

Original Article

Tightening torque of implant abutment using hand drivers against torque wrench and its effect on the internal surface of implant

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Abstract

Aim: The aim of this study was to compare the torque rendered by a handheld driver and a torque wrench and thereby evaluate its effect on the internal threads of implant.

Setting and Design: An *in-vitro* comparison of implant abutment torque using a digital torque gauge.

Materials and Methods: Thirty participants were randomly selected and were asked to torque two samples of mounted abutment analogs, one using a handheld driver and other with a torque wrench. The hex was then attached to the digital torque gauge to record the amount of torque generated and the recorded values were compared. Simultaneously, impressions of the internal threads of implant were taken using light body putty material before and after torque application. The samples were viewed under a stereomicroscope and the measurement of the initial four threads was compared.

Statistical Analysis Used: The data was subjected to statistical analysis using SPSS version 20.0 software. The intergroup comparison was done using one sample t-test , and the internal threads were analyzed using ANOVA statistical analysis.

Results: The results obtained showed that the torque generated using a handheld driver was higher (27–43 Ncm) than that of torque wrench (28–35 Ncm). Torque wrench values were within the manufacturer's recommendation. The mean of internal thread changes of the handheld driver and torque wrench was 861.033 mm and 864.350 mm, respectively, showing an insignificant difference. One-way ANOVA test showed $P < 0.01$ and difference of 11 mm for posttreatment hand torque and 14 mm for posttreatment torque wrench values.

Conclusions: The mechanical torque instrument showed specified torque values as recommended by the manufacturer. Consequently, the internal threads of the implants did not undergo any significant change using hand tightening or using a torque wrench.

Keywords: Hand torquing, digital torque gauge, torque wrench

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INTRODUCTION

Abutment screw loosening is the second most common cause of failure of implant-supported restorations.^[1] In routine practice, prosthetic components are torqued several times to adjust the temporary restorations and while making the impressions till the final prosthesis is being fabricated. Tightening of the screw with an appropriate torque is controlled by the clinician, emphasizing that a calibrated torque wrench be used. However, some clinicians use a handheld drivers instead of a torque wrench rendering a torque which is not defined. Furthermore, when the abutment is tightened, threads of the screw and internal threads of the implant can get deformed. Hence, the present study was designed to evaluate the torque difference between handheld drivers and torque wrench and thereby its effect on the internal threads of implant surface. The null hypothesis is that no difference could be found using a handheld drivers and a torque wrench.

MATERIALS AND METHODS

Sixty dental implant analogs (ADIN Dental Implant Systems Ltd., Israel) measuring 3.5 mm × 13 mm were mounted at the center of sixty autopolymerizing acrylic (DPI Cold Cure, Denture Base Material, Dental Products of India, Mumbai) blocks of approximately one inch each. These models were divided into two groups: hand torque and torque wrench, with 30 samples each. These samples were secured on the right (hand torque) and left side (torque wrench) of the table with clamps [Figure 1]. A total of 30 clinicians were included in the study: 20 males and 10 females. The age of all participants ranged from 23 to 37 years with a mean age of 27 years.

Comparison of internal threads changes of hand and wrench torque: After the models were secured, the internal surface of the implant analog was air-dried. Intraoral tip of an impression cartridge was loaded with light body impression material (ExpressTM XT Light Body, VPS Impression Material Light Body Regular Set, 3M ESPE), which was inserted as deeply as possible inside the implant body [Figure 2]. The light body was injected until it extruded from the implant shoulder. An interproximal wooden wedge was inserted in the middle of the impression and allowed to polymerize. The impression of the internal surface was carefully removed turning the wedge in a counterclockwise direction. The design of the internal threads of the implant analog was then examined under a stereomicroscope (Labovision, India) at $\times 100$ [Figure 3]. The distance between four threads at the top and bottom

