

Immediate Loading of Unsplinted Implants in the Anterior Mandible for Overdentures: A Case Series

Phillip Roe, DDS, MS¹/Joseph Y. K. Kan, DDS, MS²/Kitichai Rungcharassaeng, DDS, MS³/Jaime L. Lozada, DDS⁴/Alejandro S. Kleinman, DDS⁵/Charles J. Goodacre, DDS, MSD⁶/Jung-Wei Chen, DDS, MS, PhD⁷

Purpose: This case series evaluated the implant success rate and peri-implant tissue response of immediately loaded unsplinted implants retaining a mandibular overdenture. **Materials and Methods:** Eight completely edentulous patients (five men, three women) with a mean age of 69.1 years were included in the study. All participants received new maxillary and mandibular complete dentures prior to implant placement. Two 4.0- × 13-mm threaded implants with a fluoride-modified microrough titanium surface were placed mesial to the mandibular canine position bilaterally. Individual stud attachments were connected and torqued to 25 Ncm and the overdenture was immediately attached. The patients were evaluated clinically and radiographically at implant placement and at 3, 6, and 12 months after implant placement. The data were analyzed using the paired-samples *t* test and the Wilcoxon signed-ranks test at a significance level of $\alpha = .05$. **Results:** At 12 months, all implants remained osseointegrated and showed an overall mean marginal bone change of -0.36 ± 0.29 mm and a mean Periotest value of -6.94 ± 0.73 . The modified Plaque Index scores indicated improvements in oral hygiene over time. Surgical complications involved two episodes of implant rotational instability. Prosthetic complications were attributed to abutment loosening, the patients' inability to insert the prosthesis correctly, and soft tissue shrinkage. **Conclusions:** The results of this study suggest that favorable implant success rates and peri-implant tissue responses can be achieved with mandibular overdentures retained with two immediately loaded unsplinted threaded implants with a fluoride-modified microrough titanium surface. INT J ORAL MAXILLOFAC IMPLANTS 2010;25:1028-1035

Key words: immediate loading, implant-retained prosthesis, locator abutment, mandibular overdenture, unsplinted

¹Assistant Professor, Department of Restorative Dentistry, Loma Linda University School of Dentistry, Loma Linda, California.

²Professor, Department of Restorative Dentistry, Loma Linda University School of Dentistry, Loma Linda, California.

³Associate Professor, Department of Orthodontics and Dentofacial Orthopedics, Loma Linda University School of Dentistry, Loma Linda, California.

⁴Director and Professor, Advanced Education in Implant Dentistry, Loma Linda University School of Dentistry, Loma Linda, California.

⁵Associate Professor, Department of Restorative Dentistry, Loma Linda University School of Dentistry, Loma Linda, California.

⁶Dean and Professor, Department of Restorative Dentistry, Loma Linda University School of Dentistry, Loma Linda, California.

⁷Associate Professor, Department of Pediatric Dentistry, Loma Linda University School of Dentistry, Loma Linda, California.

Correspondence to: Dr Phillip Roe, Center for Prosthodontics and Implant Dentistry, Loma Linda University School of Dentistry, Loma Linda, CA 92350. Fax: +909-558-0324. Email: proe03d@llu.edu

This research was performed in partial fulfillment of a MS degree for Phillip Roe.

Factors affecting the retention of complete dentures have been well documented.^{1,2} Unlike the maxillary denture, which can rely on many features for its retention, the oral and facial musculature has been identified as the primary retentive factor for mandibular dentures.^{1,2} Therefore, when patients present with less than ideal oral or anatomical structures, the stability and retention of the conventional mandibular denture can become compromised. As a result, alternative treatment modalities incorporating dental implants have been implemented.³⁻¹³

Oral rehabilitation with an implant-supported prosthesis has been well documented and is a predictable treatment modality for completely and partially edentulous patients.³⁻¹³ Traditional guidelines for ensuring osseointegration have included a healing period without any functional loading for 3 to 4 months in the mandible and 5 to 6 months in the maxilla.^{3,4} However, this extended waiting period



Fig 1 Definitive prosthesis.



Fig 2 Implant placement.

prior to implant loading was based on empirical information.⁵ The immediate loading of implants has been advocated, as it provides several advantages, including the immediate restoration of esthetics and function, a decreased number of patient treatment visits, and reduced morbidity associated with a second surgical intervention.⁶⁻⁹

Whereas numerous studies regarding the immediate loading of splinted implants retaining/supporting mandibular overdentures have reported promising success rates,¹⁴⁻¹⁹ similar studies of unsplinted implants have been limited.²⁰ The purpose of this study was to evaluate the clinical success and peri-implant tissue response of immediately loaded mandibular overdentures using two unsplinted implants with a fluoride-modified microrough titanium surface.

