Five-year Prospective Evaluation of Mandibular Overdentures Retained by Two Microthreaded, TiOBlast Nonsplinted Implants and Retentive Ball Anchors

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Purpose: *The aim of this 5-year prospective evaluation was to assess the bone and peri-implant mucosa responses at unsplinted, microthread implants supporting mandibular overdentures and to determine patient responses to therapy.* ***Materials and Methods:*** *Two implants were placed by a 1-stage procedure in the parasymphyseal mandibles of 59 subjects. Implant placement was followed by immediate insertion of overdentures without connection to abutments. After 3 months, connection using Dalla Bona attachments was made and peri-implant mucosa, peri-implant bone, and patient perceptions of treatment were evaluated.* ***Results:*** *The implant success rate was 95.9% from 6 to 60 months. The changes in marginal bone levels were positive (bone gain) but did not reach statistical significance at 12, 36, or 60 months (+0.13 ± 0.59 mm, +0.23 ± 0.66 mm, and +0.09 ± 0.79, respectively). Treatment was viewed as effective; patients rating satisfaction with their teeth increased from a preoperative level of 12.1% to 94.6% at overdenture abutment connection and remained high (81.6%) after 5 years.* ***Conclusions:*** *Expedited mandibular overdenture therapy utilizing unsplinted, microthreaded mandibular parasymphyseal implants was associated with high implant survival, preservation of crestal bone, and high patient satisfaction. Complications were minor and related to prosthodontic features of therapy.* Int J Oral Maxillofac Implants 2008;23:696–704

Key words: *dental implant, mandibular edentulism, microthread, patient satisfaction*

Edentulism is a disability affecting millions of individuals worldwide. Edentulism remains prevalent in some elderly communities (> 50% of the population) and, in the United States alone, is expected to continue to affect more than 20 million individuals over the next 2 decades.[1] Tooth loss of multiple etiologies, particularly caries and periodontal disease, that leads to early edentulism is associated with residual ridge resorption and affiliated problems of removable denture use. Beyond the physiological consequences of continued resorption of the mandible, altered facial form, and diminished masticatory function, edentulism has been reproducibly associated with reduced quality of life.[2] Treatment of edentulism using removable dentures has additional, negative consequences that include denture-induced stomatitis, denture-induced residual ridge resorption, and diminished masticatory function (compared with natural teeth). The psychological aspects of edentulism include social embarrassment from denture use, measured reduction in quality of life, including sexuality, and low self-esteem. While many individuals adapt both psychologically and physiologically to edentulism, other edentulous per-

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sons never accommodate to their loss of teeth or reduced mandibular function.

Endosseous dental implants have been used for more than 30 years to retain or support mandibular dentures as removable or fixed prostheses.[3,4] The use of 4 or more parasymphyseal implants to retain and support fixed or removable prostheses is a well-defined procedure that is widely accepted and acknowledged to provide long-term (> 10 year) function.[5–7] Prosthesis success remains high over long periods of time. The acknowledged complications of bridge fracture and prosthesis wear, as well as abutment screw fracture or occasional implant fracture, occur infrequently with little biologic morbidity. The main limitations associated with the implant-supported fixed denture are cost of therapy and impairment of oral hygiene. Mandibular implant overdentures (either implant supported or retained) are less costly than implant-supported fixed dentures and have advantages with regard to oral hygiene and replacement of lost alveolar support for facial esthetics and oral comfort. When cost is considered, 2-implant ball-retained mandibular overdentures have demonstrable advantages compared to implant-supported complete dentures or 2-implant or 4-implant bar-retained options.[8] There is little data to support the splinting of implants or the use of bar-retention devices in comparison to the simpler 2-implant ball retention approach.[9]

The success rate of dental implants supporting overdentures is among the highest success rates for dental implants. The majority of reports suggest implant survival is greater than 95% after 5 years.[10] Much of the data comes from prospective clinical evaluations of treatment and has included otherwise healthy individuals in protocols involving either 1- or 2-stage surgeries. The examination of dental implant placement for overdentures using provisional or early or immediate loading procedures has been reported. Implant survival after 1 to 2 years was again greater than 95%.[11–13] In these studies, bar-retained overdentures were used to load splinted implants. Most recently, similar high short-term success has been reported for early or immediate loading of unsplinted implants.[14–17]

In 1997, a prospective clinical evaluation of 1-stage surgical placement of two parasymphyseal implants followed by denture delivery without connection to unsplinted implant abutments was initiated.[18] The aims of the 5-year prospective study were to *(1)* evaluate the clinical and self-reported outcomes of treatment and *(2)* define radiographically the marginal bone responses to a microthreaded implant design. In this report, the results of this 5-year investigation are reported.

