Accuracy of an Electric Torque-Limiting Device for Implants

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The torque output of the Nobelpharma electric torque controller was determined using a special setup on an Instron test machine. The devices were held in a vice and oriented so that activation of the drivers caused a pure torsion effect. Measured torque levels generally varied significantly between individual devices. Further, significant differences generally existed between the nominal torque levels and the corresponding measured values. Torque application errors varied from target values by 1% to 165%. For the clinician to deliver appropriate torque levels, these data indicate that a simple means for chairside calibration and adjustment should be available.
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Knowledge of the torque levels applied to the screws that retain implant abutments and their attached prostheses is necessary to achieve optimal preload. Preload occurs when torque is applied to a screw as it is tightened. As friction between opposing threads increases, the screw elongates, producing a clamping force between the screw head and its seat. If this elongation is maintained, the implant components will be held together.[1] When functional loads are applied, the screw head is compressed against its seat in the implant, thereby reducing the frictional forces between the threads. When threads disengage and the preload declines, the screw loosens.[2]

It has been reported that 90% of the torque applied to the first tightening of a screw system is used to overcome friction between the fastened components and only 10% of the initial torque serves to induce preload. After repeated tightening and loosening cycles, thread friction decreases because of burnishing of the contacting surfaces.[3] An increase in axial preload levels results. A knowledge of applied torque levels is essential to control these preloads.

When clinicians apply torque by hand, errors of 15% to 48% are to be expected.[4] Further, the amount of torque applied and therefore the amount of preload depends on the level of experience of the operator.[5] Inexperienced operators tend to undertorque screws, while experienced operators tend to overtorque them.[5] All samples are inconsistent in the torque levels generated.[5] In screw-retained orthopedic devices, standardization of torque using a torque wrench substantially reduced screw loosening.[6,7] A variety of devices have been developed to place controlled torque levels on dental implant components.[4,8] 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 variations from nominal or target torque values.[4,9]

One of the first and most popular torque-limiting devices uses an electrically controlled rheostat to apply precalibrated levels of torque to the appropriate driver (Torque Controller, Nobel Biocare, Westmont, IL). This device uses a foot-activated rheostat to drive the dental handpiece

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used to place implant components. Settings of 10, 20, 32, and 45 Ncm are preset to deliver specific torque levels to screw components. Each torque level has "high" and "low" designations, indicating high and low rotational speeds.

Carlsson has reported that the precision of this device is less than 10% when compared to the target values.[10] It was implied that errors of plus or minus 10% are considered acceptable to most clinicians. The purpose of this study was to examine the accuracy of examples of the Nobel Biocare electric torque controller that have been in clinical usage. The protocol for this study allows comparison of variations from nominal torque values within and between units.

Materials and Methods

Seven torque controllers (Nobel Biocare model DEA-020) were obtained from 6 clinical practices. A Unimat miniature lathe (American Edelstaal, New York, NY) was used as the test implant to transfer rotation generated by the torque controller to the lathe pulley. The torque-controller handpiece was held firmly in the lathe milling bed at the same angle for all tests; this prevented errors related to countertorque during activation of the electric wrench (Fig 1). The lathe was placed on the bed of an Instron test machine (Instron, Canton, MA), which was used to measure the force generated by the torque controller tangent to the pulley. In this study an "unknown" torque (T) was applied by the torque controller driving a pulley of known radius (R) acting tangentially to generate a force (F). This force could then be 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. 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 per minute, maximum torque values of 0.25 Ncm were observed.

At least 10 repetitions of torque levels of 10, 20, and 32 Ncm were recorded for each device. The torque values generated by each device, at each level, were analyzed using analysis of variance and Student's *t* test.

Results

The torque drivers tested were precise but inaccurate. Each driver gave fairly reproducible results, as seen from the small scatter about the means. However, they did not deliver the nominal or target torque values (ie, the means did not equal the target values).

Table 1 summarizes all of the data collected in this study. The data serve to illustrate the wide variations in torque output from different samples of the same model of controller. From this summary, a trend toward high measured values in the 10 Ncm settings can be seen, indicative of mean overtorque. At the 20 Ncm settings, the mean is close to the nominal setting, while at the 32 Ncm level, a mean tendency toward undertorque appears.

