The Relationship of Bone Resorption Around Dental Implants to Abutment Design: A Preliminary 1-Year Clinical Study

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The influence of abutment design on bone resorption around immediately loaded and osseointegrated implants used to support fixed partial prostheses was investigated in a 1-year study. One hundred ten implants were placed in 24 anterior partially edentulous maxillae. The probing depths of each implant were measured 6 and 12 months after abutment placement and analyzed statistically. Total probing depth was 1.75 ± 0.75 mm. There were significant differences between non- and submerged implants with angled abutments and between submerged implants with straight and angled abutments. No significant differences were observed between non- and submerged implants with straight abutments and between nonsubmerged implants with straight and angled abutments. Bone resorption around dental implants is influenced by the abutment design and the associated implantation protocol. *Int J Prosthodont 2011;24:457–459.*

Angled abutments are used to overcome a non-ideal implant location because of bone structure.[1] Functional loads are transferred through abutments and thereby through implants to the surrounding bone. Bone can tolerate strains and stresses within physiologic limits[2]; however, when these limits are exceeded, bone resorption may occur.

The aims of the present study were to validate and clarify the numeric results obtained in previous studies[3,4] by determining crestal bone resorption around implants used to support fixed partial prostheses (FPPs) in patients who were supplied with straight (SA) or angled (AA) abutments and to answer the following questions: *(1)* Does abutment design affect the amount of crestal bone resorption around implants and *(2)* Does the relation of abutment design and bone resorption depend on implantation protocol, ie, nonsubmerged (immediate loading) or submerged (osseointegration) healing?

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Materials and Methods

Patients with an edentulous maxillary anterior ridge requiring FPP treatment were selected for inclusion in this study between August 2008 and August 2009, and their data was used anonymously. Patients were in good health; diabetes patients were not excluded provided their condition was well controlled. Although smoking was discouraged, smokers were not excluded.

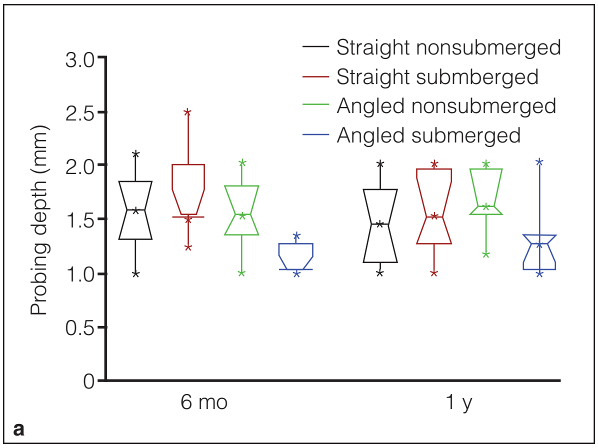
Selected patients were divided, according to treatment necessity, into two groups with two subgroups for abutment design (Table 1): a study group receiving nonsubmerged dental implants and a control group receiving submerged implants and a healing period of 5 to 6 months.

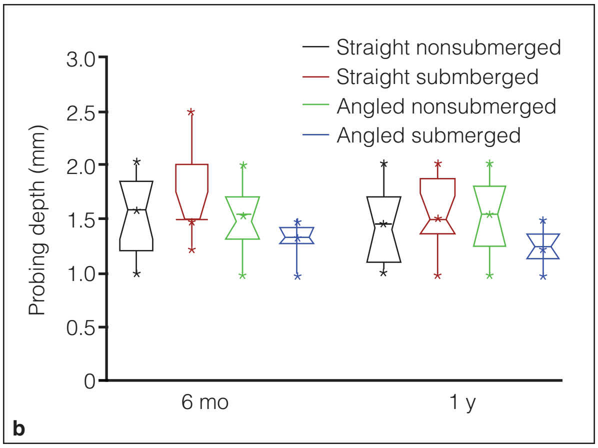
Bone resorption was determined by means of measuring the mesial and distal probing depths after 6 and 12 months from abutment placement. The implant-abutment connecting line was used as a reference.

Table 1 Characteristics of the Study Groups

	Nonsubmerged (study)	Submerged (control)
Bone quality	Type 2	Type 2
No. of straight abutments	36	24
No. of angled abutments	28	22
No. of patients	11	13
Female to male ratio	7:4	9:4
Mean age (y)	55	61
Implant type	tioLogic*	tioLogic*
Implant diameter (mm)	3.3–4.2	3.3–4.2
Implant length (mm)	9–17	9–17

*Dentaurum Implants.