MATERIALS AND METHODS

A total of 59 completely edentulous subjects were enrolled in a 60-month prospective clinical trial approved by the Institutional Committee on Human Subjects Research at the University of North Carolina School of Dentistry. All subjects meeting the inclusion and exclusion criteria of the study[18] were subjected to a comprehensive radiographic and clinical examination and signed an informed consent document approved by the institutional review board. After enrollment, new maxillary and mandibular complete dentures were constructed with standardized techniques and materials. Dentures were delivered and postinsertion care was provided for a 2-week period. The mandibular denture was duplicated in clear acrylic resin (Orthodontic Resin, Caulk; Dentsply, York, PA) and used as a tomographic and surgical template. Radiographic lead foil strips (2.0 mm width) were applied to buccal and incisal surfaces of the canine teeth of the duplicated mandibular denture (radiographic template), and standardized tomograms (Com Cat, Model IS2000; Imaging Sciences International, Gwynedd, PA) were made. With the information available from the tomographic tracings, a surgeon and a prosthodontist decided the optimum location and angulation for implant placement. The radiographic template was then drilled to use as a guide for implant placement to facilitate surgery using minimal flap design. Microthread implants (Astra Tech, Mölndal, Sweden) of 3.5 or 4.0 mm diameter and 4 lengths (Table 1) were placed as previously described using a 1-stage surgical approach. Bone quality and quantity assessments were made at the time of surgery (Table 1). Healing abutments were selected to extend beyond the mucosal tissues to a height of 2 to 3 mm. The mandibular denture was relieved only in the region of implant surgery, allowing the subject to wear the prosthesis home on the day of surgery. Seven to 10 days later, subjects returned for suture removal. The relieved tissue surface of the denture was relined using tissue conditioning material (Lynal; LD Caulk, Milford, DE), and the tissue conditioning material was changed 6 to 8 weeks afterward. Three months following implant placement, the healing abutments were replaced with ball abutments (Ball Abutments, Astra Tech, Mölndal, Sweden) and a reline impression was made with vinyl polysiloxane (Extrude; Kerr Dental Products, Romulus, MA) with inclusion of ball impression caps (Astra Tech). Using this reline impression, a relined mandibular complete denture containing Dalla Bonna–style attachments was inserted following standard prosthodontic procedures. The attachments were activated, and pressure

Table 1 Subject and Implant Variables

No. of subjects	
Male	30
Female	29
Total	59
Age (y)	
Average	58.3
Range	26 to 74
Mean bone quality (1 to 4)	2.1
No. of subjects lost to follow-up	10
Cumulative implant success rate	95.9%
Implant length	
11 mm	
3.5	15
4.0	6*
13 mm	
3.5	38
4.0	8
15 mm	
3.5	35
4.0	0
17 mm	
3.5	14†
4.0	2

*Three implants lost.
†Two implants lost.

indicator paste (PIP; Mizzy, Cherry Hill, NJ) was used to assure tissue adaptation and perform required adjustments. Insertion and activation of the relined prosthesis was considered the baseline for all subsequent measurements. In addition to peri-implant mucosal and prosthodontic measurements, standardized tomograms were taken at baseline and at 3 and 6 months, and 1, 3, and 5 years afterward. The original tomographic template was used at all subsequent visits to standardize the tomographic images. The inferior portion of the machined bevel of the implant was used as the superior reference point in all measurements. Marginal bone level data was collected for mesial, distal, facial, and lingual points around each implant at regular intervals and reported as the mean value (± SD) of the mesial-distal and facial-lingual measures.

