Accuracy of Mechanical Torque-Limiting Devices for Implants

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Purpose: *To examine the accuracy of 3 mechanical torque wrenches.* ***Materials and Methods:*** *The torque outputs of the Nobel Biocare, Straumann ITI, and DynaTorq ITL mechanical torque-limiting devices were determined using a special setup on an Instron test machine. The devices were held in the test setup and oriented so that activation of the drivers caused a pure torsion effect.* ***Results:*** *Significant differences generally existed between individual units and the target torque levels for the Nobel Biocare torque controller.* ***Discussion:*** *The mean torque values of the ITI and ITL devices were within 10% of their respective target torque levels. Knowledge of applied torque levels to the screws that retain implant abutments and their attached prostheses is necessary to achieve optimal preload. The ITI and ITL devices tested in this study were capable of providing consistent torque at or near their respective targets.* ***Conclusion:*** *The torque output of each individual device deviated in varying degrees from target torque values.* (INT J ORAL MAXILLOFAC IMPLANTS 2002;17:220–224)

Key words: *dental implants, mechanical devices, torque control*

The purpose of tightening restorative components on osseointegrated implants is to develop a preload tension in the system, thereby clamping the components together.[1] The preload generated by such screw tightening must be sufficient to prevent loosening of abutments and prostheses when subjected to functional loads. On the other hand, the preload must be limited to levels that will not result in ultimate material failure of the components, such as stripped threads or fractured abutment screws.[2,3] To achieve this desired tension, the clinician must be able to control torque input.

When clinicians apply torque by hand, errors of 15% to 48% may be expected.[4] Further, the amount of torque, and therefore the amount of preload, is dependent on the experience level of the operator.[5] Inexperienced operators tend to undertorque screws, while experienced operators tend to overtorque them.[4,5] All individuals are inconsistent in the torque levels generated.[4,5] A variety of devices, both mechanical and electrical, have been developed to place controlled torque levels on dental implant components.[4,6] These devices are usually calibrated by the manufacturer to apply appropriate torque levels for their specific implants and attachments. However, some studies have shown that these torque-limiting devices may exhibit substantial variations from nominal or target torque values.[4,7,8]

Three commonly used mechanical devices are quite different in operating principles. The Nobel Biocare mechanical torque limiter (Nobel Biocare, Göteborg, Sweden) (Fig 1a) is a latch-type dental handpiece adapted to deliver the desired torque. Two handpiece heads are preset by the manufacturer to release at target torque levels of 10 and 20 Ncm. The device is hand-held and hand-driven by rotating the knurled handle attached to the handpiece spindle. The driver is held in the latch of the torque limiter, just as dental burs are inserted in a slow-speed handpiece.

The ITI mechanical torque limiter (Institut Straumann, Waldenburg, Switzerland) is a hand-held ratchet-type torque wrench with no actual release mechanism (Fig 1b). Instead, the wrench is inserted into a spring-activated sleeve with a scale preset by the manufacturer. Torque targets of 15 and 35 Ncm are premarked on the scale. The operator applies force to the spring until the desired torque is achieved visually.

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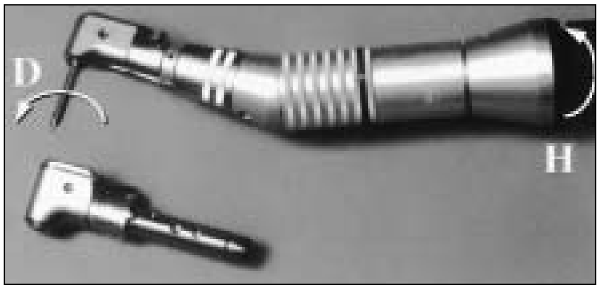

Fig 1a *(Top)* The Nobel Biocare mechanical torque-limiting device. An assembled 10-Ncm torque wrench with rotating handle (H) and driver (D). *(Bottom)* A 20-Ncm handpiece head that can be installed in place of the 10-Ncm handpiece head.

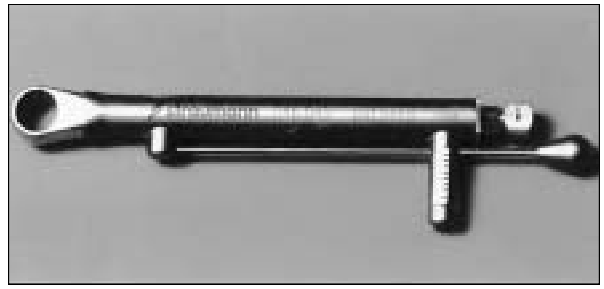

Fig 1b The ITI torque-indicating device with a wrench installed and a 1-mm indicator scale attached below the torque-applying spring.