MATERIALS AND METHODS

Patient Selection

This study was approved by the Institutional Review Board of Loma Linda University and was conducted in the Center for Prosthodontics and Implant Dentistry, Loma Linda University School of Dentistry, California. A total of five male and three female patients between the ages of 58 and 82 (mean age of 69.1 years) were included in this study. To be included, patients had to: (1) be at least 18 years old; (2) be compliant with oral health-care instructions; (3) have sufficient bone to accommodate the placement of two 4.0- × 13-mm fluoride-modified microroughened titanium implants (OsseoSpeed, Astra Tech) slightly mesial to the canine positions; (4) have an opposing maxillary complete denture; and (5) have keratinized tissue present around the proposed implant site. Those patients with (1) a history of alcohol abuse, drug dependency, smoking,²¹ bruxism,²² head and neck radiation treatment,²³⁻²⁵ poor health, or any

other medical, physical, or psychologic factor that might affect the surgical procedure or the subsequent prosthodontic treatment and required follow-up examinations; or (2) the inability to achieve primary implant stability following implant placement were excluded from this study.

Clinical Procedures

All patients received standardized diagnostic and treatment planning procedures and consented to the treatment. A conventional complete denture with a lingualized occlusal scheme²⁶ was fabricated, placed, and adjusted 2 weeks prior to the implant surgery (Fig 1).

Following the administration of local anesthetic (2% lidocaine with 1:100,000 epinephrine), a crestal incision was made from the left second premolar area to the right second premolar area. After a full-thickness flap was reflected and the surgical site was exposed, alveoplasty was performed using a Stryker surgical bur (Stryker Biotech) to remove crestal bony ledges prior to implant placement. Two 4.0- × 13-mm threaded OsseoSpeed (Astra Tech) implants were placed, mesial to the mandibular canine positions and parallel to each other, with the aid of a surgical guide with a torque of 25 to 35 Ncm (manufacturer recommendation) (Fig 2). The abutments (Locator, Astra Tech) were connected to the implants and torqued to 25 Ncm. Primary flap closure was achieved with 5-0 Vicryl Plus Antibacterial (Ethicon, Johnson & Johnson) suture material.

The position of each abutment and attachment assembly (Locator, Astra Tech) in relationship to the intaglio surface of the mandibular complete denture was recorded using a poly(vinyl siloxane) interocclusal recording material (Exabite II, GC America). A carbide bur (H251 Brasseler USA) was used to create a recess in the denture base to accommodate the abutment and attachment assembly (Locator, Astra Tech) without the presence of physical contact between



Fig 3 Rubber dam was used to protect the surgical site from excess acrylic resin and monomer.

the assembly and the acrylic resin base while the denture was properly seated on the soft tissue. Rubber dam (DermaDam, Ultradent Products) was placed around the implant abutments to protect the surgical site from exposure to excess acrylic resin and monomer (Fig 3). The attachment assembly was picked up using a reline repair resin (Perm reline repair resin, type II, class I, Coltène/Whaledent) and light retention inserts (1.5-lb Locator, Astra Tech) were placed (Fig 4).

Prescriptions for postoperative antibiotics (amoxicillin 500 mg, Ranbaxy Laboratories) and a non-steroidal anti-inflammatory drug (ibuprofen 800 mg, BASF Corporation) were given to each patient along with instructions. The patients were advised to refrain from chewing food over the surgical site and to remain on a liquid diet for the first 2 weeks and a soft diet for the remainder of the implant healing phase.²⁷ The patients were also instructed to remove the overdenture every other day to clean it and the surgical site. An oral rinse (Peridex, Zila Pharmaceuticals) was used twice a day for the first 2 weeks after implant placement. A postoperative examination was performed 1 week following the procedure. The suture material was removed 2 weeks after surgery.

Data Collection

Implant Failure. The implants were evaluated according to the success criteria of Smith and Zarb.²⁸ The implants were considered a failure if significant marginal bone loss, peri-implant radiolucency, mobility, pain, discomfort, and/or neurosensory alteration was present.