Statistical Analysis

Nonparametric data was compared using the Wilcoxon rank test, and statistics were calculated using StatXact (Cytel, Cambridge, MA). The null hypothesis tested is that the difference is equal to zero. The calculated *P* value of .05 or less was considered statistically significant. Kaplan-Meier analysis was performed to estimate implant survival while accounting for patient dropout during the 5-year follow-up period.

RESULTS

Fifty-nine individuals (30 male and 29 female) were enrolled and treated according to protocol (Table 1). The mean age was 58.3 years (±10) with a range of 26 to 74 years. The bone quantity and bone quality measures[19] for the mandibular sites treated in the study included 96 of 118 implant sites with quality 1 or 2 bone and 56 of 118 implant sites with quantity A or B. No type-4 bone was encountered; 13 subjects with a bone quantity of D or E were treated. The average mandibular parasymphyseal bone height at the time of treatment was 21.16 mm.

One hundred eighteen Microthread, TiOBlast implants were placed. One hundred two of these implants were 3.5 mm diameter, and 16 were 4.0 mm diameter (Table 1). At surgical placement, 116 of 118 were determined to possess primary stability. In all, 107 implants were placed with bicortical stabilization.

During the initial healing period (0 to 3 months), 5 implants failed in 4 subjects (Table 2). The 2 implants lacking initial primary stability at placement were among the 5 implants lost prior to abutment connection. Regarding the other 3 implants lost prior to abutment connection, one was a 4.0-mm implant that was placed subsequent to attempted placement of a 3.5-mm implant that did not attain primary stability. The other two implants were 3.5 × 17 mm implants lost in 1 subject. In 3 implants experiencing unilateral failure, the failed implant was replaced. In one subject, both implants were lost, and the patient received no further treatment under the protocol. Therefore, despite the 3 initial failures at abutment connection, 58 subjects continued treatment, and 116 implants were available for continued follow-up examination. All subjects were available for the 12-month evaluation and 54 subjects were evaluated at the 36-month evaluation. At the 60-month evaluation, 49 subjects were evaluated. Among the 10 subjects lost to follow-up, 3 died prior to the last visit, and the other 7 either refused or were physically unable to attend the follow-up appointment.

Implant survival was 95.9% at the abutment connection visit, and no other implant failure was recorded during the remaining evaluation period (Table 2). Because individual implant stability and marginal bone levels were continuously recorded, the 4-field analysis of implant success could be applied at both 36 and 60 months.

At 36 months, there were 4 subjects lost to follow-up (8/116 implants). All remaining implants were stable and functioned to support the mandibular overdentures (S_1 = 108/116 implants). Because of the stable crestal bone situation at all implants, implant success (Ss) was also 108/116 implants. Of the

Table 2 Primary Outcome Measures

Time	Marginal bone level (MBL) change		Implant loss		
	MBL	ΔMBL* (± SD)	No. of implants lost	CSR (%)	No. of subjects
Baseline	0.74 ± 0.71	—	—	—	59
3 mo	0.70 ± 0.66	+0.05 ± 0.32	5	95.9	58
6 mo	0.69 ± 0.61	+0.05 ± 0.52	0	95.9	58
12 mo	0.62 ± 0.53	+0.13 ± 0.59	0	95.9	58
36 mo	0.51 ± 0.57	+0.23 ± 0.66	0	95.9	54
60 mo	0.66 ± 0.81	+0.09 ± 0.79	0	95.9	49

*Wilcoxon rank test; *P*= .09 (ie, no statistically significant change in MBL over 5 years).
CSR = cumulative success rate.

implants placed, 5/118 implants failed during the 60-month follow-up period.

At the 60 months, 5 additional subjects were lost to follow-up and 18/116 implants were unaccounted for. In the remaining 49 subjects, all 98 implants were intact and functioning to support the mandibular overdentures. Implant survival was 98/116 implants treated per protocol. During this continued follow-up period, crestal bone levels remained stable among all subjects, providing an implant success rate of 98/116. Overall, among evaluated implants, the implant success rate remained constant at 95.9% (Table 2). Kaplan-Meier analysis was applied to implant survival over the 5-year period. Accounting for patients lost to follow-up, a 5-year survival probability estimate of 0.91 was calculated (0.95 CI = 0.80 to 0.96).

