

ORIGINAL RESEARCH



Intended and Achieved Torque of Implant Abutment's Screw using Manual Wrenches in Simulated Clinical Setting

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ABSTRACT

Objective: To measure the difference between the intended torque and the achieved torque by the operator using the spring-style mechanical torque-limiting device (MTLD).

Materials and methods: Inexperienced and experienced clinicians used one spring-type MTLD to torque two abutment screws of each anterior and posterior implants, which were attached to two digital torque meters through a jaw model. The jaw model was part of a preclinical bench manikin attached to a dental chair. The intended torque value was 35 N cm (recommended by manufacturer) and the technique of torquing was observed for all the participants (instantaneous and repeated). The mean torque value was calculated for each subject for the anterior and posterior implants independently; t-test was used to compare between the intended and achieved torque values and to compare between the experienced and inexperienced clinicians ($p \leq 0.05$).

Results: Thirty-seven clinicians participated, with an overall mean torque value of 34.30 N cm. The mean torque value of the achieved torque (34.30 ± 4.13 N cm) was statistically significantly less than the intended torque ($p=0.041$). The male clinicians produced more statistically significantly accurate torque value (34.54 ± 3.78 N cm) than the female clinicians ($p=0.034$), and the experienced clinicians produced more accurate torque values (34.9 ± 5.13 N cm) than the inexperienced clinicians ($p=0.048$).

Conclusion: Within the limitation of this study, the use of MTLDs did not always produce consistent torque values and the technique by which the operators use the MTLD might affect the torque value.

Keywords: Dental implant, Manual wrenches, Screw loosening, Torque.

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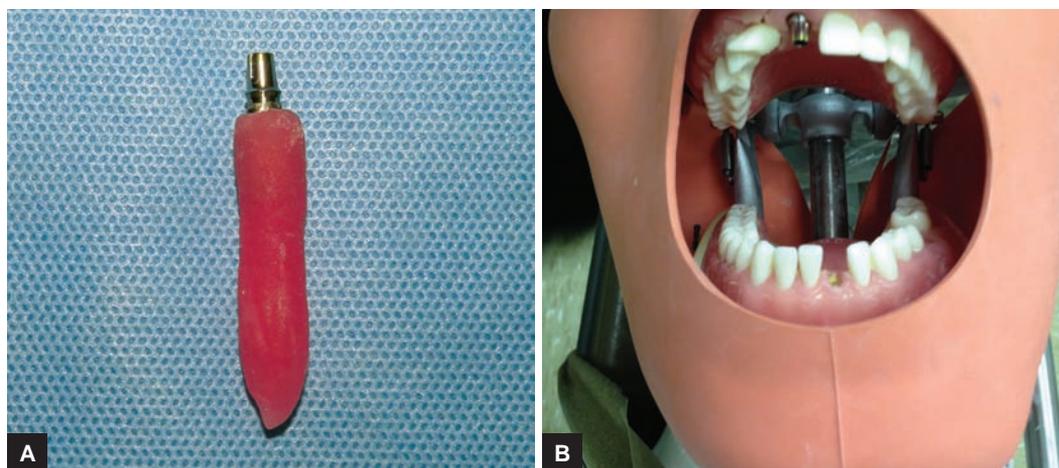
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INTRODUCTION

The use of dental implants is an established procedure for the treatment of completely and partially edentulous patients. The types of prostheses that can be used in conjunction with dental implants can vary between removable and fixed prostheses. Screw- and cement-retained prostheses are used frequently; however, many systematic reviews have indicated that screw-retained prosthesis might be biologically superior due to lower incidence of marginal bone loss and soft tissue complications.^{1,2}

The ability to generate accurate torque values when tightening the abutment's screw is essential for the long-term stability of the implant-abutment interface. The force that develops within the screw when torque is applied is known as the preload, and this force is proportional to the applied torque.³ On the one hand, inadequate torque may lead to screw fatigue, loosening, and failure, and on the other hand, excessive torque may lead to screw fracture.⁴ Therefore, it is essential to deliver an accurate level of torque, as recommended by the manufacturer, for a particular implant system.