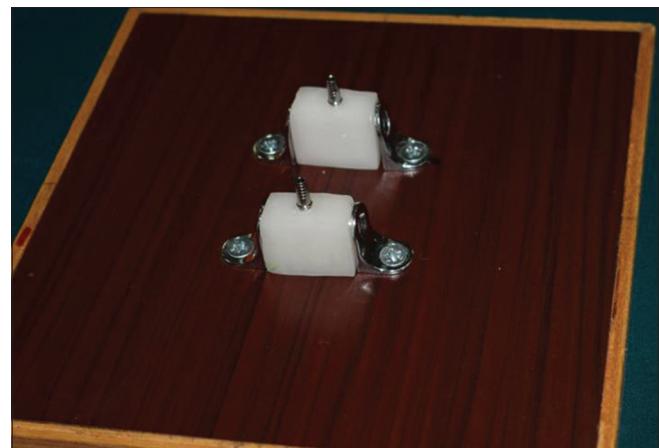


Figure 1: Acrylic model secured with clamps

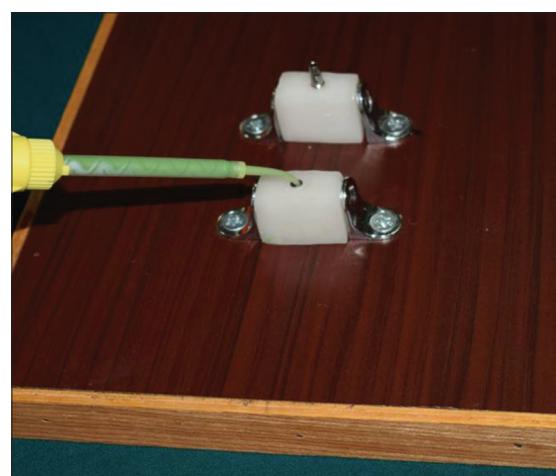


Figure 2: Light body impression



Figure 3: Stereomicroscope

was measured [Figure 4]. Measurement was done with Biowizard software and the readings were recorded.

After torquing the impression of the implant, internal threads were made again and the distance between the four

threads was measured using the stereomicroscope. The readings were recorded and compared statistically.

Comparison of hand driver and torque wrench: Digital torque gauge (SP Series, Eclatorq, Taiwan) was used to measure the torque ranging from 10 to 200 Ncm with 0.1 Ncm resolution and can be manually calibrated. It has a length of 203 mm and an auto-lock bit holder with 1/4th inch bit end fitting [Figure 5]. This 1/4th inch bit end was customized with an adapter to fit the handheld driver, measuring 1.27 inch hex head of implant system (ADIN Dental Implant Systems Ltd., Israel) for measuring torque using the handheld drivers and spring-type torque wrench (ADIN Dental Implant Systems Ltd., Israel) [Figure 6].

Each participant was asked to torque down two straight abutments (ADIN Dental Implant Systems Ltd., Israel): one using the hex torque driver and hand tightened and the other using spring-type torque wrench [Figure 7]. To reduce the settling effect, implant screws were tightened 10 minutes after the initial torque application using the same driver. After the individuals hand torqued the abutment,



Figure 4: Distance between four threads measured using Biowizard software



Figure 6: Torque wrench with hex drive

the hex driver was then attached with the adapter to the digital screwdriver (digital torque gauge with adapter SP Series, Eclatorq, Taiwan) to measure the peak tightening torque value, which was reported in Ncm [Figure 8]. The torque values were evaluated and recorded. In the similar manner, the participants were asked to torque the abutment using spring-type torque wrench. Once it was torqued, the wrench was removed and the hex was then attached with adapter to the digital screwdriver for measuring the peak torque value. Therefore, hand torque and torque wrench values were recorded for all the participants and subjected to statistical analysis.

RESULTS

The torque values of 30 operators for handheld drivers and using torque wrench were recorded and subjected to statistical analysis using SPSS software version 20.0 (SPSS Inc., Chicago, IL, USA) with the level of significance at $P = 0.05$.

Comparison of hand driver and torque wrench values: On descriptive statistical analysis, the mean torque produced by handheld drivers was 32.6 ± 5.409 Ncm and by torque wrench was 32.46 ± 2.361 Ncm. The maximum torque



Figure 5: Digital screwdriver SP series with adapter and hex drive



Figure 7: Screw tightening

**Figure 8:** Measurement of torque using digital torque driver

value for hand torquing was recorded to be 43 Ncm and for torque wrench was 35 Ncm. The range of torque values produced by handheld drivers was 27–43 Ncm and that for wrench was 28–35 Ncm. It is, however, noted that the standard deviation (SD) of handheld drivers was 5.409 which is 3 times greater than SD of torque wrench which was 2.361. The result demonstrated an operator inconsistency in generating torque with a manual driver and interoperator variability for both the groups. The mean values of both the groups were compared using one sample *t*-test and intergroup comparison was found to be significant, $P < 0.05$ [Table 1].