At abutment connection, the majority of implants received either 1.5-mm high (59/116 implants) or 3.0-mm-high ball abutments (47/116 implants). Only seven 4.5-mm-high and three 6.0-mm-high ball abutments were used. During the 60-month evaluation period, 1 ball abutment fractured. No implant fractures occurred. There were 6 (of 116) incidents of abutment screw loosening during the 36- and 60-month follow-up period. The complete details of the prosthodontic complications associated with this study after 3 years are reported elsewhere.[20]

The measurement of marginal bone levels revealed no statistically significant change in the average distance from the implant reference point to crestal bone—0.62 ± 0.53 mm at 12 months, 0.51 ± 0.57 mm at 30 months, and 0.66 ± 0.81 mm at 60 months. The associated changes in marginal bone levels were positive (bone gain) but did not reach a magnitude of statistical significance at 12, 36, or 60 months +0.13 ± 0.59, +0.23 ± 0.66, or +0.09 ± 0.79, respectively (Table 2). At 60 months, 34 of 49 subjects experienced 0.0 to 0.5 mm marginal bone loss (Fig 1). Only 4 subjects experienced greater than 1.0 mm marginal bone loss during the 5-year period.

The peri-implant tissue responses were recorded at the abutment level for 58 subjects at 12 months, for 54 subjects at 36 months, and for 49 subjects at 60 months (Table 3). The extent of plaque retention on the abutments was 84 of 232 (36.2%) of the surfaces at 12 months, 85 of 216 (39.4%) of the surfaces at 36 months, and 55 of 196 surfaces (28.1%) at 60 months. These values were statistically unchanged from the initial recordings following overdenture connection (42/232 evaluable surfaces; 18.1%; P = .23). Peri-implant inflammation was recorded as redness at the peri-implant mucosa. At 12, 36, and 60 months, 18.1% (29/160), 16.7% (36/216), and 9.7% (19/196) peri-implant mucosal surfaces displayed inflammation upon examination (Table 3). The percentage of surfaces displaying inflammation at 12, 36, and 60 months was not statistically greater than surfaces displaying inflammation at overdenture placement (3.9%; 9/232; P = .32).

The measured peri-implant sulcus depths did not change significantly over the entire 60-month evaluation period (Table 3). The average pocket depths were 1.59 mm (± 0.69), 1.90 mm (± 0.73), 1.98 mm (± 0.79) and 1.79 mm (± 0.76) at baseline, 12, 36, and 60 months, respectively. The calculated changes in pocket depths were 0.30 ± 0.73, + 0.38 ± 0.84, and + 0.19 ± 0.84 at 12, 36, and 60 months, respectively (P = .023).

When some of the functional aspects of denture use were further evaluated by self-assessment methods, the provision of an implant-supported overdenture was not regarded as influencing function (Table 4). For example, self-assessment of chewing revealed no change from baseline to posttreatment or follow-up time points. In addition, general perceptions of phonetics did not change from baseline to posttreatment or follow-up time points. For self-assessment of phonetics, a rating of good or very good was provided by 85.8% of subjects, over the duration of the study. A trend for reduced satisfaction with chewing

Table 3 Secondary Outcome Measures

Time	Plaque and Peri-implant Inflammation (# of surfaces [%])		Peri-implant sulcus depth (mm) mean (± SD)		Width of keratinized mucosa (KM) (mm) mean (± SD)	
	Plaque	Redness	Sulcus depth (mm)	Δ Sulcus depth*	Width KM	ΔWidth KM**
0D insertion	42/232 (18.1%)	9/232 (3.9%)	1.59 (± 0.69)	—	2.98 (± 1.42)	—
3 mo	59/224 (26.3%)	23/224 (10.3%)	1.58 (± 0.71)	0.00 (± 0.67)	3.23 (± 1.22)	0.24 (± 1.24)
6 mo	93/232 (40.1%)	22/232 (9.5%)	1.73 (± 0.72)	0.13 (± 0.58)	3.21 (± 1.37)	0.24 (± 0.71)
12 mo	84/232 (36.2%)	29/160 (18.1%)	1.90 (± 0.73)	0.30 (± 0.73)	3.17 (± 1.43)	0.19 (± 1.08)
36 mo	85/216 (39.4%)	36/216 (16.7%)	1.98 (± 0.79)	0.38 (± 0.84)	3.21 (± 1.60)	0.22 (± 0.99)
60 mo	55/196 (28.1%)	19/196 (9.7%)	1.79 (± 0.76)	0.19 (± 0.84)	3.23 (± 1.70)	0.25 (± 1.32)