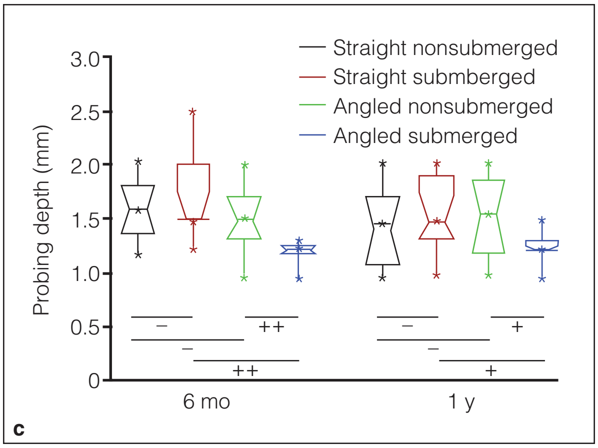


Fig 1 Box diagrams of the mean probing depth for the study (nonsubmerged) and control (submerged) groups with straight and angled abutments. **(a)** Probing depth measured mesially, **(b)** probing depth measured distally, and **(c)** mean probing depth of the mesial and distal measurements. – = not significant; + = .01 < $P \leq .05$; ++ = $P \leq .01$.

Differences in mean bone probing depths were analyzed mesially and distally in association with SAs and AAs for statistical significance using the Mann-Whitney test (WinStat, version 2003 for Microsoft Excel). Data were grouped according to abutment design and implantation protocol with the following null hypotheses (significance level: .05): no significant difference of crestal bone loss for SAs or AAs with identical implantation protocol and no significant difference of crestal bone loss with SAs and AAs for both implantation protocols.

Table 2 Probing Depth Significance Level of the Difference Between the Two Abutment Designs in Nonsubmerged and Submerged Implant Treatments at the 6-month Evaluation*

	Nonsubmerged		Submerged	
	Straight (n = 36)	Angled (n = 28)	Straight (n = 20)	Angled (n = 19)
Nonsubmerged				
Straight (n = 36)			—	
Angled (n = 28)	—			++
Submerged				
Straight (n = 20)				
Angled (n = 19)			++	

*Mann-Whitney test.
– = not significant ($P > .05$); ++ = $P \leq .01$.

Table 3 Probing Depth Significance Level of the Difference Between the Two Abutment Designs in Nonsubmerged and Submerged Implant Treatments at the 12-month Evaluation*

	Nonsubmerged		Submerged	
	Straight (n = 36)	Angled (n = 28)	Straight (n = 24)	Angled (n = 22)
Nonsubmerged				
Straight (n = 36)			—	
Angled (n = 28)	—			+
Submerged				
Straight (n = 24)				
Angled (n = 22)			+	

*Mann-Whitney test.
– = not significant ($P > .05$); + = $.01 < P \leq .05$.

Results

Probing depths were statistically higher for the study subgroup with AAs in comparison to the control subgroup 6 months and 1 year after abutment insertion ($P = .0008$ and $P = .01$, respectively).

A statistically significant decrease in probing depth for the control subgroup with AAs was noted in comparison to the control subgroup with SAs 6 months and 1 year after abutment insertion ($P = .003$ and $P = .03$, respectively).

No statistical significance was observed for the study subgroups with SAs and control subgroups with AAs ($P = .8$ and $P = .4$ for probing depth after 6 months and 1 year, respectively) and for the study subgroups with SAs and AAs for both time points (mean probing depth: 1.5 mm; $P = .8$ and $P = .2$ after 6 months and 1 year, respectively) (Fig 1 and Tables 2 and 3).

Discussion

In the present study, the impact of abutment design on the amount of cervical bone resorption was investigated. Celland et al[5] studied the effect of abutment angulation using photoelastic resin and a strain gauge in one model demonstrating a statistically significant difference for increasing abutment angulation. According to the authors, all abutments produced strains that appeared to be within the physiologic range for bone.[2] The present study showed no statistical significance of the probing depth, although a previous finite element analysis[3] showed higher stresses for nonsubmerged implants with SAs than submerged implants. Nevertheless, the stress results agree with the clinical findings for AAs when they were used with a submerged or nonsubmerged protocol.

Furthermore, no statistical significance was obtained for SAs and AAs with the nonsubmerged protocol. This agrees with the numeric results of FPPs[3] and those of the experimentally investigated bovine samples.[4] However, probing depth was statistically less for AAs with the submerged protocol than SAs, although the numeric analysis showed a minimal difference between SAs and AAs.

Conclusion

Based on the statistical analysis, implant placement protocol plays a role in the amount of cervical bone resorption if angled abutments are used.

References

1. Friedman JR. Five techniques for single tooth replacement on endosseous root-form implants. J Prosthet Dent 1993;69:582–587.
2. Martin RB, Burr DB. Structure, Function, and Adaptation of Compact Bone. New York: Raven Press, 1989:143–185.
3. Hasan I, Heinemann F, Reimann S, Keilig L, Bourauel C. Finite element investigation of implant-supported fixed partial prosthesis in the premaxilla in immedaitely loaded and osseointegrated states. Comput Methods Biomech Biomed Engin [epub ahead of print 27 July 2010].
4. Hasan I, Röger B, Heinemann F, Keilig L, Bourauel C. Influence of abutment design on the success of immediately loaded dental implants: Experimental and numerical studies. Med Eng Phys (under revision, May 2011).
5. Celland NL, Gilat A, McGlumphy EA, Brantley WA. A photoelastic and strain gauge analysis of angled abutments for an implant system. Int J Oral Maxillofac Implants 1993;8:541–548.