# The Evaluation of Unscrewing Torque Values of Implant-Abutment Connections: An In Vitro Study

Ezio Bruna, MD, DDS[1]/Andrea Fabianelli, DDS, MSc, PhD[2]/
Giacomo Mastriforti, DDS[3]/Federica Papacchini, DDS, MSc, PhD[4]

***Purpose:*** This study investigated the stability of titanium screws in implant-abutment connections by measuring the force necessary to induce unscrewing. ***Materials and Methods:*** A total of 60 implant-abutment couplings were assigned to two groups (n = 30 each). The sequence 10-20-32 Ncm was tested in Group 1; the sequence 10-20-32-32-32 Ncm was tested in Group 2. The force necessary to unscrew each abutment-implant sample was recorded and statistically analyzed. The significance level was set at $P < .05$. ***Results:*** Significant differences were found between the two sequences. Group 2 required higher forces than Group 1 to unscrew. ***Conclusion:*** The stability of the implant-abutment joint may be improved by tightening with the sequence 10-20-32-32-32 Ncm. *Int J Prosthodont 2017;30:30–32. doi: 10.11607/ijp.4817*

Unscrewing of the prosthetic abutment is one of the most frequent complications of implant-supported prostheses.[1] Screws are used to connect different frameworks. Their resistance depends on friction between the thread of the screw and the corresponding female thread inside the implant. This friction, in turn, depends on tension in the neck of the screw obtained by tightening (ie, the preload). In implant-supported prostheses, unscrewing occurs as a consequence of the forces applied on artificial teeth. The process depends on the screw stability, which is due to the quality of manufacturing, the method used for tightening, and the friction between the screw and the female screw threads. The prosthetic connection (eg, internal/external hexagon, conic coupling) and the fit precision are also significant factors.[2]

In this study, friction was evaluated as an indirect measurement of implant-abutment stability. Two tightening sequences were tested. Screw stability was measured as the force necessary for unscrewing. The null hypothesis tested was that the tightening sequence does not affect screw retention.

[1]*Private Practice, Torino, Italy.*
[2]*Visiting Lecturer, University of Sheffield, Sheffield, UK; Visiting Lecturer, University of Brescia, Brescia, Italy; Private Practice, Cortona, Arezzo, Italy.*
[3]*Private Practice, Perugia, Italy.*
[4]*Private Practice, Viterbo, Italy.*

***Correspondence to:*** *Dr Andrea Fabianelli, Via Antonio Gramsci 42/B, Cortona, Arezzo, 52044 Italy. Fax: +39 057 563 0487. Email: andy.62@virgilio.it*



## Materials and Methods

A total of 60 external-hex threaded analogues (ILA20, Biomet 3i) and 60 abutments (TM40, Biomet 3i) were coupled using titanium screws (UNIHT, Biomet 3i) and randomly divided in two groups (n = 30 each) In Group 1, screws were tightened by a modified implant unit (W&H) at 10, 20, and 32 Ncm (sequenceL 10-20-32 Ncm). In Group 2, screws were treated in the same way, but tightening at 32 Ncm was repeated three times (sequence: 10-20-32-32-32 Ncm). The force necessary to unscrew each abutment-implant coupling was recorded using the same implant device, and the collected data were statistically analyzed (Figs 1–4).

The forces able to produce unscrewing were analyzed first by Box-Cox test to verify normality of data and then by Bartlett test for homogeneity of variances (Bartlett k-squared = 2.3792; df = 1; $P = .123$). As values were normally distributed and variances were homogenous, a parametric test (*t* test) was applied to detect significant differences between the tested groups. All the analyses were performed using R 2.15.2 software (R Project for Statistical Computing). The significance level was set at $P < .05$.

## Results

Statistically significant differences were found between the two screwing sequences. Group 2 required higher forces to produce unscrewing than did Group 1 (Fig 5). In Group 2, values ranged from 26.0 to 32.0 Ncm, while Group 1 values ranged from 15.0 to 25.0 Ncm (Table 1).