Marginal Bone Change. Marginal bone change was measured using sequential periapical radiographs and the long-cone paralleling technique with a commercial Rinn XCP holder (XCP post bite blocks 54-0862, Dentsply). A poly(vinyl siloxane) (Exabite II, GC America) occlusal jig was used to standardize the



Fig 4 Locator attachments were picked up with repair resin.

angulation and position of the film to the x-ray beam. The junction between the microrough surface and the machined surface on the implants was used as the reference line (RL) (Fig 5). The distance between the reference line and the implant-bone contact point was measured. The value was positive when the implant-bone contact point was more coronal than the RL and negative when the implant-bone contact point was more apical to the RL. Measurements were made on both the mesial and distal aspects of each implant. The marginal bone levels were compared between each follow-up time interval. The intraexaminer reliability of the measurements was determined by performing double assessments of marginal bone levels performed 3 months apart by one examiner and expressed as the intraclass correlation coefficient.

Implant Mobility (Periotest Values). The Periotest instrument (Siemens)²⁹⁻³⁴ was used to evaluate implant stability at the time of the implant placement and subsequent visits. The 3-mm implant abutment (Locator, Astra Tech) was used as the tapping surface for the Periotest instrument. Measurements were made until two out of three duplicate values were registered.

Modified Plaque Index. The presence of plaque, as an indicator of the oral hygiene status of individual patients at different time intervals, was assessed at the labial, mesiolabial, distolabial, lingual, mesiolingual, and distolingual surfaces of each implant abutment according to the Modified Plaque Index³⁵ (mPI) (0 = no plaque detected, 1 = plaque only recognized by running a probe across the surface supragingivally, 2 = plaque can be visually seen with unaided vision, 3 = abundance of soft matter) at 3, 6, and 12 months.

Surgical Complications. Surgical complications were documented as any deviation from the manufacturer's placement protocol that required the surgeon to improvise and modify the protocol. These included, but were not limited to, pain/discomfort, bleeding,

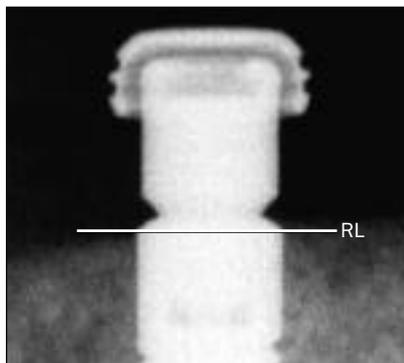


Fig 5 Reference line (RL).

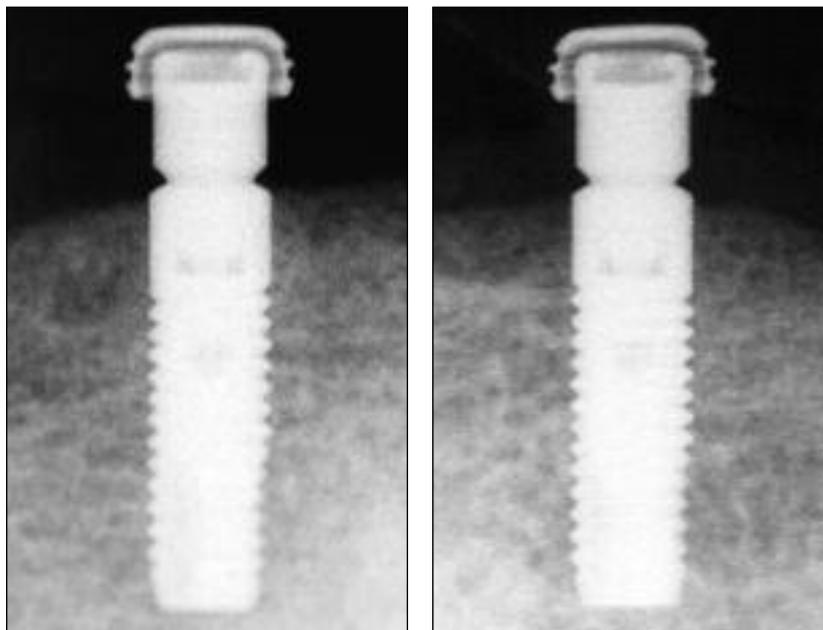


Fig 6 Marginal bone levels at 12 months.

ecchymosis, inadequate primary stability, or additional modifications to the surgical site.

Prosthetic Complications. Prosthetic complications were documented as any repairs and/or modifications of the existing prostheses. These included, but were not limited to, fracture of denture teeth, fracture of the overdenture, fracture of the opposing complete denture, damaged attachments, need for retention adjustments, abutment loosening, laboratory relines, and/or a need to remake the prosthesis.