Comparison of internal thread changes of hand and wrench torque values: The mean of pretreatment torque values was 850 mm. The posttreatment hand torque was recorded to be 861.033 ± 4.006 mm whereas the posttreatment torque wrench value was 864.350 ± 3.102 mm, with the mean difference between the two groups being 14.35 ± 3.103 mm. A difference of 11 mm and 14 mm was noticed for posttreatment hand torque and wrench values, respectively, compared to pretreatment torque values. However, there was only 3 mm difference between the posttreatment hand torque and posttreatment torque wrench values. The mean values were compared and subjected to statistical analysis using ANOVA statistical analysis. The level of significance was found to be statistically significant ($P < 0.05$) [Table 2].

DISCUSSION

Accepted implant prosthodontic techniques have emphasized that abutment cylinders and superstructure attachments should be tight and the stability of each of these components should be verified at subsequent recalls.^[2] Problems associated with abutment screw loosening and

Table 1: Comparison of hand driver and torque wrench values using one sample *t*-test test

Groups	Hand torquing	Torque wrench
Mean \pm SD	32.617 ± 5.409	32.463 ± 2.361
<i>t</i> -test	33.028	75.312
Degree of freedom	29	29
<i>P</i>	0.001*	0.002*
Range	27–43	28–35

* $P < 0.05$ is significant. SD: Standard deviation

Table 2: Comparison of internal threads changes of hand and wrench torque values using ANOVA statistical test

Torque	Posthand torque	Postwrench torque	Pretorque
Mean \pm SD	861.033 ± 4.006	864.350 ± 3.102	850
ANOVA		12.853	
Degree of freedom		59	
<i>P</i>		0.001*	

* $P < 0.05$ is significant. SD: Standard deviation

fracture may be due to inaccurate fit and improper tightening.^[3] Implant-supported prosthesis requires adequate protection of implant abutment interface to ensure longevity. Huynh-Ba *et al.*^[4] reported that the 5-year prosthetic survival rate of implant-supported prosthesis was as high as 95.8%.

Despite the high long-term success rate of implants, they are still prone to different types of complications, including mechanical complications occurring in 60%–70% of cases. The most frequent reported mechanical complication was screw loosening, with an estimated annual rate of 2.1%–10.4% and 20.8% over 5 and 10 years, respectively. Several factors can play a role in screw loosening, including screw settling, magnitude of the functional loading, and inability to apply sufficient tightening force (torque) to the screw. One of the simplest methods to prevent screw loosening is to ascertain that screws are tight.^[5]

Manual screw drivers are the most commonly used tool to initiate the screw-tightening process. The expected error rates with manual screw drivers range from 15% to 48%. According to Siamos *et al.*^[6] mechanical torque-limiting devices (MTLDs) can deliver the required torques in a consistent manner. Therefore, MTLDs such as wrenches are necessary to reach the desired torque value. Recommended closing torque can range from 20 to 30 Ncm, with the ideal torque being 32 Ncm, depending on the design.

Although the manual application of a 32 Ncm torque to implant components is interesting from an experimental viewpoint, it is not a clinically realistic expectation. The stability of the abutment-implant connection and propensity for screw loosening is also influenced by the preload. The greater the joint preload, the greater the resistance to loosening, and the more stable the joint.^[7]

Dincer Kose *et al.*^[8] in a study reported that abutment screw with a 20 Ncm preload force can function for 2–3 months and those with a 30 Ncm preload force can function for 2–3 years without any complications.

Manual tightening of abutment screws, which is generally preferred by dentists, has the chances of producing suboptimal preload. Some reports indicate that mechanical drivers also produce inconsistent torque values. Therefore, using an experimental setup, the abutment torque using hand drivers and torque wrench was compared. The result of our study suggested that there is a possibility of exceeding the manufacturer's recommended torque values with hand tightening. The data showed that the maximum mean torque using hand drivers was more than the maximum mean torque using torque wrench. The null hypothesis was rejected because there was no difference in torque using handheld and wrench drivers, because a significant difference was found using a hand torquing driver and torque wrench.

In the present study, spring-style torque-limiting device was used, because literature supports the accuracy of spring rather than friction-style torque-limiting device. In spring-style torque-limiting device, the force was applied to the spring by the operator until the desired torque of 32 Ncm was read visually on the scale of 5, 15, 25, and 35 Ncm. The torque applied depends on the flexibility of the arm and the distance it is pulled away from the body. This procedure is subjective and sensitive to manual dexterity. Nevertheless, these devices generate torque in a range close to the manufacturer's recommended levels, which is above the range of torque values that can be generated with manual drivers. In this study, the values recorded had a range of 28–35 Ncm using torque wrench and therefore were well within their tolerance limits as specified by the manufacturers.