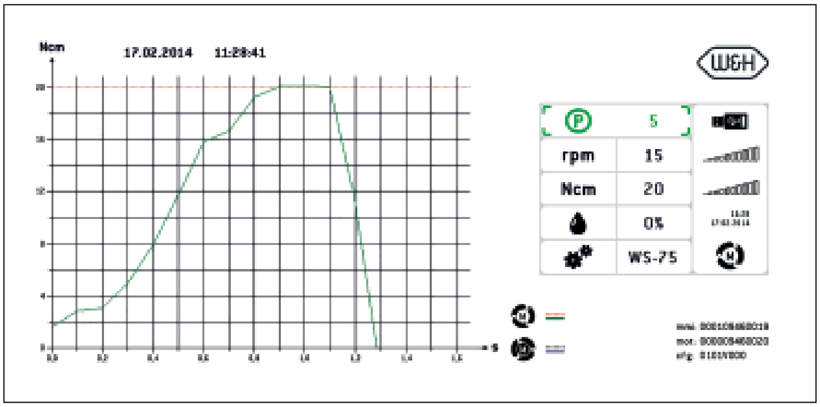


**Fig 1** Change force during tightening. The unit was set at 32 Ncm and the screw was tightened only once.

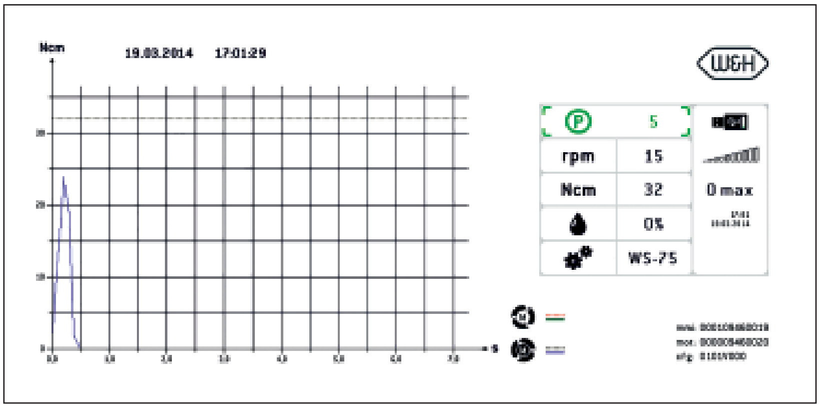


**Fig 2** In this sample from Group 1, a force of 24 Ncm was sufficient to produce unscrewing.

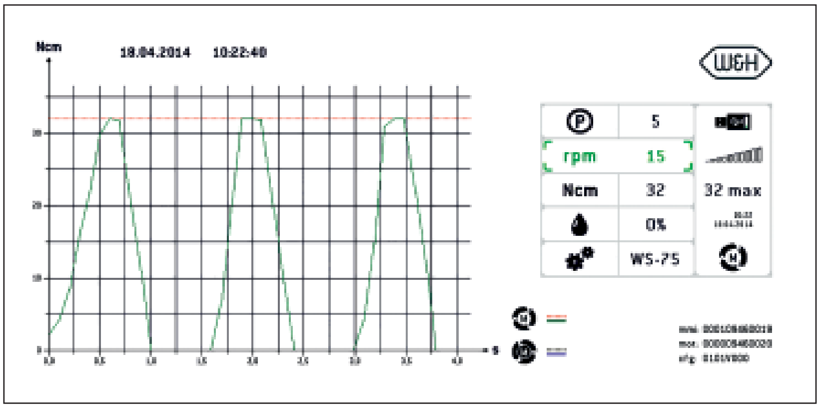


**Fig 3** Tightening of a screw in Group 2. Screwing at 32 Ncm was repeated three times.

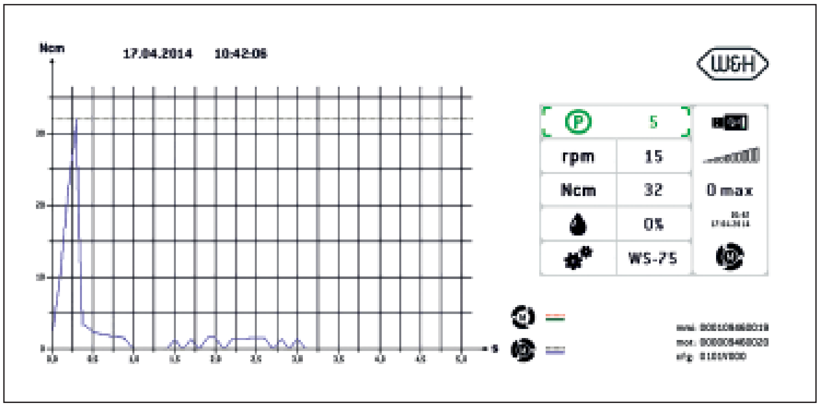


**Fig 4** In this sample from Group 2, all the preload force was transformed into screw stability. A force of 32 Ncm was needed to produce unscrewing.

**Table 1** Unscrewing Torque Results Achieved in the Experimental Groups

| Group | n | Mean | SD | SE | Median | Minimum | Maximum | Range | Skew | Kurtosis |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 30 | 19.6 | 3.1 | 0.6 | 19.0 | 15.0 | 25.0 | 10.0 | 0.4 | −1.08 |
| 2 | 30 | 29.7 | 2.3 | 0.4 | 30.0 | 26.0 | 32.0 | 6.0 | −0.4 | −1.42 |

Mean, SD, standard error (SE) median, minimum and maximum values, data range, and deviation from the normality (skew and kurtosis) are expressed in Ncm. Group 1: 95% confidence interval (CI) = 18.44–20.76 Ncm; Group 2: 95% CI = 28.55–30.87 Ncm.