Data Analysis

The paired-samples *t* test was used to evaluate the marginal bone changes, and the Wilcoxon signed-ranks test was used to evaluate the Periotest values. The level of significance was set at $\alpha = .05$.

RESULTS

Implant Failure

After 1 year of function, all implants (16/16) were stable and none had lost osseointegration, which corresponded to an overall implant success rate of 100%.

Marginal Bone Change

The intraclass correlation coefficient for the marginal bone level measurements was 0.996, indicating that the measurement method was reliable and reproducible. The overall mean marginal bone levels at 0, 3, 6, and 12 months were 0.14 ± 0.38 mm, -0.16 ± 0.18 mm, -0.19 ± 0.20 mm, and -0.22 ± 0.24 mm,

respectively (Fig 6, Table 1). Significant differences were noted between 0 and 3 months (-0.30 ± 0.26 ; $P = .015$), 0 and 6 months (-0.33 ± 0.26 ; $P = .009$), 0 and 12 months (-0.36 ± 0.29 ; $P = .001$), 3 and 6 months (-0.03 ± 0.04 ; $P = .050$), and 3 and 12 months (-0.06 ± 0.06 ; $P = .033$). However, no significant difference was noted in the mean marginal bone level between 6 and 12 months (-0.03 ± 0.06 ; $P = .293$; paired *t* test) (Table 1).

Implant Mobility

The mean Periotest values at 0, 3, 6, and 12 months were -5.00 ± 2.60 , -5.94 ± 1.18 , -6.38 ± 0.74 , and -6.94 ± 0.73 , respectively. There was no significant difference in Periotest values with respect to time ($P > .05$).

Modified Plaque Index

The frequency distribution of mPI scores showed improved oral hygiene over time. At the 3-month recall examination, one patient presented with good oral hygiene, one patient had fair oral hygiene, and six patients displayed poor oral hygiene. At the 6-month recall, two patients were rated as good, two patients were fair, and four patients showed poor oral hygiene. At the 12-month recall examination, two patients were deemed good, four patients were fair, and two patients were poor (Table 2).

Surgical Complications

Rotational instability was observed with two implants during placement. One implant (patient 6, Table 3) was unstable despite the fact that the implant osteotomy

Table 1 Comparisons of Implant Marginal Bone Level (MBL) Changes at Different Time Intervals

	Change in MBL			
	0 mo	3 mo	6 mo	12 mo
0	-	-0.30 ± 0.26 (<i>P</i> = .015*)	-0.33 ± 0.26 (<i>P</i> = .009*)	-0.36 ± 0.29 (<i>P</i> = .001*)
3	-		-0.03 ± 0.04 (<i>P</i> = .050*)	-0.06 ± 0.06 (<i>P</i> = .033*)
6			-	-0.03 ± 0.06 (<i>P</i> = .293)
12				-

*Statistically significant difference (paired-samples *t* test; $\alpha < .05$).

Table 2 Oral Hygiene Status Expressed as Mean mPI Scores Over Time

Patient no.	3 mo			6 mo			12 mo		
	G	F	P	G	F	P	G	F	P
1			3.0		1.5				1.3
2			3.0			2.3			1.1
3		2.0				2.3			1.3
4			3.0			3.0			2.4
5			3.0		2.0				1.3
6	0.8			1.0			0.3		
7			2.3	1.0			0.8		
8			3.0			3.0			3.0
Total	1	1	6	2	2	4	2	4	2

G = good (mean mPI < 1); F = fair (mean mPI > 1 and < 2); P = poor (mean mPI > 2).

Table 3 Surgical Complications with Respect to Insertion Torque

Patient no.	Insertion torque (Ncm)		Complication
	Right	Left	
1	25	25	None
2	25	25	None
3	25	25	None
4	25	25	None
5	25	25	None
6	25	35	One implant exhibited rotational instability following insertion. A 4.5- × 13-mm implant was placed without any modifications to the osteotomy site.
7	35	35	One implant exhibited rotational instability following insertion. The crestal bone was reduced by 1 mm and the osteotomy deepened by 1 mm with a smaller drill. The same 4.0- × 13-mm implant was reinserted without complications.
8	25	25	None

