# Accuracy of a Manual Torque Application Device for Morse-Taper Implants: A Technical Note

Murat C. Çehreli, DDS, PhD[1]/Kıvanç Akça, DDS, PhD[1]/Ergin Tönük, PhD[2]

***Purpose:*** *The objective of this study was to compare torques applied by new and used manual torque devices for Morse-taper implants.* ***Material and Methods:*** *Fifteen ITI manual torque devices were tested. Those in group 1 (n = 5) were new (ie, never used), those in group 2 (n = 5) had been used 50 to 200 times, and those in group 3 (n = 5) had been used 500 to 1,000 times. The torques applied by each device were measured for 35 Ncm and 15 Ncm targets in an experimental setup by a custom-made wrench with strain gauges connected to a data acquisition system. The strain-gauge signals were simultaneously delivered to a computer at a sample rate of 10,000 Hz and converted to torque units.* ***Results:*** *New devices applied higher torques than used devices for the 35-Ncm torque target ($P < .05$). The torques applied by group 3 devices were approximately 1.5 Ncm lower than those of other groups for the 35-Ncm target and approximately 1 Ncm lower for the 15-Ncm target.* ***Discussion and Conclusion:*** *ITI manual torque devices deliver consistent torque output, although a slight decrease occurs as a consequence of clinical use.* INT J ORAL MAXILLOFAC IMPLANTS 2004;19:743–748

**Key words:** *dental implants, manual torque devices, preload, screw mechanics, torque*

Retrospective clinical and experimental in vitro studies have identified a number of decisive factors influencing screw failure in implant systems. Clinical outcome studies have reported a high frequency of loosening or fracture of implant components for 2-stage external-hex implants supporting single and multiunit fixed prostheses,[1–4] while the incidence of mechanical complications encountered with Morse-taper implants is relatively low.[5] Thus, implant design appears to be one of the primary factors leading to failure of screw-joint mechanisms in dental implants.[6,7] Other cited reasons, all of which have critical effects on screw-joint stability, are inconsistencies between torque-controlling devices, torque application methods, and operators.[8–11]

The main objective in screw tightening is to build up adequate compressive clamping force to keep 2 implant components assembled and thereby achieve predictable stability across the screw joint.[12,13] At the onset of torque application, preload is generated within the screw and friction increases in the opposing threads at the joint interface, leading to elongation of the screw stem and commencement of the clamping force. The magnitude of the clamping force influences the mechanical behavior of the screw joint. Undertorquing screws frequently leads to separation of the joint under functional loads, whereas overtorquing may cause fracture of the screw or stripping of the screw threads. To avoid screw-joint failure, it is essential that either the clamping force is maximized or is at least greater than the joint separating forces.[7,14] Overall, screws must experience optimal preloads to maintain screw joint integrity.

[1]Research Assistant, Department of Prosthodontics, Faculty of Dentistry, Hacettepe University, Ankara,Turkey.
[2]Assistant Professor, Mechanical Engineering Department, Faculty of Engineering, Middle East Technical University, Ankara, Turkey.

**Correspondence to:** Dr Murat Çehreli, Gazi Mustafa Kemal Bulvari 61/11, 06570 Maltepe, Ankara, Turkey. Fax: +90 312 311 3741. E-mail: mcehreli@hotmail.com

**Fig 1** The custom-made wrench with a strain gauge attached to each side.

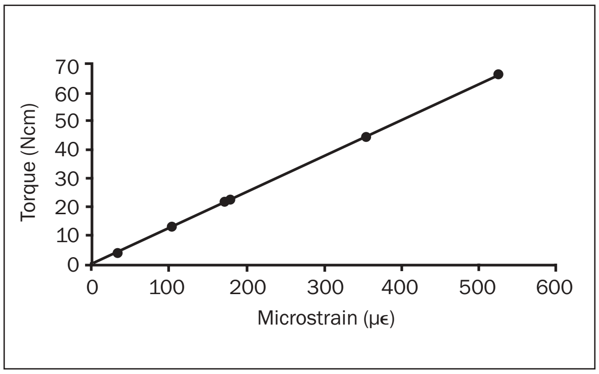



**Fig 2** Microstrain versus elicited torques during calibration of the custom-made torque device.

A variety of mechanical and electrical torque application devices have been manufactured to apply controlled torque to implant components. The ITI mechanical torque device (Straumann Institut, Waldenburg, Switzerland) is a handheld (manual) ratchet-type device with no release mechanism. The wrench is inserted into a spring-activated sleeve with a scale calibrated by the manufacturer, and force is applied until the desired torque is achieved. ITI torque application devices have been demonstrated to deliver consistent torque output within 10% of their preset targets.[11] However, no reports of the consistency between new and used ITI handheld torque devices have been published. Therefore, the purpose of this study was to gain insight into the subject by comparing torque applied by new and used torque application devices for ITI implants.

