Moderately Roughened- and Roughened-Surface Implants Used as Rigid Orthodontic Anchorage: A Case Series

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ABSTRACT

Background: Osseointegrated implants, especially Brånemark turned-surface implants, have been shown to function as stable and efficient orthodontic anchors. While it is generally accepted that prostheses can be attached to implants that have been used as anchors, it has not been clarified if the same applies to moderately roughened- and roughened-surface implants.

Purpose: The purpose of the present study was to assess the differences between moderately roughened- and roughened-surface implants that are used as orthodontic anchors and then bonded with prostheses and those that are bonded with prostheses without serving as orthodontic anchors.

Materials and Methods: A total of 43 moderately roughened- and roughened-surface implants (ITI titanium plasma spray [TPS®] [Straumann AG, Waldenburg, Switzerland], ITI sandblasted large-grit acid-etched [SLA®] [Straumann AG], Nobel TiUnite™ [Nobel Biocare AB, Göteborg, Sweden]) were placed in 11 partially edentulous patients, aged 35–61 years (two men and nine women). After an appropriate healing period, orthodontic therapy was performed in 11 patients using 27 implants as orthodontic anchors. After completion of the orthodontic therapy, the prostheses were attached at the same time to both types of implants: the 27 implants that were used as anchors, and 16 implants that were not used as anchors. All 11 patients were followed up regularly.

Results: Regardless of use as orthodontic anchorage, all implants maintained osseointegration and continued to function properly.

Conclusion: No differences existed in therapeutic results after prosthesis bonding whether or not moderately roughened- and roughened-surface implants were used as orthodontic anchors.

KEY WORDS: implants, orthodontic treatment, rigid intraoral anchorage, surface modification

Implants have been utilized for orthodontic anchorage since 1945.[1–3] However, as the predictability of these implants was still under question, it was difficult to positively evaluate studies which reported their use. With the introduction of the Brånemark Implant System® (Nobel Biocare AB, Göteborg, Sweden),[4,5] implant therapy became more popular and there is adequate clinical evidence for predictability of implant therapy in edentulous jaws,[5] partially edentulous jaws,[6] and single-tooth restoration cases,[7] thus expanding the range of clinical application. The concept of osseointegration[4] has been more widely accepted since 1982, which was 6 years after functional ankylosis between bone and titanium plasma spray (TPS) implant surface was shown histologically in 1976.[8] Subsequently, the clinical use of implants as rigid intraoral anchorage has been reported.[9–12] Today, the effectiveness of implants as orthodontic anchors is widely recognized. The surface characteristic of implants is one of the six conditions for osseointegration proposed by Albrektsson and colleagues.[13] The use of moderately roughened surfaces has resulted in a tendency to better clinical results, shorter healing period, and better outcome in soft bone compared to previously preferred surfaces.[14–17] However, there are only a few clinical studies which have used

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TABLE 1 Distribution of Moderately Roughened- and Roughened-Surface Implants as Orthodontic Anchorage Use

	Patient		Number of Implants			System of Anchorage Implants					
Case	Gender	Age	Total	Anchorage	Failures*	ITI (TPS®)	ITI (SLA®)	Nobel (TiUnite™)	Length (mm)	Anchorage Implant Width (mm)	Position
1	F	35	2	2	0	2			6, 6	4.1, 4.1	38, 48
2	F	51	4	2	0	2			6, 8	4.1, 4.1	24, 25
3	F	45	9	7	0	3	4		8, 8, 8, 12, 12, 10, 10	4.1 × 7	45, 46, 47, 44, 13, 25, 26
4	M	36	4	1	0		1		12	4.1	45
5	F	51	2	2	0		2		8, 8	4.1, 4.1	37, 45
6	F	61	8	2	0		2		10, 12	4.1, 4.1	15, 14
7	F	48	5	2	0		2		12, 12	3.3, 4.1	45, 46
8	M	55	1	1	0		1		8	4.1	36
9	F	48	2	2	0			2	13, 15	4.0, 4.0	14, 24
10	F	61	2	2	0			2	10, 7	4.0, 5.0	46, 36
11	F	48	4	4	0			4	15, 15, 15, 15	4.0 × 4	11, 13, 15, 17
	Total		43	27	0	7	12	8			

*Until September 2005.
SLA = sandblasted large-grit acid-etched; TPS = titanium plasma spray.

osseointegrated implants as orthodontic rigid intraoral anchors, and the clinical course of moderately roughened- and roughened-surface implants after being used as orthodontic intraoral anchors is not clear.