*Wilcoxon rank test; $P = .023$; statistically significant change during 5 years.
**Wilcoxon rank test; $P = .1147$; changes were not statistically significant.

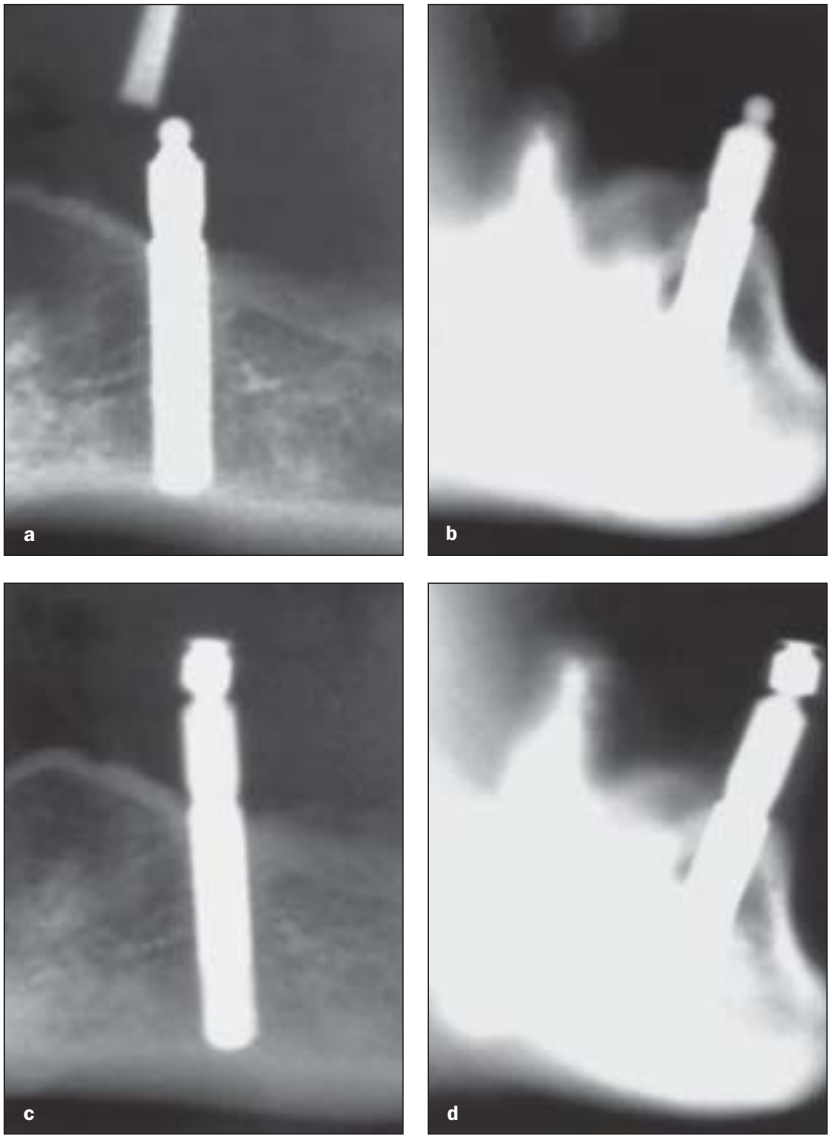

Fig 1 Serial radiographic evaluation of interproximal bone levels at microthreaded implants. *(a)* Mesiodistal image of implant at abutment placement reveals the crest of bone at both the mesial and distal aspects of the implant reference point. *(b)* Buccolingual image of the implant at abutment placement reveals buccal and lingual crestal bone approximating the implant reference point. *(c)* Mesiodistal image of implant at 60-month follow-up reveals the crest of bone at both the mesial and distal aspects of the implant reference point. *(d)* Buccolingual image of the implant at 60-month follow-up reveals buccal and lingual crestal bone approximating the implant reference point.