Gross *et al.*^[9] stated that manual driver was inconsistent with significant interoperator and intraoperator variability and concluded that to reach optimal recommended torque, mechanical torque drivers are mandatory. In our study, fastening was first done with a hand driver followed by fastening at a certain torque using a torque wrench. In our study, the hand tightening torque ranged from 27 to 43 Ncm, which significantly differed with mean maximum torque values of 9.4–19.9 Ncm as derived from the study by Gross *et al.*^[9]

Both Siamos *et al.*^[6] and Hill *et al.*^[10] showed a wide range of variability in torque force delivered with hand screwdrivers among tested individuals. Our study verified similar findings

and also demonstrated that some individuals could generate more torque than the highest desired target value of the most dental implant manufacturers (32 Ncm). Therefore, clinicians must be concerned about both undertightening and overtightening of implant components. Because of this varying degree of torquing ability among dentists, dental implant manufacturers need to be more precise regarding the recommended torque value as well as maximum allowable torque values for all components. Instructing clinicians to "finger tighten only" is not sufficient, as this could cause variation ranging from 27 to 43 Ncm (as derived from our study) depending on the clinician.

McGlumphy *et al.*^[11] have stated that the optimal torque value is 75% of the torque needed to cause the failure. The maximum tightening torque values using handheld drivers in our study was 43 Ncm, whereas using torque wrench was 35 Ncm. The torque value of 43 Ncm is close to the value causing screw fracture. It is very important to know how much torque value can be exerted with hand driver in advance.^[12]

Jaarda *et al.*^[13] compared the consistency of torque generated during manual tightening of implant components and concluded that the same operator showed a lack of consistency during multiple attempts at optimal screw tightening.

The participants in our study had clinically realistic limited access to simulate the oral cavity environment, as did the participants in the study by Hill *et al.*^[10] Despite these similarities, the participants in this study had a mean torque value of nearly 32 Ncm, which was twice (24 Ncm) as observed in a study by Kanawati *et al.*^[14] and thrice (12.9 Ncm) as observed by Hill *et al.*^[10] This could be due to other variables such as age of the participants, implant position, operator position, measuring device, and so forth. Although the study by Hill *et al.*^[10] did not provide an age range or average age, it stated that the group was composed of general dentists attending the state dental meeting. Hill's study indicated no difference in the ability to generate abutment screw preload torque based on the years of practice experience in dentistry.

The literature supports the concept that minimum abutment screw preload torque is critical and that excessive torque can exceed the yield strength of the screw material. Neiburger examined the age and dexterity of dentists and found that younger dentists tend to work faster but are less digitally sensitive than older dentists, which could explain why the inexperienced dentists were unable to produce more accurate torque values.^[15] Our study found

no significant difference among age and gender of the practitioners.

A second variable influencing the joint stability is how the contacting parts change when the screw is tightened. After being tightened together by the screw, the microroughness of all the metal contacting surfaces slightly flattens and the microscopic distance between contacting surfaces decreases.^[16] As a result of this process called “settling,” the screw loses part of its preload.^[17]

Extensive research has been carried out on deformation of abutment screw, but changes on the internal threads of dental implants have not been studied extensively.^[18] Novman *et al.*^[19] evaluated the surface changes of internal threads of the implant that occurs after repeated tightening and loosening of the abutment screw and concluded that there was no change in the internal threads of the implant on repeated screw tightening and loosening.

This study found values showing changes in the internal thread of implant after torquing with a mean difference of 14.350 ± 3.102 that clearly identifies the influence of friction on torquing. On comparing the hand tightened and torque wrench values, an insignificant difference was observed. The possible reason might be that the internal threads of dental implant are part of the dense metal body and hence it is not subjected to deformation easily. As implant alloy hardness is greater than prosthetic screw hardness, the surface alterations to implants were fewer than those observed on the prosthetic screw, as stated in a study by Guzaitis *et al.*^[20]

CONCLUSIONS

The torque values rendered with finger tightening were inconsistent, which proves that the torque varied with varying degrees of hand torquing abilities. The mechanical torque instrument showed specified torque values as recommended by the manufacturer within the limitations. The internal thread, however, did not have any changes using handheld drivers and torque wrench and seldom deformed drastically to initial tightening torque values. Thereby, it can be concluded that mechanical torque-limiting device should be mandatorily used, as handheld drivers produce varied torques.

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Conflicts of interest

There are no conflicts of interest.

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