MATERIALS AND METHODS

The patients included in this study were treated at a private clinic by a general dentist between November 1998 and September 2005. The inclusion criteria were partially edentulous maxilla and mandible with minimum alveolar bone widths of 4.0 mm regardless of unhealed or fresh extraction socket, as judged by the same dentist on clinical examination. Patients who could not receive total periodontal therapy and professional tooth cleaning during orthodontic therapy with implants once a month were excluded. Four out of the 11 patients were smokers (cases 3, 4, 5, and 8). A total of 43 moderately roughened- and roughened-surface implants (ITI Dental Implant System®, Straumann AG, Waldenburg, Switzerland, TPS surface solid-screw type 7 implants for anchorage and two for non-anchorage; sandblasted large-grit acid-etched (SLA®) (Straumann AG) surface solid-screw type 12 implants for anchorage and 11 implants for non-anchorage; Brånemark Implant System Mk IV TiUnite™ eight implants for anchorage, Mk IIITiUnite three for non-anchorage, Nobel Biocare AB) were placed in 11 partially edentulous patients, aged 35–61 years (two men and nine women) (Tables 1–3). The length of the implants ranged from 6 to 15 mm, and the diameter of the implants ranged from 3.3 to 5.0 mm. After a healing period of 1 to 5 months, orthodontic therapy was performed in all 11 patients using 27 implants (ITI TPS: three implants had a diameter of 4.1 mm and length of 6 mm, two had a diameter of 4.1 mm and length of 8 mm, two had a diameter of 4.1 mm and length of 12 mm; ITI SLA: five implants had a diameter of 4.1 mm and length of 8 mm, three had a diameter of 4.1 mm and length of 10 mm, three had a diameter of 4.1 mm and length of 12 mm, one had a diameter of 3.3 mm and length of 12 mm; Brånemark TiUnite: one implant had a diameter of 5.0 mm and length of 7 mm, one had a diameter of 4.0 mm and length of 10 mm, one had a diameter of 4.0 mm and length of 13 mm, five had a diameter of 4.0 mm and length of 15 mm) as anchors (Table 4). In one of the 11 patients, two implants (ITI TPS implants with a diameter of 4.1 mm and a length of 6 mm) were used to retract the mandibular dental arch, and on completion of the orthodontic therapy, they were not removed and prostheses were not attached (case 1). To the other implants, tubes, brackets, or arms were directly bonded. After placing a provisional restoration, the implants were used for orthodontic anchorage. Provisional restorations were retained using either screws or cement, and

TABLE 2 Distribution of Moderately Roughened- and Roughened-Surface Anchorage Implants: Healing, Orthodontic Anchorage Use, and Definitive Prosthesis Period

Patient Case	Healing Period Until Loading (months)	Healing Period Until Anchorage Use (months)	Period of Anchorage Use (months)	Remarks	Date of Anchorage Use	Definitive Prosthetic Function Period* (months)
1	3	4	36	Anchorage use only	March 2000 to February 2003	
2	3	4	13	Prostheses after anchorage	August 1999 to July 2000	62
3	3	5	4	Prostheses after anchorage	May 2001 to September 2001	48
4	3	4	19	Prostheses after anchorage	February 2002 to September 2003	24
5	3	4	14	Prostheses after anchorage	March 2002 to May 2003	29
6	3	3	8	Prostheses after anchorage	May 2002 to November 2003	22
7	3	4	8	Prostheses after anchorage	July 2002 to October 2003	23
8	3	4	33	Prostheses after anchorage	August 2002 to May 2005	4
9	0	1	8	Prostheses after anchorage	September 2004 to May 2005	4
10	4	5	7	Prostheses after anchorage	November 2004 to June 2005	3
11	0	1	6	Prostheses after anchorage	December 2004 to June 2005	3

*Until September 2005.