Table 4 Self-reported Outcomes

	Patient Evaluation Category											
	Chewing (%)			Phonetics (%)			"Satisfaction" (%)			Overall facial attractiveness (%)		
Score*	Baseline	12 mo	60 mo	Baseline	12 mo	60 mo	Baseline	12 mo	60 mo	Baseline	12 mo	60 mo
1	0	0	0	0	0	0	0	0	0	6.9	3.4	0
2	1.8	1.7	8.2	1.8	0	6.1	3.6	1.7	8.2	17.2	12.1	8.2
3	8.9	12.1	10.2	5.4	8.6	8.2	3.6	6.9	8.2	55.2	19.0	16.3
4	28.6	31	20.4	35.7	36.2	32.7	33.9	27.6	22.4	15.2	62.1	65.3
5	60.7	55.2	61.2	57.1	55.2	53.1	58.9	63.8	61.2	5.2	3.4	10.2

*1 = very bad, 2 = bad, 3 = neither bad nor good, 4 = good, 5 = very good.

Table 5 Self-reported Components of the Oral Facial Body Score

	Components of the Oral Facial Body Score (%)											
	Lips			Mouth			Teeth			Facial complexion		
Score*	Baseline	3 mo	60 mo	Baseline	3 mo	60 mo	Baseline	3 mo	60 mo	Baseline	3 mo	60 mo
1	0	0	2	8.6	1.8	2	34.5	0	2	3.4	1.8	2.0
2	12.1	3.4	6.1	29.3	1.8	0	31.0	3.6	8.2	12.1	5.4	6.1
3	60.3	5.4	8.2	43.1	3.6	14.3	22.4	1.8	8.2	53.4	5.4	8.2
4	25.9	78.6	73.5	17.2	73.2	71.4	6.9	60.7	57.1	27.6	71.4	71.4
5	1.7	12.5	10.2	1.7	19.6	12.2	5.2	33.9	24.5	3.4	16.1	12.2

*1 = very bad, 2 = bad, 3 = neither bad nor good, 4 = good, 5 = very good.

was recorded; baseline assessments revealed 89.3% of individuals rated chewing as good or very good and 60-month assessments revealed 81.6% of individuals rated chewing as good or very good.

This study also measured subject's perception of treatment outcome by a satisfaction questionnaire and use of an orofacial body image survey. While general satisfaction with their protheses did not change appreciably, marked changes in overall facial attractiveness were recorded (Table 4).

The self-assessment of teeth revealed that the majority of subjects possessed a general dissatisfaction with their teeth at baseline (12.1% good or very good, Table 5). At mandibular overdenture connection, 94.6% of this population assessed their teeth as good or very good. At 36 and 60 months, a reduction in self-reported satisfaction of good or very good was recorded for teeth (83.3% and 81.6%, respectively), but this level of satisfaction remained greater than baseline measures ($P < .05$). In the context of the orofacial body score, scoring of teeth was not related to the scoring of the functional attributes of chewing or phonetics.

Beyond the functional aspects of teeth, the scoring of teeth paralleled scoring of facial attractiveness (Table 5). When recorded, self-assessment of facial attractiveness was compared longitudinally among this treatment population, only 20.4% of individuals rated their facial attractiveness as good or very good at baseline. Upon attachment of the mandibular overdenture at 3 months, 87.5% of individuals rated their facial attractiveness as good or very good. At 36 and 60 months, 65.5% and 75.5% of individuals considered their own facial attractiveness as good or very good (Table 4). This overall rating of attractiveness was supported by other ratings as well, most notably ratings of perceived attractiveness of lips, facial complexion (Table 5), and facial profile (not shown).