Table 4 Individual Prosthodontic Maintenance Events

Maintenance event	No.
Per implant (n = 16)	
Abutment loosening	1
Wearing of the attachment insert	4
Attachment insert replaced	4
Per patient	
Fractured implant overdenture, puncture fracture of acrylic resin over abutment, or fracture of denture teeth	0
Reline of overdenture	1

was prepared according to the manufacturer's recommendation. A larger-diameter implant (4.5- × 13-mm Osseospeed, Astra Tech) was inserted and torqued to 35 Ncm without any further complications. In another case (patient 7, Table 3), the implant bottomed out before reaching the planned depth, leading to rotational instability. The apical portion of the osteotomy was extended with an osteotomy drill that was one size smaller (Astra Tech). The implant was reinserted to the desired depth and good stability was achieved at an insertion torque of 35 Ncm.

Prosthetic Complications

One patient presented with a loose abutment at 5 months, and the complication was resolved after the abutment was retorqued to 25 Ncm. Two patients required the replacement of their attachment inserts following wear and loss of retention prior to the 1-year recall examination. One patient required a denture reline 5 months after surgery following recurrent incidences of food collecting underneath the mandibular implant overdenture (Table 4).

DISCUSSION

Numerous studies have shown good success with early loading of two unsplinted implants to retain a mandibular overdenture opposing a maxillary denture.^{36–44} However, the authors found only one study that provided data regarding the immediate loading of two unsplinted implants to retain a mandibular overdenture.²⁰ The results of the study have shown that, when using strict criteria in selecting edentulous patients, it is possible to achieve an implant success rate of 100% (16/16) when immediately loading two unsplinted threaded implants in the anterior mandible with a fluoride-modified microrough titanium surface (OsseoSpeed, Astra Tech). These results are comparable to the implant success rates reported with an early loading protocol (70.8% to 100%)^{36–45} as well as survival rates reported with an immediate loading protocol (100%).²⁰

Studies involving two unsplinted implants retaining an overdenture^{37,39,41–45} have reported peri-implant marginal bone level changes ranging from -0.07 to -0.35 mm for conventional loading and -0.12 to -0.27 mm for early loading.^{37,39,41–45} In 2007, Marzola et al reported a marginal bone level change of -0.71 mm 1 year after immediately loading two unsplinted implants to retain mandibular overdentures.²⁰ In the present study, the mean peri-implant marginal bone level change following 1 year of function was -0.36 mm, which was within the range of the aforementioned studies and other studies that are similar in nature.^{16,17,36–46} This finding suggests that immediate loading of unsplinted mandibular implant overdentures may not negatively influence the pattern of peri-implant marginal bone change.

The validity of the Periotest instrument for evaluating implant stability and diagnosing early signs of implant failure has often been questioned.^{29,30} However, the instrument has been previously recommended with evidence-based validity.^{30,31} Numerous authors have corroborated that the quantitative and reproducible attributes of the Periotest make it an objective and simple method for evaluating implant stability.^{29–34} Truhlar et al³² stated that Periotest values ranging from -8 to 9 coincided with a clinical mobility of zero (no discernible movement). In the present study, with the exception of one implant, all implants consistently produced readings between -8 and 0 at 0, 3, 6, and 12 months. The one positive value recorded may have been associated with a slightly enlarged osteotomy site. Although a positive value was registered on one implant immediately following placement, this implant had been successfully torqued to 35 Ncm, and negative values were registered at subsequent follow-up evaluations. Since primary stability

had been established, the prosthesis was immediately attached to the implants and functionally loaded. These findings indicate that all implants remained stable from the time of placement to 12 months following implant placement.

The influence of oral hygiene on implant success has been controversial.^{47–50} The consensus is that plaque accumulation could induce a negative mucosal response.^{27,47–50} With implant-retained overdentures, inflammation of the peri-implant tissues as a result of plaque accumulation is commonly encountered.⁵¹ This is often the result of the patient's inability to access certain areas of the implant abutment or suprastructure. Because of the possibility of soft tissue disturbance following surgery, patients were advised to refrain from brushing the surgical site during the first month. Oral hygiene was adequately maintained through light swabbing of the area with a cotton-tipped applicator soaked in 0.12% chlorhexidine gluconate (Peridex).²⁷ Over the course of 12 months, most patients gradually improved their oral hygiene. At 12 months, the increased percentage of low mPI scores (0 and 1) demonstrated that most patients had developed and maintained a fair level of hygiene.