TABLE 3 Distribution of Moderately Roughened- and Roughened-Surface Implants as Non-Orthodontic Anchorage

Patient		Number of Implants			System of Non-Anchorage Implants			Non-Anchorage Implant		
Case	Age	Total	Non-Anchorage	Failures*	ITI (TPS®)	ITI (SLA®)	Nobel (TiUnite™)	Length (mm)	Width (mm)	Position
1	35	2	0							
2	51	4	2	0	2			12, 10	4.1 × 2	46, 47
3	45	9	2	0		2		12, 10	4.1 × 2	15, 17
4	36	4	3	0		3		12, 10, 10	4.8, 4.8, 4.1	16, 17, 36
5	51	2	0							
6	61	8	6	0		6		8, 8, 10, 10, 10, 12	4.1 × 6	37, 47, 36, 45, 46, 44
7	48	5	3	0			3	15, 13, 10	3.75, 3.75, 4.0	23, 25, 26
8	55	1	0							
9	48	2	0							
10	61	2	0							
11	48	4	0							
Total		43	16	0	2	11	3			

*Until September 2005.
SLA = sandblasted large-grit acid-etched; TPS = titanium plasma spray.

TABLE 4 Length and Diameter of the Anchorage and Non-Anchorage Implants

Implant Surface	Length (mm)	Anchorage Diameter			Non-Anchorage Diameter			Total
		3.3	4.1	4.8	3.3	4.1	4.8	
ITI (TPS®)	6		3					3
	8		2					2
	10					1		1
	12		2			1		3
ITI (SLA®)	6							0
	8		5			2		7
	10		3			4	1	8
	12	1	3			3	1	8
		Diameter			Diameter			
		3.75	4.00	5.00	3.75	4.00	5.00	
Nobel (TiUnite™)	7			1				1
	10		1					1
	13		1			2		3
	15		5		1			6
		1	25	1	1	13	2	43

SLA = sandblasted large-grit acid-etched; TPS = titanium plasma spray.

they were also bonded to implants that were not used for anchorage during orthodontic therapy. In each patient, the number of implants placed was kept to a minimum; more implants were not placed to strengthen orthodontic anchorage. The number of implants for anchorage per patient ranged from one to four, and anchor implants were used in various ways, but in all patients, therapy was planned to maximally utilize the advantages of anchor implants. During orthodontic therapy, the amount of force applied to anchor implants was set between 150 and 400 g.[9,10] Professional tooth cleaning was performed once a month to ensure proper oral hygiene. After completion of the orthodontic therapy, final prostheses were bonded to both types of implants at the same time: 16 implants (ITI TPS: one implant had a diameter of 4.1 mm and length of 10 mm, one implant had a diameter of 4.1 mm and length of 12 mm; ITI SLA: two implants had a diameter of 4.1 mm and length of 8 mm, four implants had a diameter of 4.1 mm and length of 10 mm, one implant had a diameter of 4.8 mm and length of 10 mm, three had a diameter of 4.1 mm and length of 12 mm, one had a diameter of 4.8 mm and length of 12 mm; Brånemark TiUnite: one implant had a diameter of 3.75 mm and length of 15 mm, one implant had a diameter of 3.75 mm and length of 13 mm, one had a diameter of 4.0 mm and length of 10 mm) that were not used for orthodontic anchorage, and 25 of the 27 anchorage implants that were used as prostheses abutments (see Table 4). All 11 patients were followed up after prosthesis bonding (see Tables 2 and 3). The following clinical parameters were recorded: plaque score, bleeding on probing, and pain that are the signs of peri-implant mucositis. Intraoral periapical radiographic examination was performed when the orthodontic therapy with implants began as the baseline for marginal bone level measurements. At 6