DISCUSSION

This prospective cohort study investigated individual subject responses to dental implant overdenture therapy using a 1-stage surgical approach with denture delivery at the time of implant surgery. All dentures were retained by ball abutments on unsplinted endosseous dental implants (Fig 2). The presently reported 5-year evaluation reiterates the high success rates for osseointegrated endosseous dental implants used in this manner and confirms that individuals receiving this treatment obtain important benefits measured at the level of self-perceived satisfaction and facial attractiveness. Naert et al[9] concluded from a 10-year prospective evaluation of 2-implant overdenture treatment of mandibular edentulism that the absence of implant failure and

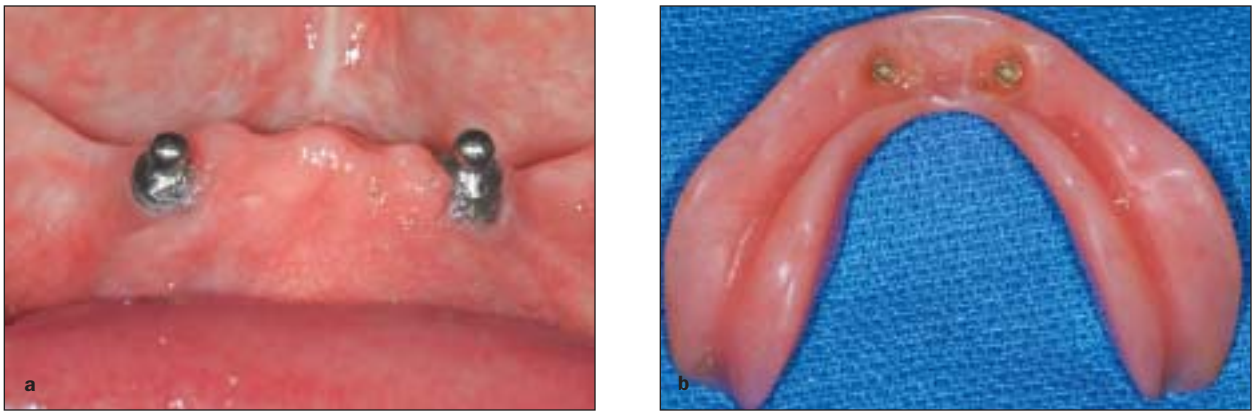

Fig 2 Ball abutments retain mandibular overdentures on unsplinted microthreaded implants. *(a)* The mandibular alveolar ridge and ball abutments at the 60-month follow-up. Note the relative absence of inflammation in the peri-implant mucosa and the related implant hygiene. *(b)* The intaglio surface of the mandibular overdenture reveals the dalla bona attachments intact after 60 months. Note the full extension of the mandibular overdenture permits physiological adaptation as well as optimal support from the denture-bearing areas.

the limitation of overall marginal bone loss to the first year of bone remodeling suggested that this treatment concept has an excellent prognosis. Visser et al[21] confirmed that there is no apparent benefit of 4 splinted versus 2 unsplinted implants for mandibular overdentures. The present result supports this important conclusion.

The logistical benefits of placing the denture over healing abutments immediately following surgery enhanced clinical management of the edentulous implant patient. The advantages of peri-implant tissue adaptation during the healing phase as well as avoidance of second-stage surgery must be weighted against potential risks for early implant failure due to uncontrolled loading by a shifting or rocking denture. The present study mandated that a minimum of 3 to 5 mm of circumferential relief be provided around each abutment to avoid any contact with the healing abutments during the healing period. The inclusion of a soft tissue conditioning or vinyl polysiloxane reline material is presently advocated to aid in stability without disruption of osseointegration.