Figure 2 illustrates the target torque values in comparison to the full range of data. At the 10 Ncm setting, an undertorque error of 22% and

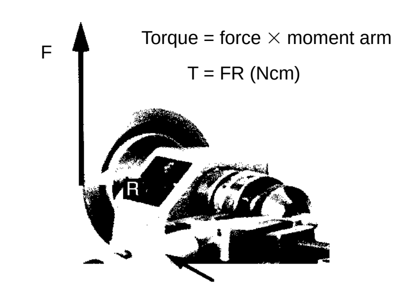

Fig 1 Diagram of test setup.

Table 1 Mean Torque Values (± SD) at Corresponding Controller Settings for 7 Devices Tested

Controller settings	Torque controller						
	1	2	3	4	5	6	7
10 low	7.78 ± 0.39	16.24 ± 0.88	17.32 ± 2.24	14.46 ± 0.47	20.04 ± 0.17	9.64 ± 0.17	16.58 ± 0.3
10 high	7.89 ± 0.23	19.55 ± 0.89	20.01 ± 0.58	17.65 ± 0.47	22.60 ± 1.78	12.10 ± 3.81	26.48 ± 1.12
20 low	15.72 ± 1.45	20.27 ± 0.91	17.99 ± 0.32	15.62 ± 0.39	22.87 ± 0.53	11.70 ± 0.19	22.28 ± 0.39
20 high	17.97 ± 0.39	23.09 ± 0.51	20.32 ± 0.52	17.97 ± 1.24	26.53 ± 0.77	14.25 ± 0.66	29.42 ± 0.58
32 low	20.10 ± 0.52	22.17 ± 0.16	21.13 ± 1.01	20.28 ± 0.65	36.42 ± 0.88	26.69 ± 0.36	24.40 ± 0.36
32 high	22.88 ± 0.26	24.00 ± 0.26	22.04 ± 1.72	22.13 ± 0.98	31.58 ± 3.63	17.79 ± 1.22	30.47 ± 0.77

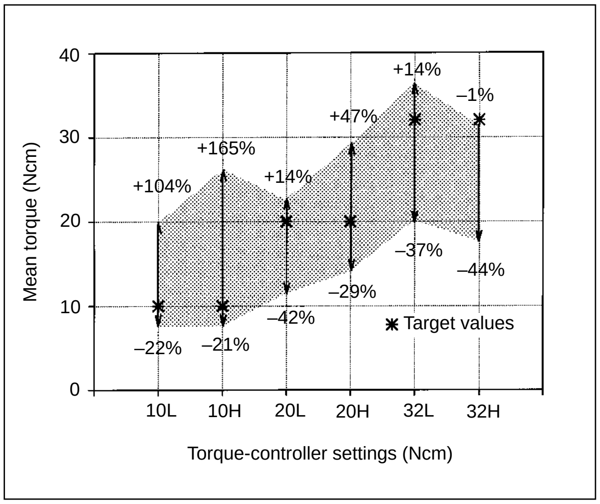

Fig 2 Graph indicating percentage variation from target values (indicated by *) by maximum torque error values.

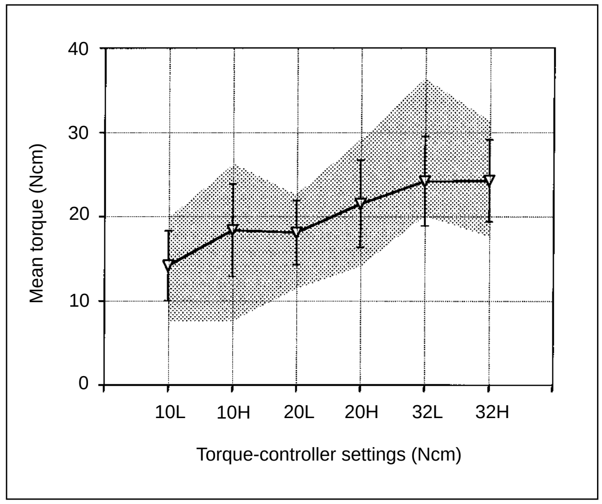

Fig 3 Graph indicating mean torque, with standard deviations for all controllers tested, superimposed on a background of all data collected in the study.