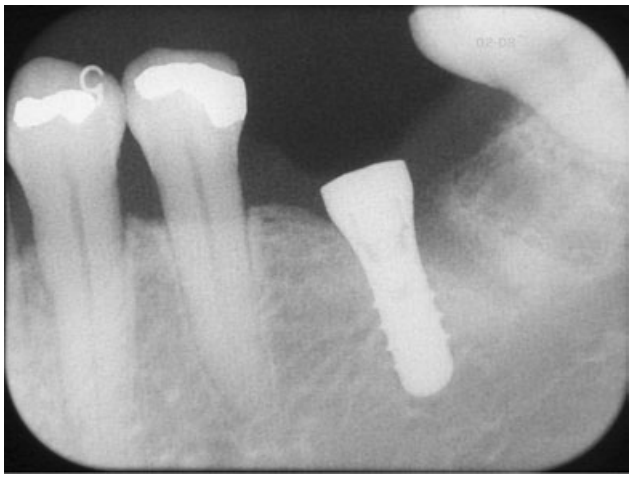

Figure 1 A periapical radiograph taken just before using the implant as orthodontic anchorage (case 8).

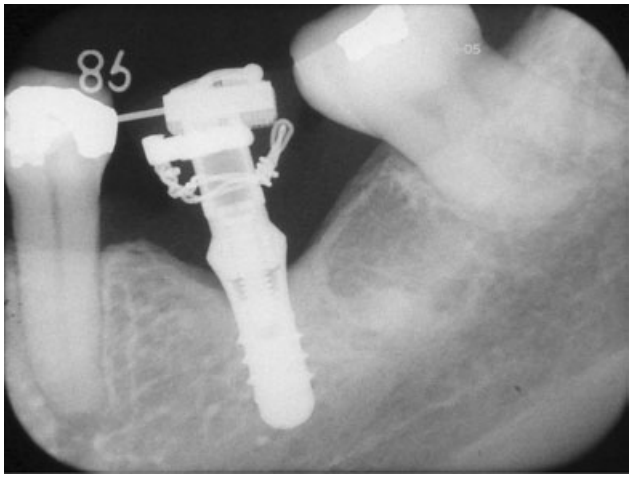

Figure 2 The periapical radiograph taken 3 years after the implant placement (case 8).

months interval, radiographic examinations were also conducted during and after the treatment (Figures 1 and 2). The marginal bone level was measured (in millimeters) at the mesial and distal aspects of each implant using periapical radiographs and was calculated by the same person based on the average of the mesial and distal values. The implants were assessed using the criteria for success 13.

RESULTS

None of the subjects was lost to follow up. The follow-up periods of each moderately roughened- (ITI SLA, Nobel TiUnite) and roughened-surface (ITI TPS) implants at the end of the study were as follows: ITI TPS was from 4.4 to 6.0 years, ITI SLA was from 3.0 to 4.4 years, Nobel TiUnite was from 0.8 to 3.0 years (Figure 3). Marginal bone height measurements were performed in each implant using periapical radiographs from the day of orthodontic therapy with implants (baseline) to the end of the study. Three implants (two TPS 6 mm–long implants and one SLA 10-mm long) that served as orthodontic anchorage and two as non-anchorage implants (an SLA 10-mm long and an SLA 12-mm long) could not be measured from radiographs due to poor quality reasons. Bone reduction of the anchored TPS implants was 0.3 mm on average (maximum: 0.9 mm; minimum: −0.5 mm) and non-anchored TPS implants was 1.2 mm on average. Bone reduction of the anchored SLA implants was 0.3 mm (maximum: 4.0 mm; minimum: −0.8 mm) on average and that of non-anchored SLA implants was −0.5 mm (maximum: 1.2 mm; minimum: 1.7 mm). Bone reduction of the anchored TiUnite implants was 0.4 mm (maximum: 2.0 mm; minimum: −0.3 mm) and non-anchored TiUnite implants was 0.6 mm (maximum: 1.4 mm; minimum: 0.1 mm) (Table 5). One patient showed signs of peri-implant mucositis with pain and bleeding on probing during the orthodontic therapy with this implant. The provisional restoration screw had been loose in this case. The provisional restoration was removed temporarily and the area around the implant was irrigated with physiological saline for 5 minutes. The provisional implant was reattached and tightened by manual control and orthodontic therapy was continued. The implant has passed the 2-year follow up without any further problem and is classified as survival (case 8). In another patient, fracture of the provisional implant bridge used as anchorage occurred twice. This happened at the interface of the reinforced metal of the provisional restoration. The provisional was repaired each time and the implants were confirmed normal by clinical and radiographic examination (case 11).

