Removal Torques of Conical, Tapered Implant Abutments: The Effects of Anodization and Reduction of Surface Area

Rachel S. Squier, DMD[1]/Walter J. Psoter, DDS[2]/Thomas D. Taylor, DDS, MSD[3]

Purpose: *To examine the effects of anodization (surface coating) and reduction of internal Morse taper surface area on the reversal torque values of Straumann ITI dental implants and abutments.* ***Materials and Methods:*** *Eighty ITI solid screw implants were mated with corresponding 5.5-mm solid abutments. The assemblies were divided into 4 test groups of 20 specimens. All abutments were torque tightened into the implant to 35 Ncm. Half of the abutments were anodized and half were in their as-machined state. Each of these 2 groups included half of the implants with the standard internal Morse taper configuration and half with the synOcta (Straumann USA, Waltham, MA) internal positioning interface (indexed). Torque removal testing was then performed on the assemblies. The 4 groups were compared statistically to examine the effect of the 2 variables (anodization and reduction in surface area). Scheffe's test for multiple comparisons was used to compare groups at an adjusted significance level of ≤ .05.* ***Results:*** *Torque removal of all specimens revealed that the indexed implant with the non-anodized abutment demonstrated superior removal torque.* ***Discussion:*** *The indexed and standard implants with anodized abutments, and the standard implant with the non-anodized abutment had lower reversal torque values.* ***Conclusion:*** *The addition of the indexed internal surface to the ITI implant did not have deleterious effect on the resistance to loosening of standard solid abutments.*
(Int J Oral Maxillofac Implants 2002;17:24–27)

Key words: *abutment loosening, dental implants, implant restorations, reverse torque, surface area*

The preferred method of connection between endosseous dental implants and the restorative abutment/component has been a topic of discussion in implant dentistry. A number of commercially available dental implant systems utilize a mating configuration between implant and abutment that is located within the implant body itself rather than an external connection located on top of the implant body. Increased interfacial strength between components, antirotation, and resistance to abutment screw loosening are some of the reasons cited in the commercial literature for using an internal design. The incidence of clinical complications resulting from problems associated with the implant-abutment interface is frequently cited in the literature as the rationale for using an internal connection.[1–5]

A number of studies examining the strength and integrity of various implant to abutment configurations have been published.[6–12] Some of these design concepts are intended to reduce the incidence of screw fracture and loosening by increasing resistance to micromovement between implant and abutment. However, there is a clinical concern that some of the internally retained implant abutment systems might not be retrievable due to cold welding, resulting in the removal torque being higher than the original tightening torque of the abutment into the implant.[13] Sutter and coworkers reported that removal torque values were higher (124%) than

[1]Graduate Student in Prosthodontics; Formerly Straumann Implant Research Fellow, Department of Prosthodontics and Operative Dentistry, University of Connecticut, School of Dental Medicine, Farmington, Connecticut.
[2]Postdoctoral Fellow in Oral Epidemiology, New York University College of Dentistry, New York, New York.
[3]Professor and Head, Department of Prosthodontics and Operative Dentistry, University of Connecticut, School of Dental Medicine, Farmington, Connecticut.

Reprint requests: Dr Thomas D. Taylor, Department of Prosthodontics and Operative Dentistry MC 1615, University of Connecticut School of Dental Medicine, Farmington, CT 06030-1615. Fax: 860-679-1370. E-mail: ttaylor@nso.uchc.edu

Fig 1a Cut-away view of the internal aspect of the standard ITI implant Morse taper surface.

Fig 1b Cut-away view of the internal aspect of the synOcta ITI implant Morse taper surface.

Table 1 Make-Up of the 4 Test Groups

	Test groups			
	1	2	3	4
Implant type	Standard	Standard	synOcta	synOcta
Anodized	No	Yes	No	Yes

Each group contained 20 specimens.
No specimens were reused.

tightening torque values for the ITI type implant (Institute Straumann AG, Waldenburg, Switzerland).[11] This is in contrast to the work of Norton who examined the loosening torque values of Astra (Astra Tech AB, Molndahl, Sweden) and ITI dental implants and reported that cold welding did not occur at clinically relevant levels of tightening.[13]

Recent design modifications of the ITI dental implant system have raised several questions about the ability of the so-called "Morse taper" connection to remain as stable as that reported by Sutter and associates and confirmed by Norton.[11,13] The ITI implant system has incorporated internal positioning grooves or notches into the internal tapered portion of the implant to permit implant level indexing and impression making (Figs 1a and 1b). The surface area of the original standard ITI Morse taper of 24 mm^2 is reduced to 16.5 mm^2 with the new synOcta design. The 31% reduction in surface area of the implant-abutment interface has raised concern that resistance to loosening might also be reduced with this modification (Figs 1a and 1b).

