Comparison of Angled and Standard Abutments and Their Effect on Clinical Outcomes: A Preliminary Report

Dorothy E. Eger, DDS[1]/John C. Gunsolley, DDS, MS[2]/Sylvan Feldman, DDS, MLA[3]

This study was conducted to compare the success of implants restored with angled abutments to implants restored with standard abutments. Eighty-one implants in 24 patients were evaluated for up to 36 months. Measurements included probing depths, gingival level, gingival index, and mobility. No significant difference could be found for any of the parameters examined between implants restored with angled and standard abutments. This suggests that the angled abutment may be considered a suitable restorative option when implants are not placed in ideal axial positions. (INT J ORAL MAXILLOFAC IMPLANTS 2000;15:819–823)

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Anatomic constraints sometimes make it necessary to surgically position implants at angles that are not optimal for prosthetic restorations. The width, height, and angle of the residual bony ridge, the presence of bony undercuts, the shape of the arch, and maxillomandibular arch relationships are considerations in implant placement. The position of the mandibular canal and ridge proximity to the paranasal sinuses are additional factors that may influence implant alignment.[1,2] Clinical management of these circumstances may include surgical correction, such as bone augmentation of the alveolar ridge, sinus elevation, or nerve repositioning.[3–6] Another possibility is implant placement in the area with the greatest available bone with the intention of correcting the mesiodistal and buccolingual implant alignment at the time of implant restoration. This is made possible, in carefully planned cases, with the use of angled implant abutments (Figs 1a and 1b).

A variety of pre-angled abutments are available at specified divergence angles (Fig 2).[7] Additionally, custom-angled abutments may be cast to the profile necessary for an acceptable prosthetic outcome. With clinical loading of implants restored using angled abutments, lateral occlusal forces may increase. Clelland and coworkers found a statistically significant increase in stress and strain with increase in abutment angulation when evaluating 0-degree, 15-degree, and 20-degree abutments, but principal strains were considered to be within the physiologic zone for bone.[8] Celletti and coworkers found no adverse effect on surrounding bone with straight or pre-angled abutments in monkeys.[9] Based on histologic examination at 1 year after loading, excellent osseointegration was reported. In their study, failure of abutment screws, rather than breakage or rejection of the implant, was observed. Dixon and colleagues found no significant difference between straight and angled abutments for deflection, rotation, and torque required to loosen abutment screws.[10]

Limited information is available in the literature regarding the clinical success of angled abutments, and studies have failed to show any contraindication to their use. Therefore, the purpose of this study was to evaluate a series of implants restored with angled abutments and to compare them to implants restored with standard abutments in the same group of patients.

[1]Department of Periodontics, Baltimore College of Dental Surgery, Dental School, University of Maryland, Baltimore, Maryland.
[2]Professor, Department of Periodontics, Baltimore College of Dental Surgery, Dental School, University of Maryland, Baltimore, Maryland.
[3]Associate Professor, Department of Periodontics, Baltimore College of Dental Surgery, Dental School, University of Maryland, Baltimore, Maryland.

Reprint requests: Dr Dorothy E. Eger, Department of Periodontics, Baltimore College of Dental Surgery, Dental School, University of Maryland, Baltimore, 666 W. Baltimore Street, Baltimore, Maryland 21201. Fax: (410) 706-3028.

Fig 1a Axially inclined implants.

Fig 1b Angled implant abutments permit optimal implant restoration.

Fig 2 Implants with abutments angled at (*left*) 15 degrees, (*center*) 25 degrees, and (*right*) 35 degrees.

MATERIALS AND METHODS

The subject sample in this study consisted of patients who had been examined either in a private practice by 1 of 2 dual-trained periodontist-prosthodontists, or at the postgraduate periodontal clinic at the Baltimore College of Dental Surgery, Dental School, University of Maryland, Baltimore. Each subject signed an informed consent form, approved by the Institutional Review Board of the University of Maryland, Baltimore, and agreed to participate in a controlled, prospective 5-year study evaluating implant success.