The survival rate of 43 implants was 100% at the end of the study. The implant outcome is indicated by a four-field table:[18] 37 were successful implants, six implants were survival, five of which had no proper radiographs, and there were no unaccounted cases or failures (Figure 4). All the moderately roughened- and roughened-surface implants, including those used for anchorage and those that were not, maintained osseointegration regardless of the implant system, surface condition, length, and diameter, and they continued to function properly during the observation period.

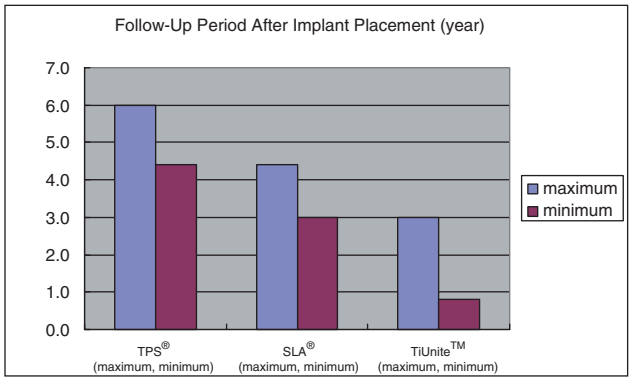

Figure 3 Follow-up period after placement of rough surface (titanium plasma spray [TPS]) and moderately roughened-surface (sandblasted large-grit acid-etched [SLA®], TiUnite™) implants. The follow-up period for TPS implants was from 4.4 to 6.0 years, SLA implants from 3.0 to 4.4 years, and TiUnite implants from 0.8 to 3.0 years until the end of the study. SLA = sandblasted large-grit acid-etched; TPS = titanium plasma spray.

TABLE 5 Marginal Bone Height Measurement from the Starting Day of Orthodontic Therapy to the End of the Study

Case	Anchorage			Non-anchorage		
	ITI (TPS®)	ITI (SLA®)	Nobel(TiUnite™)	ITI (TPS)	ITI (SLA)	Nobel(TiUnite)
1	*(4.1, 6)					
	*(4.1, 6)					
2	0.1			1.3		
	−0.1			1.0		
3	0.9	4.0		*(4.1, 10)		
	0.9	−0.3		*(4.1, 12)		
	−0.5	0.7				
		*(4.1, 10)				
4		−0.5			0.2	
					1.2	
					−0.7	
5		−0.8				
		−0.3				
6		−0.4			−0.6	
		−0.3			−1.0	
					−0.2	
					−0.8	
					−1.7	
					−1.0	
7		0.3				0.1
		0.0				0.4
						1.4
8		0.4				
9			0.0			
			0.0			
10			1.0			
			2.0			
11			0.2			
			0.9			
			−0.3			
			−0.3			
Average	0.3	0.3	0.4	1.2	−0.5	0.6
Range	−0.5 to 0.9	−0.8 to 4.0	−0.3 to 2.0		−1.7 to 1.2	0.1 to 1.4

*Three implants of anchorage and two implants of non-anchorage could not be measured.
SLA = sandblasted large-grit acid-etched; TPS = titanium plasma spray.

DISCUSSION

The characteristics of the implant surface with roughness (Sa) used in this study were classified into two: (1) ITI TPS is rough (>2.0 μm, Sa); and (2) ITI SLA and Nobel TiUnite is moderately rough (1.0–2.0 μm, Sa).[19] The Brånemark turned surface with roughness is minimally rough (0.5–1.0 μm, Sa).[19] Today, it is well known that implants of moderate roughness (about 1.5 μm, Sa) show stronger bone response than Brånemark turned and TPS implants.[19] However, we must recognize the fact that the most commonly used implants which are moderately roughened (ITI SLA, Nobel TiUnite) have been clinically documented for only 1–3 years.[19,20] Whereas, from personal clinical experience, moderately roughened-surface implants are much easier to handle than previously used implants. Under optimal conditions, immediate loading was also possible by

Ss 37	U 0
Sl 6	F 0

Figure 4 Four-field table of this study. Of the 43 implants, 37 filled the criteria of success (Ss), six were survival of which five had no proper radiograms and one did not meet the criteria of success; none was unaccounted for or failure.

combining guided bone regeneration without cross-arch stabilization.[21] In the radiographic examination of this study, none of the implant sites exhibited continuous peri-implant radiolucency, moreover not only bone loss but also bone gain was observed. This may be due to the immediate placement of implants at the unhealed or fresh extraction sites where bone formation occurred in the interfaces of the implants.