A second design modification of the ITI implant system is that 2 of the 3 available abutment types have become available in color coded (anodized) form to facilitate component selection. The anodizing or coating process used to color the titanium components has not been examined as to its effect on resistance to loosening.

The purpose of this project was to examine the effects of anodization and reduction of internal Morse taper surface area on the reversal torque values of ITI dental implants and abutments.

MATERIALS AND METHODS

Eighty ITI solid screw implants were mated with corresponding 5.5-mm solid abutments. All abutments were torque tightened into the implant to 35 Ncm, which is the recommended tightening for clinical application. A Mark-10 Model Series BGI torque controller was used both for placement of the abutments initially and for the reverse torque test (Mark-10, Hicksville, NY). During tightening and reverse torque testing, the implants were held in a machinist's lathe to insure stability.

The specimens were divided into 4 groups of 20 specimens each and tested according to Table 1. Half of the abutments were anodized and half were in their as-machined state. Each of these 2 groups included half of the implants with the standard internal Morse taper configuration and half with the indexed internal positioning interface (Figs 1a and 1b).

No specimens were retightened or retested to control for variability that might be introduced as an effect on the components with multiple tightening/loosening cycles.[14] All specimens were initially

Table 2 Results of Removal Torque Tests

	Test groups			
	1	2	3	4
Mean (Ncm)	30.65	27.62	37.16	28.15
SD	3.63	3.78	6.15	1.61
Range (Ncm)	23.8–35.2	19.0–31.7	28.1–44.5	26.5–33.5
Percent*	87.6	78.9	106.2	80.4

SD = standard deviation.
*Percentages signify percent of original tightening torque (35 Ncm) based on the group mean loosening torque values.

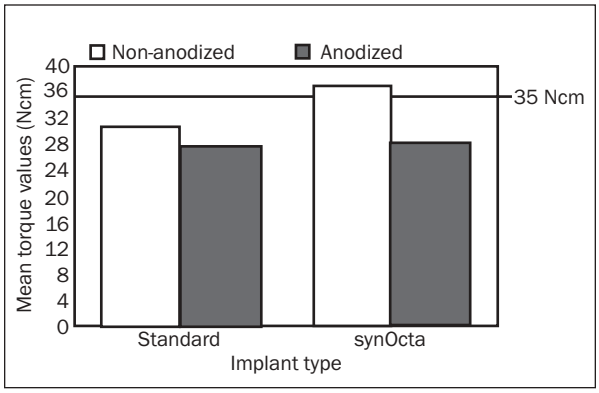

Fig 2 Mean reverse torque values (Ncm) for the standard and synOcta ITI implants. All abutments were originally torque tightened to 35 Ncm.

tightened during the same laboratory session and were stored at room temperature in a dry environment. Reverse torque testing was separated from initial tightening by at least 30 days for all specimens to minimize the effect of time on abutment tightness.

The 4 groups were compared statistically to examine the effect of the 2 variables. Scheffe's test for multiple comparisons was used to compare groups at an adjusted significance level of ≤ .05. The dependent variable was the torque values and the independent variable was group assignment (groups 1 to 4).

Null Hypothesis

Two null hypotheses were constructed for testing.

1. There is no difference in removal torque value between anodized and non-anodized abutments.
2. There is no difference in removal torque value between standard abutments placed into standard implants versus the indexed implants.

RESULTS

The results (means) of torque removal of all specimens are listed in Table 2. Groups were tested by general linear modeling with Scheffe's adjustment for multiple comparisons of groups. Groups 1, 2, and 4 were homogenous (ie, did not have statistically significant differences). Figure 2 illustrates that the indexed implant with the non-anodized abutment demonstrated superior removal torque (mean = 37.16 Ncm). All the other implant groups had significantly lower torque removal values: the indexed implant with anodized abutment (mean = 28.15 Ncm); the standard implant with anodized abutment (mean = 27.62 Ncm); and the standard implant with the non-anodized abutment (mean = 30.65 Ncm).

DISCUSSION

Thermocycling was performed on half of the implant-abutment assemblies with the goal to determine if it had any effect on the reverse torque values. After data analysis was performed, no difference could be demonstrated between thermocycled and non-thermocycled groups, and all data were subsequently pooled for further analysis of the other 2 variables: anodization and the reduction of internal Morse taper surface area.