Twenty-four patients between the ages of 15 and 74 years, with a mean age of 57.5, received at least 1 dental implant that required a pre-angled or custom-angled abutment for appropriate fabrication of an implant restoration. Eighty-one threaded, self-tapping titanium or acid-etched titanium dental implants (Implant Innovations Inc, West Palm Beach, FL) were placed in these patients; 56 implants were restored with angled abutments and 25 were restored with standard abutments. Sixty-nine of the implants in 19 patients were placed in private practice settings, and 12 implants in 5 patients were placed by residents at the Baltimore College of Dental Surgery. All implants were subsequently restored with either pre-angled, custom-angled, or standard abutments. Implant evaluations were conducted at the time of prosthesis placement and again at 3, 6, 12, 18, 24, and 36 months after loading.

Clinical Measurements

Clinical measurements consisted of probing depth, gingival level, gingival index,[11] and mobility. Measurements were made, to the nearest millimeter, with a Maryland standard periodontal probe. Probing depth was measured at 4 sites around the implant: mesial, distal, buccal, and lingual. Gingival level was measured from the line formed at the junction of the implant body and the abutment to the gingival margin on the buccal and lingual. The gingival level was recorded as a positive value if the gingival margin was coronal to this junction, and as a negative value if the gingival margin was apical to it. To determine implant attachment level, the gingival level was subtracted from the probing depth at the mid-buccal and mid-lingual. Gingival inflammation (gingival index) was measured as 0 if no visible inflammation was present; 1 if mild inflammation, apparent as a color change, was present; 2 if the tissue was moderately inflamed, as indicated by bleeding upon probing; and 3 if the gingiva was severely inflamed and demonstrated spontaneous bleeding. Mobility of the implant was evaluated with instrument pressure and scored as 0 if no mobility was present or 1 if mobility was clinically evident. Demographic data collected included patient age, gender, and smoking status. Subjects were defined as smokers if they were current smokers (at any level) at the time of implant placement.

Implant evaluations conducted in private practice were performed by the surgeon who placed the implants, while evaluations conducted at the University of Maryland were completed by periodontal residents who had not necessarily placed the implants.

Statistical Methods

To evaluate the effect of abutment type (angled versus standard) on clinical parameters, repeated-measures analysis of variance (ANOVA) was used for subjects who had both types of abutments. This result was confirmed by ANOVA for all implants and subjects. To determine whether age, gender, time since placement, and operator had an effect on clinical parameters, stepwise ANOVA was used. The authors chose $P \leq .05$ as the level of significance for the study. It should be noted that there were no significant differences in the initial bivariate analysis that preceded the stepwise analysis.

RESULTS

The average age of the patients followed was 57.5 (± 3.28) years. There were 14 females and 10 males. Only 3 of the patients described themselves as smokers (10 implants).

Patients received between 1 and 8 implants each to restore partially or completely edentulous areas in both arches. The implant restorations included single-unit, tooth/implant-supported, and entirely implant-supported restorations. Unless cemented, prostheses were removed for implant evaluation.

Altogether, 81 implants were evaluated. Fifty-six of these were restored with angled abutments, and 25 were restored with standard abutments. Nine of the 24 patients had only angled abutments, and 15 had both angled and standard abutments placed. In the 15 subjects with both angled and standard abutments there were 65 implants, with 40 angled and 25 standard abutments. Of these subjects, all had evaluations at 3 and 6 months after loading, and 11 subjects had 12-month evaluations at the time of this analysis. There were 2 implant failures after prosthesis loading, which required implant removal. These 2 failures occurred in 1 patient, with 2 implants restored with one of each type of abutment. The patient was a 59-year-old, non-smoking male whose implants were splinted together by the prosthesis. Implants were removed because of loss of integration at 3 years.

Table 1 shows mean probing depths and attachment levels on the buccal for patients restored with both types of abutments.

Analysis of the data revealed no significant differences ($P \geq .05$) between angled and standard abutments for any of the clinical variables measured. There were no effects on probing depth, attachment level, or demographic factors as a result of time or abutment type. No significant mean difference was found in gingival inflammation or mobility between the groups (data not shown).

DISCUSSION

Examination of clinical parameters evaluated revealed no significant differences ($P \geq .05$) between implants restored with angled or standard abutments. This would imply either that there were no real differences between groups or that the study lacked sufficient statistical power to find differences. In this investigation, there was sufficient statistical power to find an approximate mean difference between groups of 1.37 mm in attachment level and 0.46 mm in probing depth. Thus, the study appears to have sufficient statistical power to find clinically significant differences in probing depth, but not attachment level, between groups. These results imply that there probably are no clinically evident physiologic disadvantages in the use of angled abutments, although conclusions about attachment level need to be followed up by studies with larger sample size.