Pain and discomfort from the surgical procedure appeared to be within the limits of a two-stage implant placement procedure. No incidences of abnormal bleeding or ecchymosis were observed or reported during the first 2 weeks of follow-up. Surgical complications encountered in this study were related to the surgeons' initial inability to establish the manufacturer's recommended acceptable insertion torque value for two implants. Regardless, all implants in this study were successfully torqued to the manufacturer's minimum recommended insertion torque value of 25 Ncm. The 100% implant success rate in this study is most likely a result of careful patient selection, proper surgical planning and execution, a balanced occlusal scheme, proper tissue adaptation and extension of the prostheses, and adequate patient compliance with instructions and postoperative care in conjunction with the fluoride-modified microrough titanium surface implant.

The consensus of many studies indicates that the prosthetic maintenance requirements of a removable prosthesis are greatest during the first year of service.^{52–54} This is related to the alteration of contours and repair of the abutment or attachment.⁵⁵ Prosthetic complications encountered in this study were primarily associated with a decrease in attachment retention. It was noted that the patients who required the attachment insert to be replaced within the first year displayed less coordination and dexterity than the other patients. Difficulty in positioning and placing the mandibular prosthesis may have accelerated the wear of the attachments.

During this study, all patients exhibited a degree of soft tissue shrinkage around the surgical site, which concurs with previously published literature for implant overdentures.⁴⁵ Of the eight patients enrolled in this study, one patient experienced a significant degree of soft tissue shrinkage, which resulted in food collecting underneath the overdenture and around the previous surgical site. A relining procedure was completed for this patient, which resolved the issue. Abutment loosening was observed on only one implant, which may have been a result of inadequate torque application during placement of the abutment.

CONCLUSIONS

Within the limits of this case series, the immediate loading of two unsplinted implants in the mandibular symphysis area supporting and retaining an overdenture can result in implant success and a favorable peri-implant tissue response. Nevertheless, a larger sample size with a control group and long-term follow-up will undoubtedly provide more insight on the viability of this procedure.

ACKNOWLEDGMENTS

The authors thank Astra Tech, Inc, Waltham, MA, for partially funding this research.

