J Prosthet Dent 1998;79:66–73.
8. Awad MA, Lund JP, Shapiro SH, et al. Oral health status and treatment satisfaction with mandibular implant overdentures and conventional dentures: A randomized clinical trial in a senior population. Int J Prosthodont 2003;16:390–396.
9. Thomason JM. The McGill consensus statement on overdentures. Mandibular 2-implant overdentures as first choice standard of care for edentulous patient. Eur J Prosthodont Restorative Dent 2002;10:95–96.
10. Batenburg RH, Meijer HI, Raghoebar GM, Vissink A. Treatment concept for mandibular overdentures supported by endosseous implants: A literature review. Int J Oral Maxillofac Implants 1998;13:539–545.
11. Timmerman R, Stoker GT, Wismeijer D, Osterveld 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.
12. Naert I, Gizani S, Vuylsteke M, van Steenberghe D. A 5-year randomized clinical trial on the influence of splinted and unsplinted oral implants in the mandibular overdenture therapy. Part I: Peri-implant outcome. Clin Oral Implants Res 1998;9:170–177.
13. 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 patients satisfaction. J Oral Rehabil 1999;26:195–202.
14. Van Kampen F, Cune M, van der Bilt A, Bosman F. Retention and postinsertion maintenance of bar-clip, ball and magnet attachments in mandibular implant overdenture treatment: An in vivo comparison after 3 month of function. Clin Oral Implants Res 2003;14:720–726.
15. 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.
16. 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.
17. Walton JN, MacEntee MI. A prospective study on the maintenance of implant prostheses in private practice. Int J Prosthodont 1997;5:453–458.
18. Payne AGT, Solomons YF. Mandibular implant-supported overdentures: A prospective evaluation of the burden of prosthodontic maintenance with three different attachment systems. Int J Prothodont 2000;13:246–253.
19. Spiekermann H, Jansen VK, Richter EJ. A 10-year follow-up study of IMZ and TPS implants in the edentulous mandible using bar-retained overdentures. Int J Oral Maxillofac Implants 1995;10:231–243.
20. Heckmann SM, Schrott A, Graef F, Wichmann M, Weber HP. Mandibular two-implant telescopic overdentures. Clin Oral Implants Res 2004;15:560–569.
21. den Dunnen ACC. Professional hygiene care, adjustments and complications of mandibular implant-retained overdentures: A 3-year retrospective study. J Prosthet Dent 1997;78:387–390.
22. Takanashi Y, Penrod JR, Lund JP, Feine JS. A cost comparison of mandibular two-implant overdenture and conventional denture treatment. Int J Prosthodont 2004;17:181–186.
23. MacEntee MI, Walton JN, Glick N. A clinical trial of patients satisfaction and prosthodontic needs with ball and bar attachments for implant-retained complete overdentures: Three-year results. J Prosthet Dent 2005;93:28–37.

24. Heckmann SM, Winter M, Meyer M, Weber HP, Wichmann M. Overdenture attachment selection and the loading of implant and denture-bearing area. Part I: In vivo verification of stereolithographic model. Clin Oral Implants Res 2001;12:617–623.
25. Heckmann SM, Winter M, Meyer M, Weber HP, Wichmann M. Overdenture attachment selection and the loading of implant and denture-bearing area. Part II: A methodical study using five types of attachments. Clin Oral Implants Res 2001;12:640–647.
26. Wenz HJ, Hertrampf K, Lehmann KM. Clinical longevity of removable partial dentures retained by telescopic crowns: Outcome of the double crown with clearance fit. Int J Prosthodont 2001;134:207–213.
27. Wenz HJ, Lehmann KM. A telescopic crown concept for the restoration of the partially edentulous arch: The Marburg double crown system. Int J Prosthodont 1998;11:541–550.
28. Aparicio C. The use of Periotest value as the initial success criteria of an implant: 8-year report. Int J Periodontics Restorative Dent 1997;17:150–161.
29. Mombelli A, van Oosten MAC, Schurch E, Lang NP. The microbiota associated with successful or failing osseointegrated titanium implants. Oral Microbiol Immunol 1987;2:145–151.
30. Löe H, Silness J. Periodontal disease in pregnancy. II: Correlation between oral hygiene and periodontal condition. Acta Odontol Scand 1963;21:533–551.
31. Gomez-Roman G, d´Hoedt B, Axmann D, Schulte W. Visual-metric measurement of peri-implant bone defects on radiographs—A reliability study [in German]. Zeitschr Zahnärztl Implantol 1999;12:104–109.
32. 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.
33. Payne AGT, Solomons YF. The prosthodontic maintenance requirements of mandibular mucosal- and implant-supported overdentures: A review of the literature. Int J Prosthodont 2000;13:238–245.
34. Mericske-Stern R, Steinlin-Schaffner T, Marti P, Geering AH. Peri-implant mucosal aspects of ITI implants supporting overdentures. A five-year longitudinal study. Clin Oral Implants Res 1994;5:9–18.
35. Hartman GA, Cochran DL. Initial implant position determines the magnitude of crestal bone remodelling. J Periodontol 2004;75:572–577.
36. Hermann JS, Buser D, Schenk RK, Schoolfield JD, Cochran DL. Biologic width around one- and two-piece titanium implants. Clin Oral Implants Res 2001;12:559–571.
37. Balfour A, O'Brien GR. Comparative study of antirotational single tooth abutments. J Prosthet Dent 1995;73:36–43.
38. Mollersten L, Lockowandt P, Linden LA. Comparison of strength and failure mode of seven implant systems: An in vitro test. J Prosthet Dent 1997;78:582–591.

Literature Abstract

Effect of repeated closures on opening torque values in 7 abutment-implant systems

The purpose of this study was to compare torque loss as a result of multiple consecutive closures within and between systems. Seven abutment/implant (A/I) systems were selected. Three identical A/I assemblies were tested for each of the following systems: *(1)* morse tapered interface with 6-degree abutment; *(2)* morse tapered straight abutment; *(3)* Spline interface with fixed abutment; *(4)* flat rim integral interface with fixed abutment; *(5)* internal octagon with fixed abutment; *(6)* external hex interface with HL straight abutment; and *(7)* external hex with standard abutment. One operator closed each abutment to 20 N/cm for 5 seconds. After a resting period of 10 seconds, the abutment screw was opened and the opening torque recorded. This procedure was repeated for 200 closing/opening cycles. Linear regression analysis was performed separately for each A/I assembly for all 7 systems. One-way analysis of variance (ANOVA) was applied. After closures at 20 N/cm, a progressive decrease in opening torque values was measured in all implant systems. Significant differences were found between the systems studied. Systems that consistently maintained the highest opening torque values contained either tapered frictional elements or interlocking tines. Opening torque values continued to decline for all systems progressively up to 200 c/o cycles, indicating decreased resistance to opening (probably because of the decrease in coefficient of friction). To minimize screw loosening, it is recommended that the number of closing/opening cycles in clinical and laboratory procedures before final abutment closure be reduced.

Weiss EI, Kozak D, Gross MD. *J Prosthet Dent* 2000;84:194–199. **Reference**: 14. **Reprints**: Dr Ervin I. Weiss, Department of Restorative Dentistry, The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel Aviv University, Tel Aviv 69978 Israel. Fax: 972-3640-9250. E-mail: ervinw@post.tau.ac.il—*Khaldoun Alajlouni, UNMC College of Dentistry, Lincoln, NE.*