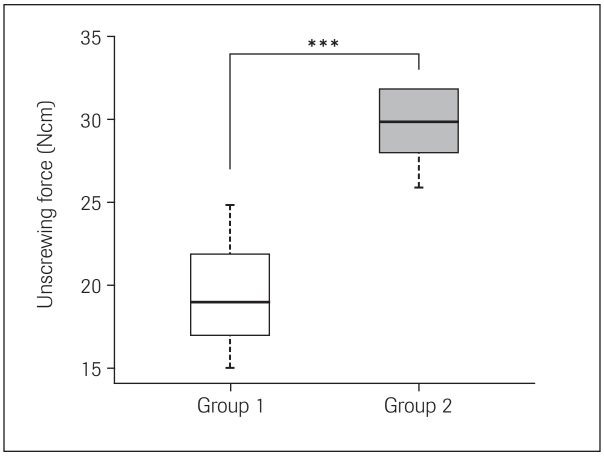


**Fig 5** Box plot showing the statistically significant differences achieved between the tested groups.

## Discussion

The tightening sequence had a significant effect on the unscrewing forces of implant-abutment joints, thus the null hypothesis was rejected. The stability of an implant-abutment coupling may be compromised and missed if the external separating forces are greater than the clamping force.[3] Dynamic load during functional and parafunctional activity, lateral/transverse misfit, elastic deformations subsequent to acute trauma, vibrations, and sudden changes in intraoral temperature may impair screw resistance.[4]

The subsidence of a screw-retained prosthesis happens in two steps: the preload steadily decreases due to functional loads, then functional loads prevail over preload and unscrewing occurs. Implant-restoration position, inclination and overlapping, presence/extension of a cantilever, occlusal shape, and type of occlusion influence joint-separating forces.[3]

The maximum manually achievable torque is usually about 8 to 10 Ncm, thus mechanical (spring action) or electronic (regulated by the prosthetic unit) dynamometers must be used to ensure the right tightening force.[5]

## Conclusions

In this study, friction produced by preload was evaluated as an indirect method for measuring screw stability.[6] Nanotribology theories might explain the superior results achieved by the sequence 10-20-32-32-32 Ncm.[7] The repeated tightening at 32 Ncm presumably induces a plastic deformation of peaks present on the asperities of the opposing surfaces, enhancing friction between the screw and the female threads; however, it is currently impossible to understand whether this improvement is due to plastic deformation of asperities or to their abrasion. Though the torque used is always the same (32 Ncm), it probably increases also the elastic deformation of the screw neck, causing an improvement in the coupling stability. Increasing torque at values > 32 Ncm could presumably produce the same results, but the augmented plastic deformation of the screw could lead to screw fracture. Further clinical tests are necessary to validate these in vitro results.

## Acknowledgments

The authors reported no conflicts of interest related to this study.

## References

1. Behr M, Lang R, Leibrock A, Rosentritt M, Handel G. Complication rate with prosthodontic reconstruction on ITI and IMZ dental implants. Internationales Team für implantologie. Clin Oral Implants Res 1998;9:51–58.
2. Freitas AC Jr, Bonfante EA, Rocha EP, Silva NR, Marotta L, Coelho PG. Effect of implant connection and restoration design (screwed vs cemented) in reliability and failure modes of anterior crowns. Eur J Oral Sci 2011;119:323–330.
3. McGlumphy EA, Mendel DA, Holloway JA. Implant screw mechanics. Dent Clin North Am 1998;42:71–89.
4. Farina AP, Spazzin AO, Pantoja JM, Consani RL, Mesquita MF. An in vitro comparison of joint stability of implant-supported fixed prosthetic suprastructures retained with different prosthetic screws and levels of fit under masticatory simulation conditions. Int J Oral Maxillofac Implants 2012;27:833–888.
5. Dellinges MA, Tebrock OC. A measurement of torque values obtained with hand-held drivers in a simulated clinical setting. J Prosthodont 1993;2:212–214.
6. Byrne D, Jacobs S, O'Connell B, Houston F, Claffey N. Preloads generated with repeated tightening in three types of screws used in dental implant assemblies. J Prosthodont 2006;15:164–171.
7. Ortorp A, Jemt T, Wennerberg A, Berggren C, Brycke M. Screw preloads and measurements of surface roughness in screw joints: An in vitro study on implant frameworks. Clin Implant Dent Relat Res 2005;7:141–149.