The results of this study should eliminate concern that the addition of the internal positioning grooves to ITI implants reduces the resistance of standard solid abutments to loosening. The lack of an effect caused by the reduction in contact surface area may be the result of higher net force per unit area generated when an abutment is tightened against the new surface. Thirty-one percent reduction in surface area would result in a 31% net increase in force per mm^2 of the reduced surface. The finding that abutments tightened against the indexed surface actually have higher resistance to loosening than those placed against the original Morse taper surface is interesting and lends support to the idea that both surface area and force per unit of surface area are important in resistance to loosening.

Loosening torque values found in this study are somewhat less than those described by Sutter and coworkers. Their finding of 124% loosening torque compared to tightening torque was not reproduced

in this study. Mean loosening torque values ranged from 78.9% to 106.2% of tightening torque. Only one group had means at or above the 100% level, the indexed implants with the non-anodized abutments. The findings in the present study are more closely in line with those of Norton, who described reverse torque values in the 84% to 91% range when initially tightened to 30 or 40 Ncm.[13]

The effect of abutment anodization on reverse torque values was somewhat surprising (Fig 2). The mean values for combined anodized versus non-anodized groups were 27.9 Ncm and 33.9 Ncm, respectively ($P \leq .001$). This suggests a possible lubricating effect for the anodized or coated surface. While the difference is statistically significant, the clinical relevance cannot be determined from the results of this study.

CONCLUSION

The addition of the indexed internal surface to the ITI implant did not have deleterious effect on the resistance to loosening of standard solid abutments. Anodization of the abutment surface reduced the resistance to loosening by approximately 20%. The clinical significance of this reduction is not known.

ACKNOWLEDGMENTS

Thanks to Institute Straumann AG (Waldenburg, Switzerland) for providing the implant components for this study.

REFERENCES

1. Jemt T, Linden B, Lekholm U. Failures and complications in 127 consecutively placed fixed partial prostheses supported by Brånemark implants: From prosthetic placement to first annual checkup. Int J Oral Maxillofac Implants 1992;7:40–44.
2. Jemt T. Failures and complications in 391 consecutively inserted fixed prostheses supported by Brånemark implants in edentulous jaws: A study of treatment from the time of prosthesis placement to first annual checkup. Int J Oral Maxillofac Implants 1991;6:270–276.
3. Zarb G, Schmitt A. The longitudinal clinical effectiveness of osseointegrated dental implants: The Toronto study. Part III: Problems and complications encountered. J Prosthet Dent 1990;64:185–194.
4. Carlson B, Carlsson G. Prosthodontic complications in osseointegrated dental implant treatment. Int J Oral Maxillofac Implants 1994;9:90–94.
5. Taylor T. Prosthodontic problems and limitations associated with osseointegration. J Prosthet Dent 1998;79:74–78.
6. Sakaguchi R, Borgersen S. Nonlinear contact analysis of preload in dental implant screws. Int J Oral Maxillofac Implants 1995;10:295–302.
7. Jaarda M, Razzoog M, Gratton DG. Effect of preload torque on the ultimate tensile strength of implant prosthetic retaining screws. Implant Dent 1994;3:17–21.
8. Schulte JK. External hex manufacturing tolerances of six implant systems: A pilot study. Implant Dent 1994;3:51–53.
9. Norton MR. An in vitro evaluation of the strength of an internal conical interface compared to a butt joint interface in implant design. Clin Oral Implants Res 1997;8:290–298.
10. Sutter F, Schroeder A, Buser D. The new concept of ITI hollow-cylinder and hollow-screw implants: Part I. Engineering and design. Int J Oral Maxillofac Implants 1988;3: 161–172.
11. Sutter F, Weber H, Sorensen J, Belser U. The new restorative concept of the ITI dental implant system: Design and engineering. Int J Periodontics Restorative Dent 1993;13: 409–431.
12. Binon P. Evaluation of machining accuracy and consistency of selected implants, standard abutments, and laboratory analogs. Int J Prosthodont 1995;8:162–178.
13. Norton MR. Assessment of cold welding properties of the internal conical interface of two commercially available implant systems. J Prosthet Dent 1999;81:159–166.
14. Weiss EI, Kozak D, Gross MD. Effect of repeated closures on opening torque values in seven abutment-implant systems. J Prosthet Dent 2000;84:194–199.