## MATERIALS AND METHODS

A torque wrench was custom-made to measure the torque applied by torque application devices created for use with ITI implants. This torque wrench consisted of a handle and an aperture designed to hold a unique ITI screwdriver. A strain gauge (EA-XX-062AK-120; Vishay Micromeasurements Group, Raleigh, NC) was attached to each side of the handle (Fig 1).

The strain gauges were wired into a half-bridge configuration for measurements. A calibration experiment was devised to obtain the calibration constant of the wrench and to assess the quality and repeatability of the torque measurements. For the experiment, the head of the wrench was secured to a clamp, leaving the handle as a cantilever. Six different weights, whose corresponding torque values were known, were applied to the handle at a predetermined distance from the strain gauges. For each weight, 5 strain gauge measurements were undertaken in separate sessions using a data acquisition system (ESAM Traveller 1; Vishay Micromeasurements Group), and the data were collected using a computerized system and corresponding software (ESAM; ESA Messtechnik, Olching, Germany) at a sample rate of 10,000 Hz. The strain gauge readings versus the elicited torques are presented in Fig 2. After repeated loading, the highest standard deviation (SD) in strains (0.84 microstrain [με]) occurred for 67 Ncm torque. The linear regression to data points yielded the calibration constant as 0.126 Ncm/με with $R^2$ = 0.99997.

Fifteen manual torque application devices (Straumann Institut) were tested. They were divided into 3 equal groups:

- **Group 1:** New devices (ie, devices that had never been used)
- **Group 2:** Devices used in clinical practice 50 to 200 times
- **Group 3:** Devices used in clinical practice 500 to 1,000 times

To undertake the experiments, an apparatus to hold the custom-made wrench and an ITI torque device was fabricated (Fig 3). This apparatus consisted of a machined stainless steel bar designed to attach both torque devices, which was then placed vertically into 2 low-friction Teflon bearings (DuPont, Wilmington, DE) integrated into a stainless steel frame. To place the torque devices in the apparatus, the upper part was unscrewed. A machined probe was also fixed into the base of this apparatus for the calibration experiments; it also served as a stop for the wrench during torque application with ITI torque devices.

Each ITI torque device was tested as follows: At the outset, the test device and the custom-made wrench were place in the apparatus. An operator who had tightened more than 1,000 ITI implant components manually applied the target torques (35 Ncm and 15 Ncm) 7 times per target. The strain gauge data from the wrench were simultaneously digitalized by the same data acquisition system and software used in the calibration experiment at a sample rate of 10,000 Hz. The maximum strain value achieved for each torque application was then detected by the software. The microstrain reading was linearly proportional to the torque applied by the ITI torque device, where the constant of proportionality was the calibration constant (K = 0.126 Ncm/$\mu\epsilon$).

### Statistical Analysis

Intergroup comparisons were undertaken by Kruskal-Wallis tests followed by Mann-Whitney tests at confidence levels set at 95%. Intragroup comparison of group 1 data was performed by 1-way analysis of variance (ANOVA) at the 95% confidence level.

## RESULTS

In each experiment, a sharp increase in torque was followed by immediate tension relief and a return to a torque of 0 Ncm (ie, 0 $\mu\epsilon$). This pattern was extremely consistent for all trials with all devices (Fig 4).

The torque applied by each device is presented in Table 1 along with the mean ± SD torque for each group. For the 35-Ncm torque target, the mean ± SD for group 1 (34.94 ± 0.32 Ncm) was slightly higher than the mean for group 2 (34.32 ± 0.24 Ncm), and both were higher than the mean for group 3 (33.57 ± 0.53 Ncm). The differences between groups 1 and 2 and between groups 1 and 3 were significant ($P < .05$), whereas the difference between groups 2 and 3 was insignificant ($P > .05$). This trend of decrease in applied torque was also exhibited for the 15-Ncm target. The mean applied torque of group 1 devices (16.41 ± 0.17 Ncm) was slightly higher than the mean for group 2 (16.28 ± 0.35 Ncm), and both were higher than the mean for group 3 (15.16 ± 0.09 Ncm). The difference between groups 1 and 2 was insignificant for the 15-Ncm target ($P > .05$), but the differences between groups 1 and 3 and groups 2 and 3 were significant ($P < .05$). The intragroup comparison of new torque devices revealed that there were no discernable differences between the devices in either the 35-Ncm or 15-Ncm target trials ($P > .05$).