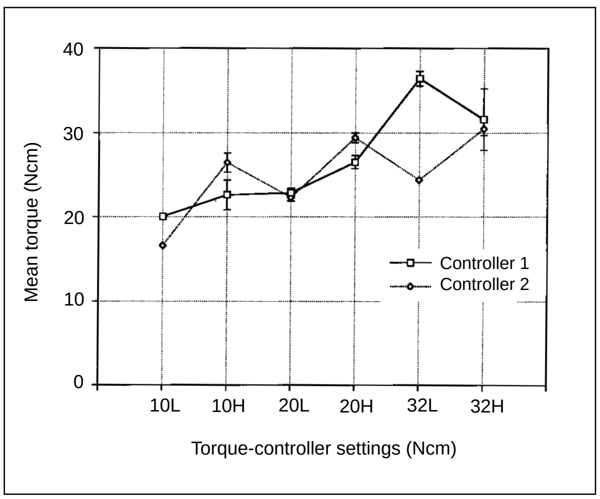

Fig 4 Graph indicating measured torque values for 2 torque controllers from the same oral surgery practice.

overtorque error of 165% were seen. At the 20 Ncm setting, both positive and negative errors greater than 40% were possible. At the 32 Ncm setting there was overtorque of 14% and undertorque of 44%.

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 standard deviation and outliers are the torque values that will be most likely to cause problems. Figure 3 shows that at the 10 Ncm settings these devices could be undertorqued at 7 Ncm or overtorqued at 28 Ncm. At the nominal 20 Ncm level, a range of –10 Ncm to 10 Ncm is possible. At the 32 Ncm settings, values were generally lower than the target values, with a possible negative error of 14 Ncm and positive error of 6 Ncm.

The results shown in Fig 4 came from 2 torque controllers from the same oral surgery practice. Fairly acceptable levels of torque for abutments to be placed at 20 Ncm or 32 Ncm could be realized if the 20 low and 32 high settings were used. However, if the application were a prosthodontic practice placing small-diameter gold screws at 10 Ncm, these controllers could be problematic. At the 10 high and 10 low settings, torque levels of 17 to 27 Ncm were actually delivered. Errors of over 3 times the prescribed torque at the 10 Ncm level, as demonstrated in this study, could be a contributing factor in screw failure.[11]

It has been suggested that abutment screws can be torqued over their recommended target levels to increase retention[11] or retorqued at frequent postinsertion intervals to achieve increased preload levels.[12] Such overtorque application is useful only as long as excessive plastic deformation or failure of the screw does not occur.[11] In short, screws that are undertorqued can become loose. Screws that are overtorqued can fracture, either at placement or after application of functional loading cycles.[13] The low levels of torque found at the 32 Ncm setting of the Nobel Biocare electric torque controllers used in this study preclude desirable overtorquing at the abutment-implant interface. The levels of torque delivered at the 10 Ncm and 20

Ncm settings were only slightly lower than the mean torque delivered at 32 Ncm (see Fig 4). The 45 Ncm setting could be used but would probably result in more overtorque than is prudent (this torque level is usually used in reverse to remove implant components).

This study shows that for the torque controllers tested, torque levels were unpredictable because of large errors within and between devices. The clinician should be aware of the actual torque output of the torque-limiting device in use. It would be even more advantageous if adjustments could be made to set these devices to desired levels. Unfortunately, the Nobel Biocare torque controller does not provide such adjustments. Until torque levels are predictable or controlled by surgeons in the operatory, these devices can be considered to be of little practical use.

Conclusions

The torque output of Nobel Biocare electric torque controllers obtained from active clinical practices was determined using a special setup on an Instron test machine. After application of the manufacturers' preset torque levels, significant variations were observed between individual devices. Each torque controller had a unique profile of actual torque output that was different from the other units tested. Further, the torque output of each individual device deviated from target torque values. This means that dentists may not know what torque these instruments are actually delivering. For the clinician to deliver the appropriate torque levels to achieve optimal preload, a simple means of chairside monitoring and torque adjustment should be made available.

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