One aim of this evaluation was to define the behavior of microthreaded implant design used in an unsplinted clinical situation. The absence of marginal bone loss recorded from the time of implant placement to 60 months following attachment of the implant to the overdenture prosthesis suggests that the microthread design can support positive marginal bone responses for unsplinted implants. Because this study did not compare the crestal bone responses between a microthread design and a conventional implant design, it is not possible to directly attribute the marginal bone response to the microthread feature of the experimental implant design. However, other studies of microthread design on TiO_2-grit blasted implants with conical seal design abutments have shown similar low levels of marginal bone loss.[22–24]

This measured absence of marginal bone loss differs from other reports for unsplinted implants supporting mandibular overdentures. van Steenberghe et al[25] have shown that following an initial marginal bone adaptation of 1 mm from the reference point of unsplinted Brånemark implants supporting mandibular overdentures, marginal bone levels were 2.1 and 2.4 mm from the reference point after 4 and 8 years. Behneke et al[26] reported 0.5 mm of marginal bone loss between surgery and prosthetic loading of 1-stage implants. Immediate loading using 2 unsplinted SLA-surfaced ITI solid-screw dental implants in the interforaminal region were associated with marginal bone level changes of 0.71 mm after 1 year.[27] When the change in marginal bone levels were directly compared between immediate loaded and conventional 1-stage implants in mandibular overdenture subjects (0.35 mm versus

0.27 mm), no significant differences were observed.[15] However, Lorenzoni et al[28] demonstrated that early mean marginal bone level changes at prosthetic delivery were 0.9 mm and 0.33 mm for loaded and nonloaded Frialit-2 implants ($P < .001$). The reported variations in marginal bone responses at implants require further investigation into the relationship of design features and clinical protocols (eg, timing, prosthetic design, splinting).

It was of importance to define the potential effect of a moderately roughened surface (TiO_2-grit blast) and microthreaded implant design on peri-implant mucosal responses. In the presence of increasing plaque scores from baseline to 5 years (ranging from the baseline of 18.1% to 28.1% of evaluated surfaces at 60 months), the measured inflammation remained low throughout the 5-year evaluation period (3.9% at baseline and 9.7% and 60 months). If the effects of peri-implant inflammation are of concern to peri-implant mucosal attachment or for the maintenance of marginal bone levels, then absence of marginal bone changes and the modest changes in peri-implant sulcus depth (0.19 mm; $P = .23$) or keratinized tissue measurements (0.25 mm, $P = .11$) indicate that moderately rough surface implants with microthreads are of little consequence to local inflammation in this clinical scenario. This study underscores the advantage of accessibility the overdenture treatment choice provides to maintenance of peri-implant tissue health.

It is now widely appreciated that implant-supported overdentures in the mandible provide predictable results with improved stability, retention, function, and patient satisfaction compared with conventional dentures.[10,29] The improvements in self-reported satisfaction may be related to masticatory and social functions. In this study, the activation of the attachments of the mandibular overdenture coincided with improvements in self-reported overall facial attractiveness and particular improvements in self-reported measures of features indirectly related or unrelated to the prostheses such as the appearance of the mouth and facial complexion (Table 5; compare baseline and 3-month data). This underscores the general impact of this therapy on the edentulous patient.[30]

In another 5-year prospective study of edentulous patients treated with mandibular overdentures retained by 2 implants interforaminally, implant subjects had higher satisfaction scores than complete-denture subjects. Irrespective of design (2 or 4 implants), masticatory function improved following treatment with an implant-supported mandibular overdenture. The authors suggested that stabilization rather than support or retention of the implant-retained mandibular overdenture is the dominant factor in the observed improvement of masticatory function.[31] A 2-year follow-up report of mandibular implant-retained overdentures also indicated that the high patient satisfaction reported shortly after implant overdenture insertion was related to mastication and denture stability and not to appearance.[32] However, Cune et al[33] reported that mandibular implant-supported overdenture treatment reduced various denture complaints without a relationship between self-reported satisfaction and measured masticatory function. The present study revealed improvement in self-reported orofacial appearance without self-reported improvements in phonetics or chewing.

In conclusion, this 5-year prospective evaluation of treatment of mandibular edentulism using unsplinted implants and retentive ball abutments to retain mandibular overdentures revealed that *(1)* patient satisfaction was high following activation of the implant attachments, *(2)* patient satisfaction was related to improved self-perception of facial attractiveness, *(3)* implant success was high (> 95%) using a 1-stage procedure, and *(4)* no marginal bone loss was recorded over the 5-year period at these unsplinted implants. Expediting treatment of mandibular edentulism is possible using 1-stage procedures that involve denture insertion on the day of surgery.

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