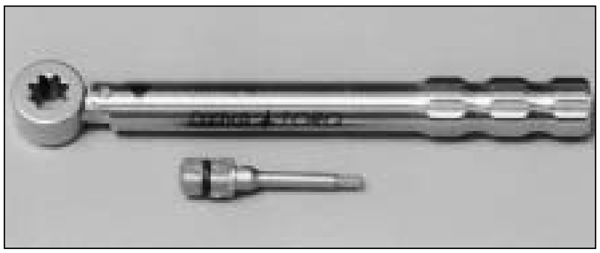

Fig 1c The DynaTorq ITL mechanical torque-limiting device and *(top)* and a hex driver *(bottom)*.

Fig 1d *(Right)* The DynaTorq ITL torque-limiting device after exceeding the manufacturer's programmed target torque level. The handle has released near the wrench head.

The DynaTorq ITL mechanical torque limiter (Implant Technologies, Santa Ana, CA) is a hex wrench with a handle release mechanism preset by the manufacturer to release at target torque levels of 10, 20, and 30 Ncm (Fig 1c). The driver is inserted into the wrench, and force is applied to the implant component until the handle releases, stopping torque application (Fig 1d).

The purpose of this investigation was to determine and compare the accuracy of these 3 mechanical torque-limiting devices.

MATERIALS AND METHODS

Six Nobel Biocare and 5 ITI torque controllers were obtained from clinical practices. Six DynaTorq ITL controllers for each of 3 preset torque levels were obtained from the manufacturer. A Unimat miniature lathe (American Edelstaal, New York, NY) was used to transfer rotation generated by the torque wrenches to the lathe pulley. The driver transmitting the rotation from each torque-limiting device was held by a collet centered in the lathe spindle (Fig 2). The lathe was secured to the bed of an Instron test machine (Instron, Canton, MA), which was used to measure the force generated tangent to the pulley by the torque controller. In this study an "unknown" torque was applied by the torque controller driving a pulley of known radius acting tangentially to generate a force. This force was then used to compute actual torque values. The torque value generated is the product of the length of the lever arm and the force exerted perpendicular to the lever arm.

Each type of mechanical torque-limiting device had target torque values preset by the manufacturer (Table 1). The Nobel Biocare device was set at 10 and 20 Ncm. The ITI device is preset at 15 and 35 Ncm, but is adjustable from 0 to 45 Ncm along a spring-loaded scale. An additional series of readings were made for the ITI device along a superimposed scale of 1-mm increments. The ITL devices were set at 10, 20, and 30 Ncm. The devices were tested at slow (5.2 Ncm/sec) and fast (16.4 Ncm/sec) rates of torque application as measured on the Instron print out. The test setup was evaluated for the effects of inertia and internal friction; when placed in tension at crosshead speeds of 0.05, 5, and 20 inches/min, maximum torque values of 0.25 Ncm were observed. The Instron load cell was calibrated for accuracy

Fig 2 Test setup for measurement of accuracy of the DynaTorq device. Rotation generated by the torque device is transferred to the pulley of the lathe (radius R) connected by cable to the load cell of the Instron machine (F).

Table 1 Torque Levels Tested

Device	Preset torque levels (Ncm)
Nobel Biocare	10, 20
ITI	15, 35
ITL*	10, 20, 30

*Slow = 5.2 N-cm/sec; fast = 16.4 N-cm/sec.

before each testing series. At least 10 repetitions of each target torque level were recorded for each device. The torque values generated by each device, at each level, were analyzed using analysis of variance and the Student *t* test.

RESULTS

For the Nobel Biocare device, variations were seen in torque output from individuals of the same model of controller (Fig 3). From this summary, a trend can be seen toward more accurate measured values for handpieces with target values of 10 Ncm. However, at the 20-Ncm torque level, the means are generally lower than the target release points for these wrenches. Individual torque controllers usually delivered consistent force values at their preset release points, resulting in small standard deviations. However, measured torque levels varied significantly between individual devices and with the target torque values. Maximum and minimum variations of 8% to 41% from target torque values were observed.

Individual ITI torque limiters delivered consistent torque values, the means of which did not vary more that 10% from the target values. Although 2 of the devices exhibited somewhat wider ranges at the 15-Ncm level, there was no significant difference between individual devices ($P < .05$). Measured torque output for individual devices resulted in small to moderate standard deviations from the target torque values of 15 and 35 Ncm (Fig 4). The torque values for ITI torque limiters varied linearly along the superimposed 1-mm incremental scale (Fig 1b) up to 40 Ncm, forming a straight line for each device tested (Fig 5). This composite graph of mean measured torque illustrates the close correlation between devices.