The torque can be delivered manually using screw-drivers; however, the level of experience can affect the accuracy of the manually applied torque, where both experienced and inexperienced subjects were unable to reach the recommended torque value.⁵ It was found that the average torque applied with a screw driver is only 10 N cm.⁶ It is difficult to generate more than 20 N cm



Figs 1A and B: (A) implant fixture embedded in acrylic resin; and (B) implant stabilized in dentoform model with a straight abutment attached to the implant

manually, which may lead to an inadequate preload of the implant screw joint, and mechanical torque-limiting devices (MTLDs) are used to precisely set the fastening force to the abutment screw.⁷

Mechanical torque-limiting devices are available as either friction style or spring style. The friction-style MTLD is a hex wrench with a handle-release mechanism preset by the manufacturer; the spring-style MTLD is a ratchet-type torque wrench with no release mechanism. The target torque value is marked on the scale and the clinician applies a force until the desired torque is visually reached.⁸

Many *in vitro* studies that compare the ability of MTLDs to deliver the desired torque value have been published.^{7,9,10} In these, one or two trained operators perform the experiment to compare the devices. However, and to the best of our knowledge, the ability of experienced and inexperienced dentists to properly use the MTLDs and achieve the desired torque value recommended by the manufacturer is not known.

The aim of this study was to measure the difference between the intended torque and the achieved torque by the operator when using the spring-style MTLD. The null hypothesis was that there is no difference between the intended and achieved torque applied to the abutment screw.

MATERIALS AND METHODS

Approval from the College of Dentistry Research Centre (CDRC) ethical subcommittee was obtained prior to the commencement of the study. Dental clinicians with different experience in implant dentistry participated in this study, and consent form was obtained from each participant prior to the start of the experiment. The demographic data were collected from all the participants, including gender, specialty, and level of experience (30 or more

implants or less than 30 implants treated). A dentoform (Dentoform model R861, Kavo, Germany), modified by attaching two digital torque meters (Tohnici torque gauge model BTGE50CN, Tonichi, Japan) was used. Two regular platform ($4.3 \times 13 + 3$) internal connection implants (Replace™ Select TC, Nobel Biocare, Goteborg, Sweden) were attached to the digital torque meter. Implant fixtures were embedded in acrylic resin (Triad VLC, Dentsply, York Division, USA) (Fig. 1A) and inserted into the dentoform model in the area of maxillary right central incisor and mandibular left first molar, where it is attached to the torque gauge penetrating the jaw model in these areas (Fig. 1B). The dentoform was part of a preclinical bench manikin (Kavo, DSP plus 5192, Germany) that was attached to a dental chair with an adhesive strap (PAOKO Industrial Co., Ltd., China) (Fig. 2).

A straight abutment (Replace™ Select Nobel Biocare, Goteborg, Sweden) was attached to the implant. Each subject was asked to apply the recommended torque (35 N cm) on two abutment screws for the anterior and the posterior implant using the spring-type MTLD (Manual



Fig. 2: A dental manikin attached to dental chair with adhesive strap

Torque Wrench Prosthetic, 29165, Replace™ Select, Nobel Biocare, Goteborg) with a universal manual screw driver, featuring a uniGrip 20 mm (29148, Replace™ Select, Nobel Biocare, Goteborg, Sweden). The subjects used the same spring-type MTLD throughout the experiment, changing the abutment screw for each torque application, using a total of 148 screws. The clinicians were asked to wear gloves (latex examination gloves, Medicare, Malaysia) and wet it before the experiment to simulate the clinical situation. The mode of torque application was observed and recorded by the investigators during the experiment, whether instantaneous or repeated.

The mean torque value was calculated for each subject for the anterior and posterior implants independently. The data were analyzed using the one-sample t-test to compare the intended and the achieved torque values at 35 N cm, which is the torque value recommended by the manufacturer. Independent t-test was also used to compare the torque values between male and female, and between instantaneous and repeated, and finally between anterior and posterior implants. The p value was set at 0.05.

RESULTS

The total number of clinicians who participated in the study was 37, among whom 19 were females (9 inexperienced and 10 experienced clinicians) and 18 were males (11 inexperienced and 7 experienced clinicians). All the participants were supposed to reach the accurate cut point of 35 N cm, which represents the torque value recommended by the manufacturer for the Nobel replace implant system. At a sample number of 37 participants and estimated standard deviation (SD) equal to 3 and a target mean value of 35 N cm, the power was 0.88.

Table 1: The mean torque value of the intended and achieved torque values

Torque	Mean torque	n	SD
Intended torque	35.00	148	0
Achieved torque	34.30	148	4.13*

*Statistically significant at p≤0.05

The mean torque value of the achieved torque was 34.30±4.13 N cm, which is significantly less than the intended torque (35 N cm) (p=0.041) (Table 1).