REFERENCES

- Shay K. The retention of complete dentures. In: Zarb G, Bolender C, Carlsson G (eds). *Boucher's Prosthetic Treatment for Edentulous Patients*, ed 11. St Louis: Mosby, 1997:400–411.
- Jacobsen TE, Krol AJ. A contemporary review of the factors involved in complete denture retention, stability, and support. Part I: Retention. *J Prosthet Dent* 1983;49:5–15.
- Adell R, Lekholm U, Rockler B, Brånemark PI. A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. *Int J Oral Surg* 1981;10:387–416.
- Jemt T, Lekholm U, Adell R. Osseointegrated implants in the treatment of partially edentulous patients: A preliminary study on 876 consecutively placed fixtures. *Int J Oral Maxillofac Implants* 1989;4:211–214.
- Albrektsson T. A multicenter report on osseointegrated oral implants. *J Prosthet Dent* 1988;60:75–84.
- Adell R, Eriksson B, Lekholm U, Brånemark PI, Jemt T. Long-term follow-up study of osseointegrated implants in the treatment of totally edentulous jaws. *Int J Oral Maxillofac Implants* 1990;5:347–359.
- Johns RB, Jemt T, Heath MR, et al. A multicenter study of overdenture supported by Brånemark implants. *Int J Oral Maxillofac Implants* 1992;7:513–522.
- Jemt T, Lekholm U. Oral implant treatment in posterior partially edentulous jaws. A 5-year follow-up report. *Int J Oral Maxillofac Implants* 1993;8:635–640.
- Lekholm U, van Steenberghe D, Hermann I, et al. Osseointegrated implants in the treatment of partially edentulous jaws. A prospective 5-year multicenter study. *Int J Oral Maxillofac Implants* 1994;9:627–635.
- Brånemark PI. Osseointegration and its experimental background. *J Prosthet Dent* 1983;50:399–410.
- Brånemark P-I, Hansson BO, Adell R, et al. Osseointegrated implants in the treatment of the edentulous jaw: Experience from a 10-year period. *Scand J Plast Reconstr Surg* 1977;11:1–132.
- Palmer RM, Smith B, Palmer P, Floyd P. A prospective study of Astra single tooth implants. *Clin Oral Implants Res* 1997;8:173–179.
- Åstrand P, Engquist B, Dahlgren S, Engquist E, Feldmann H, Gröndahl K. Astra Tech and Brånemark system implants: A prospective 5-year comparative study. Results after one year. *Clin Implant Dent Relat Res* 1999;1:17–26.
- Babbush CA, Kent JN, Misiek DJ. Titanium plasma-sprayed (TPS) screw implants for the reconstruction of the edentulous mandible. *J Oral Maxillofac Surg* 1986;44:274–282.
- Chiapasco M, Gatti C, Rossi E, Haefliger W, Markwalder TH. Implant-retained mandibular overdentures with immediate loading. A retrospective multicenter study on 226 consecutive cases. *Clin Oral Implants Res* 1997;8:48–57.
- Gatti C, Haefliger W, Chiapasco M. Implant-retained mandibular overdentures with immediate loading: A prospective study of ITI implants. *Int J Oral Maxillofac Implants* 2000;15:383–388.
- Chiapasco M, Abati S, Romero E, Vogel G. Implant-retained mandibular overdentures with Brånemark system MKII implants: A prospective comparative study between delayed and immediate loading. *Int J Oral Maxillofac Implants* 2001;16:537–546.
- Chiapasco M, Gatti C. Implant-retained mandibular overdentures with immediate loading: A 3- to 8-year prospective study of 328 implants. *Clin Implant Dent Relat Res* 2003;4:51–61.
- Gatti C, Chiapasco M. Immediate loading of Brånemark implants: A 24-month follow-up of a comparative prospective pilot study between mandibular overdentures supported by conical transmucosal implants and standard MKII implants. *Clin Implant Dent Relat Res* 2002;4:190–199.
- Marzola R, Scotti R, Fazi G, Schincaglia GP. Immediate loading of two implants supporting a ball attachment-retained mandibular overdenture: A prospective clinical study. *Clin Implant Dent Relat Res* 2007;9:136–143.
- Bain CA. Smoking and implant failure: Benefits of a smoking cessation protocol. *Int J Oral Maxillofac Implants* 1996;11:756–759.
- Lobbezoo F, Brouwers JE, Cune MS, Naeije M. Dental implants in patients with bruxing habits. *J Oral Rehabil* 2006;33:152–159.
- Esposito M, Grusovin MG, Patel S, Worthington HV, Coulthard P. Interventions for replacing missing teeth: Hyperbaric oxygen therapy for irradiated patients who require dental implants [review]. *Cochrane Database Syst Rev* 2008;23:CD003603.
- Granström G. Osseointegration in irradiated cancer patients: An analysis with respect to implant failures. *J Oral Maxillofac Surg* 2005;63:579–585.
- Granström G. Placement of dental implants in irradiated bone: The case for using hyperbaric oxygen. *J Oral Maxillofac Surg* 2006;64:812–818.
- Becker CM, Swoope CC, Guckes AD. Lingualized occlusion for removable prosthodontics. *J Prosthet Dent* 1977;38:601–608.