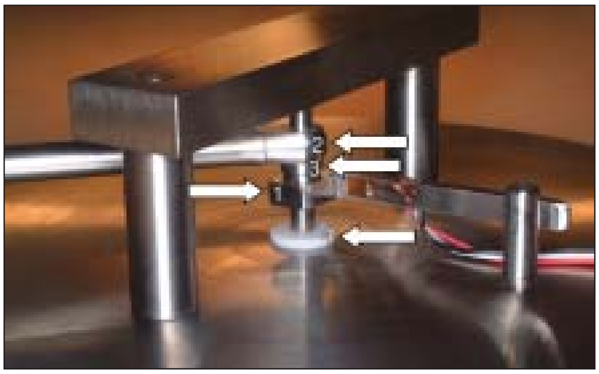
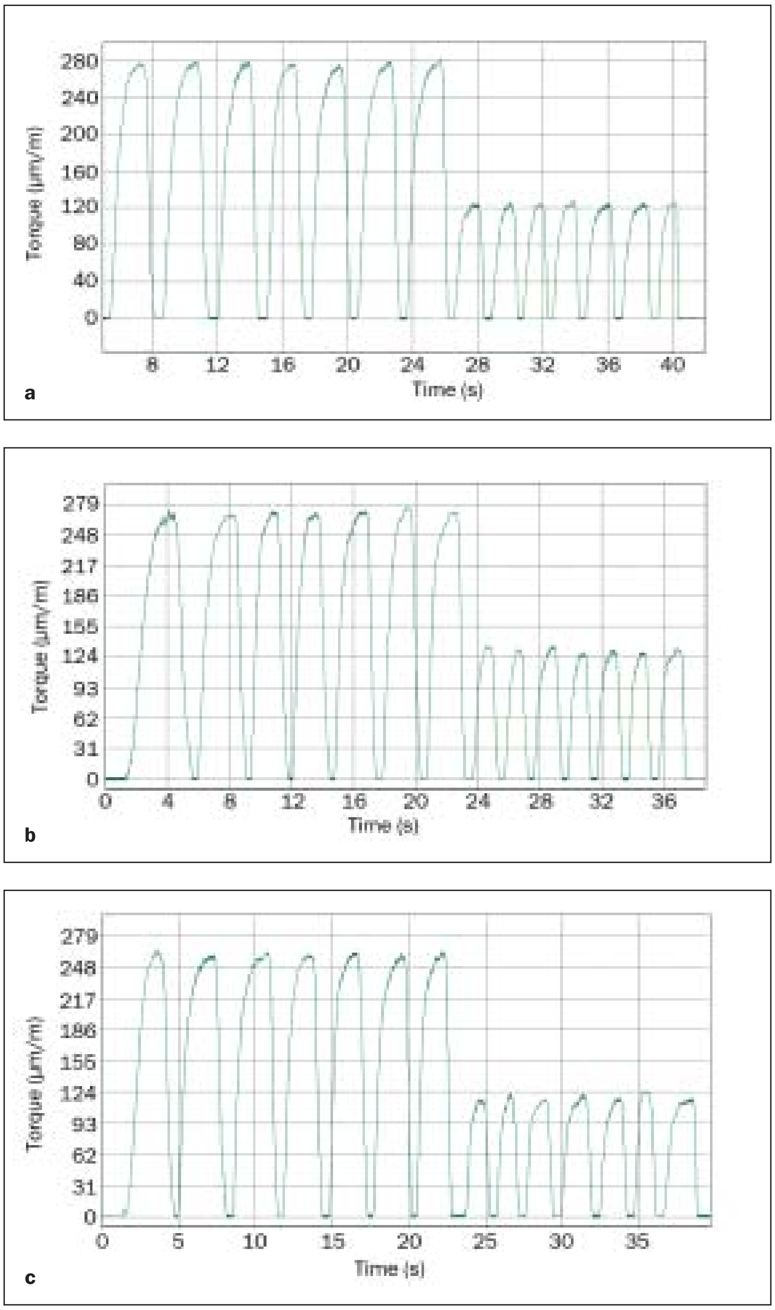



**Fig 3** The apparatus harboring the custom-made wrench and *(1)* an ITI torque device *(2)*. A machined stainless steel bar *(3)* was used to attach both torque devices. It was placed vertically into low-friction Teflon bearings *(4)*.