Individual ITL torque limiters delivered consistent torque values that did not vary more than 10% from the target values at the slower loading rate. At the faster loading rates, torque levels were significantly below the target values (Fig 6). There was no significant difference between individual devices ($P < .05$).

DISCUSSION

Mean errors are not as important in the analysis of these data as the extreme variations recorded in the full range of torque output for the study. The extremes are the torque values that will be most likely to cause problems. Thus, the Nobel Biocare devices tested in this study were seen to demonstrate variations from the set target values that were almost as large as the errors seen in studies on application of torque by hand (Fig 7). The ITL and ITI devices tested delivered fairly consistent torque output—within 10% of their preset target values. The ITI torque limiter had the added advantage of being adjustable by the operator from 0 to 40 Ncm along the linear path illustrated in Fig 5 with the possibility of selection of other target torque values by the clinician. The exact clinical consequences of using the tested devices within the range of variability observed in this study are not known. However, it is obvious that the use of the ITI and ITL devices will deliver more consistent control of torque than the Nobel Biocare mechanical device. Such control cannot help but contribute to more standardized torque transfer to the prosthetic complex and tissues supporting the implant.

It has been suggested that abutment screws can be torqued over their recommended target levels to increase retention or retorqued at frequent postinsertion intervals to achieve increased preload levels.[1] Of the 3 types of mechanical torque limiters tested in this study, only the ITI device could be employed by the clinician in this way. Such overtorque application is useful only as long as excessive plastic deformation or

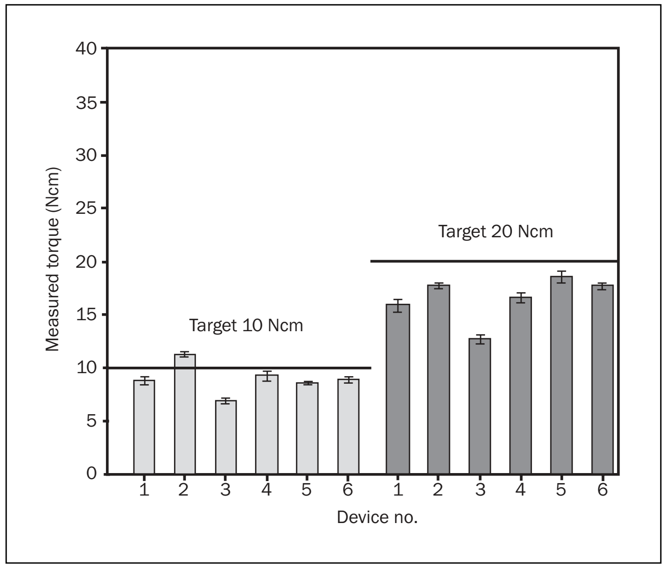

Fig 3 Torque values and standard deviations for the Nobel Biocare torque-limiting devices in relation to their target torque levels.

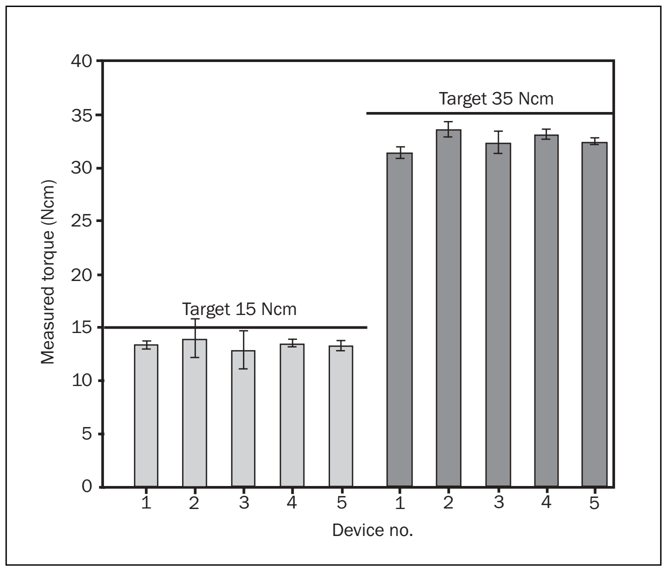

Fig 4 Torque values and standard deviations for the ITI torque-limiting devices in relation to their target torque levels.