The response of moderately roughened-surface implants to orthodontic force has been investigated in animal studies.[22–24] One study found that 2–6 N/cm of orthodontic force did not adversely affect the maintenance of osseointegration in human subjects.[25] As 1 N/cm of force is equivalent to approximately 102 g of force 10), 6 N/cm is about 612 g of force, which is slightly higher than the figure reported by Higuchi and Slack.[9] The amount of force normally required to move the teeth in orthodontic therapy is around 50–150 g. However, because Newton's third law would be applicable in the case of anchorage teeth and teeth that are being moved, if 100 g of force is required to move a canine, then due to friction, 200 g of force should be applied to attain the required amount of force to the canine through an arch wire and bracket.[10,26] This can explain the anchorage loss, if natural teeth are used as orthodontic anchors.[27] If up to about 400 g of force can be applied to anchor implants, then it not only simplifies and shortens orthodontic therapy, but also resolves occlusal problems.

In cases 9 and 11, after immediate loading, mucosal healing took 1 month before we performed orthodontic therapy, and the implants were used as orthodontic anchors with no problems during the observation period (Tables 1 and 2). A study has shown that the cumulative survival rates of both ITI TPS and Brånemark turned-surface implants were similar and indicated excellent clinical results in the 2 to 3-year follow up.[28] Another study reported that the success rate for roughened-surface implants tended to decrease rapidly after 6 to 7 years.[29] Therefore, long-term observations are needed. Oral hygiene is important following orthodontic anchorage, and longer follow-up observations are required for moderately roughened- and roughened-surface implants.

CONCLUSIONS

During the observation period in the present study, there were no differences between the moderately roughened- and roughened-surface implants that were used as orthodontic anchors and those that were not used as orthodontic anchors, in therapeutic results following prosthesis bonding.

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REFERENCES

1. Gainsforth BL, Higley LB. A study of orthodontic anchorage possibilities in basal bone. Am J Orthod Oral Surg 1945; 31:406–416.
2. Linkow LI. Implant-orthodontics. J Clin Orthod 1970; 4:685–705.
3. Linkow LI. The endosseous blade implant and its use in orthodontics. Int J Orthod 1969; 18:149–153.
4. Brånemark PI, Hannson BO, Adell R, Breine U, Lindström J, Hallen O, Öhman A. Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10-year period. Scand J Plast Reconstr Surg 1977; 11:16(Suppl): 1–132.
5. 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.
6. Van Steenberghe D, Lekholm U, Bolender C, et al. The applicability of osseointegrated oral implants in the rehabilitation of partial edentulism: a prospective multicenter study on 558 fixtures. Int J Oral Maxillofac Implants 1990; 5:272–281.
7. Jemt T, Lekholm U, Grôndahl K. A 3-year follow-up study of early single implant restorations and modum Brånemark. Int J Periodont Rest Dent 1990; 10:341–349.
8. Schroeder A, Pohler O, Sutter F. Gewebsreaktion auf ein Titan-Hohlzylinderimplantat mit Titan-Sprintzschichtoberfläche. Shuweizerisches Monatsshrift für Zahnheilkunde 1976; 86:713–727.
9. Higuchi KW, Slack JM. The use of titanium fixtures for intraoral anchorage to facilitate orthodontic tooth movement. Int J Oral Maxillofac Implants 1991; 6:338–344.