## DISCUSSION

At the 35-Ncm target level, the applied torques of both new and used devices were somewhat lower than the target value, although the experiments were performed by an experienced operator.[8,9] Interestingly, the mean applied torque of 1 brand-new device was slightly higher than 35 Ncm. The mean torques for group 3 devices were approximately 1.5 Ncm lower than those obtained for group 1 devices. This implies that the ability of the devices to apply torque decreases slightly with age. The clinical relevance of this finding with regard to the longevity of screw joints is questionable because of exceptionally high interface fidelity of the Morse-taper joint.[6,7] Nonetheless, the effects of aging on torque application devices need further evaluation to explore the effect, if any, on abutment loosening, as the incidence of abutment screw loosening for ITI implants has been reported to be 3.6% to 5.3% after 2 years.[5]

Slight overtorquing or retorquing of ITI implants at frequent intervals can help increase retention.[4,13] It should be taken into account that this application is effective only when the deformation of the material falls within elastic limits.[13] Tightening to 50% to 60% of the ultimate tensile strength of the screw may be another option, as this level is below the yield strength of the materials.




**Figs 4a to 4c** A sharp increase in torque can be seen, followed by immediate tension relief and a return to a torque of 0 Ncm (ie, 0 με). *(a)* A new device; *(b)* a device used 50 to 100 times; *(c)* a device used 500 to 1,000 times.

Slight overtorquing or retorquing also appears to have some clinical importance when reduced bone healing times are employed for ITI implants with sandblasted, large-grit, acid-etched surfaces.[15–17] Torque levels in the 20- to 30-Ncm range at the bone-implant interface are not assumed to pose a threat to the maintenance of the interface.[14] During tightening of ITI abutments into ITI solid-screw implants after a tissue healing period of 6 to 8 weeks, 35 Ncm torque is applied with the ratchet via the screwdriver, but countertorquing is not provided with an instrument such as the countertorque device used for Brånemark System implants (Nobel Biocare, Göteborg, Sweden). In these cases, countertorquing is apparently provided solely by the stiffness of the bone-implant interface. Failure may result if the implant cannot withstand the stress generated by the 35-Ncm torquing without more countertorque. Abutment connections for such clinical applications should be performed with extensive care, and, preferably, with some modifications,[17] as the applied torque of new and used ITI torque-limiting devices are indeed very close to 35 Ncm. The results of this study showed that the ITI manual torque device applies torque predictably and does not lead to inadvertent overtorquing of abutment screws.

The applied torque of group 1 and 2 devices was approximately 1 Ncm higher than the target 15 Ncm value, but the group 3 devices delivered torques very close to the target. This implies that there was a slight decrease in applied torque after 500 to 1,000 torque applications. The clinical relevance of this finding is a matter of debate, as the incidence of occlusal screw loosening is generally low for the ITI implant system. One factor leading to this clinical outcome may be overtorquing occlusal screws with 16 Ncm. The design of the ITI manual torque device does not provide "absolute" torque limiting, since a mechanical stop has not been included in the design. Experience with the device may be necessary for optimum torque application. However, the device's ability to apply a torque slightly higher than 15 Ncm may be necessary for retightening loose screws.

In the present study, intragroup comparisons were performed only for new devices. Because the exact use number was unknown for other devices, intragroup comparisons were not undertaken for groups 2 and 3. The rationale for collecting devices from clinical practices, instead of "aging" new devices, was to incorporate the possible effects of operator-dependent inconsistencies regarding the use of these devices into the experiment. The SDs of all devices for both torque targets were generally lower than 0.5 Ncm, suggesting high consistency within groups, and no operator-dependent effects on the fatigue behavior of the torque devices were observed. Accordingly, it seems that the deformation of ITI torque-limiting devices is absolutely within elastic limits. Fatigue in the part of the device that connects that ratchet to the string may be the factor that leads to the slight decrease in torque output seen.