27. Kan JY, Rungcharassaeng K, Lozada J. Immediate placement and provisionalization of maxillary anterior single implants: 1-year prospective study. *Int J Oral Maxillofac Implants* 2003;18:31–39.
28. Smith DE, Zarb GA. Criteria for success of osseointegrated endosseous implants. *J Prosthet Dent* 1989;62:567–572.
29. Meredith N. Assessment of implant stability as a prognostic determinant. *Int J Prosthodont* 1998;11:491–501.
30. Olivé J, Aparicio C. Periotest method as a measure of osseointegrated oral implant stability. *Int J Oral Maxillofac Implants* 1990;5:390–400.
31. Aparicio C. The use of the Periotest value as the initial success criteria of an implant. *Int J Periodontics Restorative Dent* 1997;6:151–161.
32. Truhlar RS, Morris HF, Ochi S, Winkler S. Assessment of implant mobility at second-stage surgery with the Periotest: DICRG interim report No. 3. Dental Implant Clinical Research Group. *Implant Dent* 1994;3:153–156.
33. Walker L, Morris HF, Ochi S. Periotest values of dental implants in the first 2 years after second-stage surgery. DICRG interim report No. 8. Dental Implant Clinical Research Group. *Implant Dent* 1997;6:207–212.
34. Faulkner MG, Giannitsios D, Lipsett AW, Wolfaardt JF. Use and abuse of the Periotest for 2-piece implant/abutment systems. *Int J Oral Maxillofac Implants* 2001;16:486–494.
35. 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.
36. Roynesdal AK, Amundrud B, Hannaes HR. A comparative clinical investigation of 2 early loaded ITI dental implants supporting an overdenture in the mandible. *Int J Oral Maxillofac Implants* 2001;16:246–251.
37. Tawse-Smith A, Payne AGT, Kumara R, Thomson WM. Early loading of unsplinted implants supporting mandibular overdentures using a one-stage operative procedure with two different implant systems: A 2-year report. *Clin Implant Dent Relat Res* 2002;4:33–42.
38. Payne AGT, Tawse-Smith A, Kumara R, Thomson WM. One-year prospective evaluation of the early loading of unsplinted conical Brånemark fixtures with overdentures immediately following surgery. *Clin Implant Dent Relat Res* 2001;3:9–19.
39. Payne AGT, Tawse-Smith A, Duncan WD, Kumara R. Conventional and early loading of unsplinted ITI implants supporting mandibular overdentures. Two-year results of a prospective randomized clinical trial. *Clin Oral Implants Res* 2002;13:603–609.
40. Payne AGT, Tawse-Smith A, Thompson WM, Kumara R. Early functional loading of unsplinted roughened surface implants with mandibular overdentures 2 weeks after surgery. *Clin Implant Dent Relat Res* 2003;5:143–153.
41. Turkyilmaz I. Clinical and radiological results of patients treated with two loading protocols for mandibular overdentures on Brånemark implants. *J Clin Periodontol* 2006;33:233–238.
42. Turkyilmaz I, Tumer C. Early versus late loading of unsplinted TiUnite surface implants supporting mandibular overdentures: A 2-year report from a prospective study. *J Oral Rehabil* 2007;34:773–780.
43. Turkyilmaz I, Sennerby L, Tumer C, Yenigul M, Avci M. Stability and marginal bone level measurements of unsplinted implants used for mandibular overdentures: A 1-year randomized prospective clinical study comparing early and conventional loading protocols. *Clin Oral Implants Res* 2006;17:501–505.
44. Turkyilmaz I, Tozum TF, Tumer C, Ozbek EN. A 2-year clinical report of patients treated with two loading protocols for mandibular overdentures: Early versus conventional loading. *J Periodontol* 2006;77:1998–2004.
45. Tawse-Smith A, Payne AGT, Kumara R, Thomson WM. One-stage operative procedure with two different implant systems: A prospective study on implant overdentures in the edentulous mandible. *Clin Implant Dent Relat Res* 2001;3:185–193.
46. Cooper LF, Moriarty JD, Guckes AD, et al. Five-year prospective evaluation of mandibular overdentures retained by two microthreaded, TiOblast nonsplinted implants and retentive ball anchors. *Int J Oral Maxillofac Implants* 2008;23:696–704.
47. Adell R, Lekholm U, Rockler B, et al. Marginal tissue reaction at osseointegrated titanium fixtures. I. A 3-year longitudinal prospective study. *Int J Oral Maxillofac Surg* 1986;15:39–52.
48. van Steenberghe D, Klinge B, Linden U, Quirynen M, Herrmann I, Garpland C. Periodontal indicies around natural teeth and titanium implants. A longitudinal multicenter study. *J Periodontol* 1993;64:538–541.
49. Berglundh T, Lindhe J, Marinello CP, Ericsson I, Lilienberg B. Soft tissue reactions to de novo plaque formation at implants and teeth. *Clin Oral Implant Res* 1992;3:1–8.
50. Apse P, Zarb GA, Schmitt A, Lewis DW. The longitudinal effectiveness of osseointegrated dental implants. The Toronto study: Peri-implant mucosal response. *Int J Periodontics Restorative Dent* 1991;11:95–111.
51. Cune MS, de Putter C, Hoogstraten J. Treatment outcome with implant-retained overdentures: Part I—Clinical findings and predictability of clinical treatment outcomes. *J Prosthet Dent* 1994;72:144–151.
52. 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.
53. Payne AGT, Solomons YF. Mandibular implant-supported overdentures: A prospective evaluation of the burden of prosthodontic maintenance with 3 different attachment systems. *Int J Prosthodont* 2000;13:246–253.
54. Gotfredsen K, Holm B. Implant-supported mandibular overdentures retained with a ball or bar attachments: A randomized prospective 5-year study. *Int J Prosthodont* 2000;13:125–130.
55. Payne AGT, Solomons YF. The prosthodontic maintenance requirements of the mandibular mucosa- and implant-supported overdentures: A review of literature. *Int J Prosthodont* 2000;13:238–245.