However, there are a number of advantages to the use of angled abutments. When an improper jaw relationship exists because of alveolar resorption or skeletal discrepancy, angulated abutments may compensate for buccolingual and mesiodistal implant angulation problems. In some situations, when a computed tomographic scan may not be available, it is not possible to determine the required implant angulation until the contours of bone are exposed and evaluated at the time of surgery (Figs 3a and 3b). An angled abutment allows the placement of implants in the most favorable quantity and quality of available bone in patients with compromised osseous anatomy, while improving the engineering and mechanics of the prosthesis by correcting spatial relationships. Gelb and Lazzara discussed the use of preangulated abutments as the treatment of choice when anatomic limitations preclude the axial placement of an implant.[12]

In the present investigation, 81 implants in 24 patients were evaluated. The total sample was evaluated for 6 months. The longest follow-up was 36 months, with only 15 patients examined for

Table 1 Mean Attachment Levels and Probing Depths for Angled and Standard Abutments

Time (mo)	No. of implants	Buccal attachment level (mm) (SD)	Probing depth (mm) (SD)
All angled abutments			
0	56	3.10 (0.37)	2.92 (0.11)
3	56	3.03 (0.35)	2.74 (0.10)
6	52	3.64 (0.43)	2.96 (0.12)
12	41	3.41 (0.49)	2.70 (0.11)
18	43	3.29 (0.41)	2.92 (0.12)
24	34	2.81 (0.37)	3.00 (0.16)
36	15	3.07 (0.84)	2.83 (0.21)
Angled abutments*			
0	40	2.92 (0.34)	2.84 (0.12)
3	40	2.91 (0.37)	2.72 (0.10)
6	40	3.42 (0.45)	2.99 (0.13)
12	27	3.13 (0.59)	2.90 (0.14)
18	31	3.27 (0.50)	2.99 (0.13)
24	27	2.87 (0.45)	3.03 (0.16)
36	12	2.83 (1.05)	3.10 (0.19)
Standard abutments			
0	25	2.78 (0.42)	2.58 (0.15)
3	25	3.15 (0.46)	2.69 (0.17)
6	25	3.58 (0.49)	2.92 (0.22)
12	21	3.29 (0.52)	2.99 (0.13)
18	20	3.08 (0.48)	2.94 (0.18)
24	11	3.41 (0.53)	2.78 (0.29)
36	5	4.00 (1.92)	3.50 (0.29)

*In patients who received both angled and standard abutments.

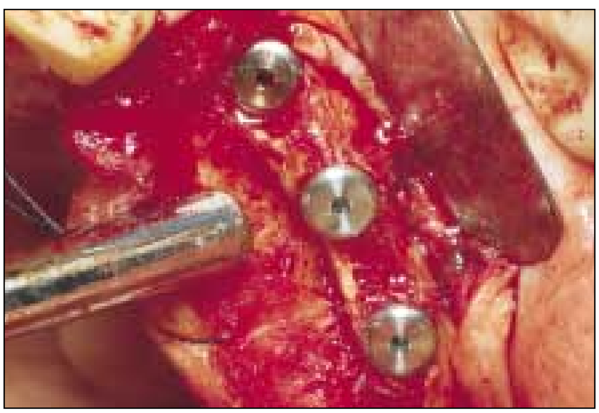

Fig 3a Implant placement within existing maxillary bone.

Fig 3b The implants are restored with screw-retained angled abutments.

this duration. All patients evaluated in this study, however, are a part of a 5-year study evaluating implant success, which will allow later analysis of data from this implant population to determine whether the findings presented here remain consistent at 5 years.

CONCLUSIONS

The results of this preliminary investigation suggest that endosseous implants placed at unfavorable angles may be restored with angled abutments without compromise of function or esthetics. A comparison of clinical and demographic variables, evaluated for implants restored with angled and standard abutments, yielded no significant differences for any parameter at any time period. Further evaluation of the long-term success of implants restored with angled abutments should be pursued.

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