**Table 1 Torque Output (Ncm) for 35-Ncm and 15-Ncm Torque Targets**

| Device | 35 Ncm | 15 Ncm |
|---|---|---|
| Group 1 | | |
| 1 | 34.89 | 16.41 |
| 2 | 35.04 | 16.40 |
| 3 | 34.41 | 16.67 |
| 4 | 34.82 | 16.35 |
| 5 | 34.87 | 16.58 |
| Mean (SD) | 34.94 (0.32) | 16.41 (0.17) |
| Group 2 | | |
| 1 | 34.13 | 16.41 |
| 2 | 34.75 | 16.37 |
| 3 | 34.28 | 16.63 |
| 4 | 34.26 | 15.68 |
| 5 | 33.04 | 16.33 |
| Mean (SD) | 34.32 (0.24) | 16.28 (0.35) |
| Group 3 | | |
| 1 | 33.04 | 15.00 |
| 2 | 33.47 | 15.11 |
| 3 | 34.47 | 15.22 |
| 4 | 33.54 | 15.29 |
| 5 | 33.35 | 15.15 |
| Mean (SD) | 33.57 (0.53) | 15.16 (0.09) |

## CONCLUSIONS

Under the conditions of this study the following conclusions were drawn:

1. The torque delivered by new ITI torque-limiting devices fell slightly short of the 35-Ncm target but slightly exceeded the 15-Ncm target.
2. Torque output decreased about 1 to 1.5 Ncm after 500 to 1,000 applications.
3. ITI torque-limiting devices can be user-friendly and deliver remarkably consistent torque output.
4. The ITI torque-limiting devices did not exhibit any signs of operator-dependent aging in this experiment.

## ACKNOWLEDGMENTS

This study was partially supported by the State Planning Organization, Prime Ministry, Republic of Turkey (Project no. 02K120290-10).

## REFERENCES


1. Zarb GA, Schmitt A. The longitudinal clinical effectiveness of osseointegrated implants: The Toronto study, Part III: Problems and complications encountered. J Prosthet Dent 1990;64:185–194.
2. Jemt T, Lekholm U, Gröndahl K. Three-year followup study of early single implant restorations ad modem Brånemark. Int J Periodontics Restorative Dent 1990;10:341–349.
3. Jemt T, Linden B, Lekholm U. Failures and complications in 127 consecutively placed fixed partial prostheses supported by Brånemark implants: From prosthetic treatment to first annual checkup. Int J Oral Maxillofac Implants 1992;7:40–44.
4. Naert I, Quirynen M, van Steenberghe D, Darius P. A study of 589 consecutive implants supporting complete fixed prostheses. Part II: Prosthetic aspects. J Prosthet Dent 1992;68:949–956.

5. Levine RA, Clem DS III, Wilson TG Jr, Higginbottom F, Solnit G. Multicenter retrospective analysis of the ITI implant system used for single-tooth replacements: Results of loading for 2 or more years. Int J Oral Maxillofac Implants 1999;14:516–520.
6. Merz BR, Hunenbart S, Belser UC. Mechanics of the implant-abutment connection: An 8-degree taper compared to a butt joint connection. Int J Oral Maxillofac Implants 2000;15:519–526.
7. Schwarz M. Mechanical complications of dental implants. Clin Oral Implants Res 2000;11(suppl 1):156–158.
8. 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.
9. Goheen KL, Vermilyea SG, Vossoughi J, Agar JR. Torque generated by handheld screwdrivers and mechanical torquing devices for osseointegrated implants. Int J Oral Maxillofac Implants 1994;9:149–155.
10. Standlee JP, Caputo AA. Accuracy of an electric torque-limiting device for implants. Int J Oral Maxillofac Implants 1999;14:278–281.
11. Standlee JP, Caputo AA, Chwu MJ, Sun TT. Accuracy of mechanical torque-limiting devices for implants. Int J Oral Maxillofac Implants 2002;17:220–224.
12. Haack JE, Sakaguchi RL, Sun T, Coffey JP. Elongation and preload stress in dental implant abutment screws. Int J Oral Maxillofac Implants 1995;10:529–536.
13. Sakaguchi RL, Borgersen SE. Nonlinear contact analysis of preload in dental implant screws. Int J Oral Maxillofac Implants 1995;10:295–302.
14. McGlumphy EA, Mendel DA, Holloway JA. Implant screw mechanics. Dent Clin North Am 1998;42:71–89.
15. 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.
16. Payne AG, Tawse-Smith A, Duncan WD, Kumara R. Conventional and early loading of unsplinted ITI implants supporting mandibular overdentures. Clin Oral Implants Res 2002;13:603–609.
17. Roccuzzo M, Wilson T. A prospective study evaluating a protocol for 6 weeks' loading of SLA implants in the posterior maxilla: One-year results. Clin Oral Implants Res 2002;13:502–507.