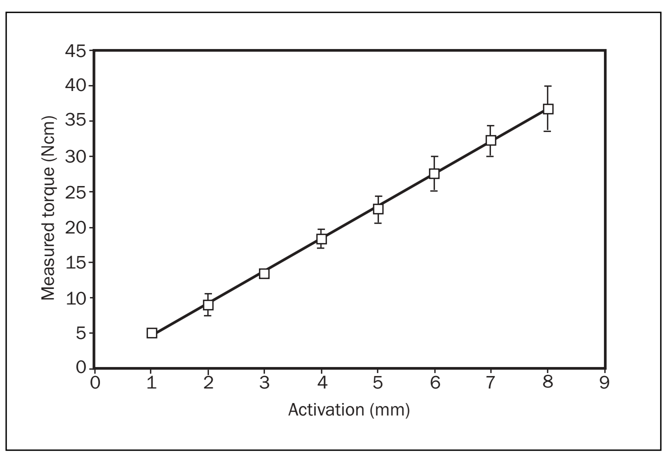

Fig 5 Torque values and standard deviations for the ITI torque-limiting devices activated along a superimposed 1-mm scale. Note the linear relationship between activation (mm) and torque (Ncm).

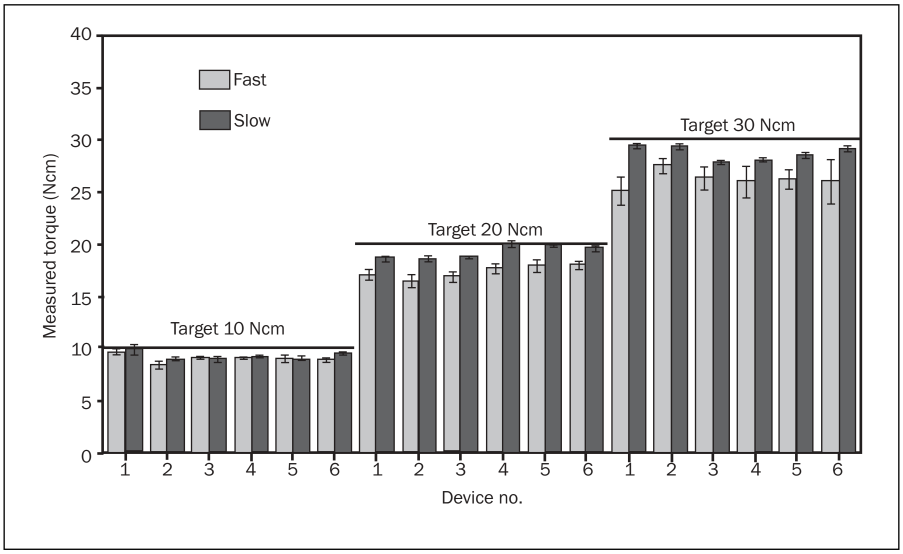

Fig 6 Torque values and standard deviations for the Dynatorque ITL torque-limiting device at fast (16.4 Ncm/sec) and slow (5.2 Ncm/sec) speeds of torque application.

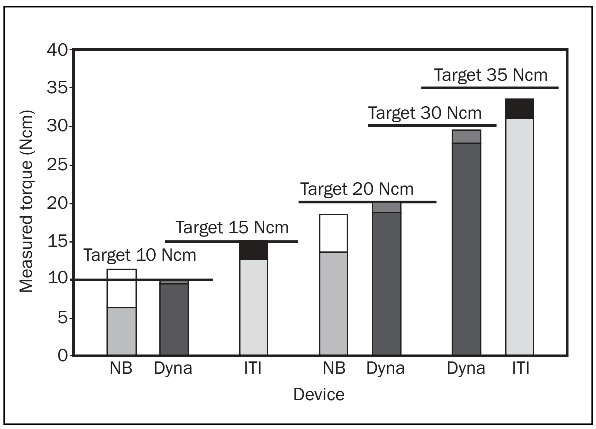

Fig 7 A comparison of mean torque values and standard deviations for all devices tested in this study in relation to their respective target torque levels. NB = Nobel Biocare; Dyna = DynaTorq ITL.

failure of the screw does not occur.[1] In short, screws that are under-torqued can become loose. Screws that are over-torqued can fracture, either at insertion or after application of functional loading cycles.[1]

CONCLUSIONS

The torque output of 3 mechanical torque-limiting devices was determined using a special setup on an Instron test machine accurate to within ± 0.25 Ncm. After application of the manufacturers' preset torque levels, significant variations were observed between individual devices. The torque output of each individual device deviated in varying degrees from target torque values.

1. The Nobel Biocare mechanical torque limiters tested exhibited the largest variations from target torque values.
2. The means of the ITI mechanical torque limiters were within 10% of the set target values and were adjustable by the clinician to other torque levels from 0 to 45 Ncm.
3. The means of the ITL mechanical torque limiters tested were within 10% of the set target values when used with slow force applcation.

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