10. Higuchi KW. Fixture survival associated with orthodontic anchorage: 9 years experience. In: Ueda M, ed. Proceedings of the Third International Congress on Tissue Integration in Oral and Maxillofacial Reconstruction. Chicago, IL: Quintessence, 1999:35–36.
11. Roberts WE, Arbuckle GR, Analoui M. Rate of mesial translation of mandibular molars utilizing implant-anchorage mechanics. Angle Orthod 1996; 66:331–337.
12. Roberts WE, Nelson CL, Goodacre CJ. Rigid implant anchorage to close a mandibular first molar extraction site. J Clin Orthod 1994; 28:693–704.
13. Albrektsson T, Zarb G, Worthington P, Eriksson AR. The long time efficacy of currently used dental implants: a review and proposed criteria of success. Int J Oral Maxillofac Implants 1986; 1:11–25.
14. Friberg B, Billström C. Preliminary results of a prospective multicenter clinical study in TiUnite™ implants. Appl Osseointegration Res 2002; 3:29–31.
15. Glauser R, Gottlow J, Lundgren AK, et al. Immediate occlusal loading of Brånemark Mk IV TiUnite™ implants placed in bone quality type 4. Appl Osseointegration Res 2002; 3:22–24.
16. Cochran DL, Buser D, ten Bruggenkate CM, et al. The use of reduced healing times on ITI implants with a sandblasted and acid-etched (SLA) surface: early results from clinical trials on ITI SLA implants. Clin Oral Implants Res 2002; 13:144–153.
17. Bornstein MM, Lussi A, Schmid B, Belser UC, Buser D. Early loading of nonsubmerged titanium implants with a sandblasted and acid-etched (SLA) surfaces: 3-year results of a prospective study in partially edentulous patients. Int J Oral Maxillofac Implants 2003; 18:659–666.
18. Albrektsson T, Zarb GA. Cuurent interpretations of the osseointegrated response: clinical significance. Int J Prosthodont 1993; 6:95–105.
19. Albrektsson T, Wennerberg A. Oral implant surfaces: part 1 – review focusing on topographic and clinical properties of different surfaces and in vivo responses to them. Int J Prosthodont 2004; 17:536–543.
20. Albrektsson T, Wennerberg A. Oral implant surfaces: part 2 – review focusing on clinical knowledge of different surfaces. Int J Prosthodont 2004; 17:544–564.
21. Glauser R, Lundgren AK, Gottlow J, et al. Immediate occlusal loading of Brånemark TiUnite implants placed predominantly in soft bone: 1-year result of a prospective clinical study. Clin Implant Dent Relat Res 2003; 5(Suppl 1):47–56.
22. Gotfredsen K, Berglundh T, Lindhe J. Bone reactions adjacent to titanium implants subjected to static load: a study in the dog (I). Clin Oral Implants Res 2001; 12:1–8.
23. Gotfredsen K, Berglundh T, Lindhe J. Bone reactions adjacent to titanium implants with different surface characteristics subjected to static load: a study in the dog (II). Clin Oral Implants Res 2001; 12:196–201.
24. Gotfredsen K, Berglundh T, Lindhe J. Bone reactions adjacent to titanium implants subjected to static load of different duration: a study in the dog (III). Clin Oral Implants Res 2001; 12:552–558.
25. Wehrbein H, Mertz BR, Hämmerle CHF, Lang NP. Bone-to-implant contact of orthodontic implants in human subjected to horizontal loading. Clin Oral Implants Res 1998; 9:348–353.
26. Triplett RG, Show SR, Laskin DM. Oral and maxillofacial surgery advances in implant dentistry. Int J Oral Maxillofac Implants 2000; 15:47–55.
27. Proffit WR. Mechanical principles in orthodontic force control. In: Proffit WR, ed. Contemporary orthodontics. 3rd ed. St. Louis, MO: Mosby, 2000:346–347.
28. Becker W, Becker BE, Ricci A, et al. A prospective multicenter clinical trial comparing one- and two-stage titanium screw-shaped fixtures with one-stage plasma sprayed solid screw fixtures. Clin Implant Dent Relat Res 2000; 2:159–165.
29. Brocard D, Barthet P, Baysse E, et al. A multicenter report on 1022 consecutively placed ITI implants: a 7-year longitudinal study. Int J Oral Maxillofac Implants 2000; 15:691–700.