Generally, male clinicians produced more statistically significant accurate torque value (34.54±3.78 N cm), in comparison with female clinicians (34.07±5.29 N cm) (p=0.034), and the experienced clinician, regardless of gender, produced a more accurate torque value (34.9±5.13 N cm) than the inexperienced clinicians (33.79±4.08 N cm) (p=0.048).

The repeated technique was used less frequently by the participants but resulted in more accurate torque values (35.31±5.8 N cm) in comparison to the instantaneous technique (33.77±3.77 N cm) (p=0.000).

The inexperienced male using the instantaneous technique for torquing demonstrated the most accurate torque value (34.87±3.91 N cm), while the experienced females using repeated technique for torquing demonstrated the least accurate torquing, with values being higher and lower than recommended and which were statistically significant (38.72±5.89 N cm) (Table 2).

Effect of Implant Location (Access) on the Accuracy of Torque Application

The instantaneous technique was the most commonly used technique for torquing of anterior and posterior implants (Table 3). The torquing of the posterior implants resulted in torque values closer to that recommended by the manufacturer, regardless of the technique, gender,

Table 2: The mean torque values distributed by level of experience, gender, and technique used

Technique	Gender	Participants	n	Mean torque	SD
Instantaneous	Female	Inexperienced	16	32.65	2.45
		Experienced	20	32.51	3.98
	Male	Inexperienced	35	34.87	3.91
		Experienced	26	33.96	3.85
Repeated	Female	Inexperienced	20	32.13	4.99
		Experienced	20	38.72	5.89
	Male	Inexperienced	9	35.33	3.43
		Experienced	2	32.95	2.69

Table 3: Comparison of mean torque values on the instantaneous and repeated techniques of anterior and posterior implants using t-test (p ≤ 0.05)

Implant location	Technique	n	Minimum	Maximum	Mean torque	SD
Anterior	Instantaneous	48	21.90	38.65	32.79	3.51
	Repeated	26	27.05	47.40	35.24	5.75
Posterior	Instantaneous	49	27.50	45.60	34.73	3.80
	Repeated	25	19.25	46.30	35.38	5.96

and experience level. However, this difference was not found to be statistically significant between the anterior and posterior implants ($p=0.2$).

DISCUSSION

There is a wide variation in the ability of clinicians to perceive adequate torquing forces that are applied to implant components.¹¹ Studies evaluating the torque generated by various operators who use hand drivers have shown a wide range of results.^{11,12} The use of MTLDs was advocated to ensure more consistent torque application.^{13,14}

However, based on the results obtained from this study, the null hypothesis was rejected. That is to say, there was a statistically significant difference between the intended and the achieved torque values.

The subject's level of experience with the implant's screw torquing was determined based on the average number of screws torqued during practice. The level was set at 30 implants, where less than 30 represented the inexperienced group and 30 or more represented the experienced group. Generally, male subjects were able to generate more accurate torque values than female subjects, and the experienced subjects, regardless of gender, were able to generate more accurate torque values. This is consistent with the results reported in the literature.¹³ Neiburger¹⁵ 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 (most of them are new graduates) were unable to produce more accurate torque values. It is worth mentioning that the female subjects produced the lowest and highest torque values (19.25 and 47.40 N cm respectively), indicating that there was more variation among the female subjects regardless of the level of experience.

Generally, the subjects were able to torque the posterior implant more accurately than the anterior implants. In spite of the direct access to the anterior implant, the operator position in relation to the patient's head, which was beside and slightly behind the participant, might make the use of the MTLD more difficult than the torquing of the posterior implant where the participants had a direct view of the marked incremental scale of the spring MTLD.

For the final torquing of abutment or prosthetic screws, the company recommends that the operator apply a force on the spring until the appropriate torque value is reached. It was noticed that the participants (regardless of the gender or level of experience) used the MTLDs in different ways. Some participants followed the manufacturer's recommended technique (the instantaneous technique), but others tended to reach the target torque value, release the spring, and then reapply torque to the

target value again (the repeated technique). Although the participants used the repeated technique less often (used 51 out of 148 times), it resulted in more accurate mean torque values than the instantaneous technique. When the instantaneous technique was used to torque the anterior implant, it resulted in significantly lower torque values. Siamos et al¹⁶ suggested a more controlled form of retorque (repeated technique) where the abutment screws are retorqued 10 minutes after the initial torque applications, and according to their results, this technique will enhance the stability of the screw. It has also been suggested by several authors that the implant-abutment joint must be retorqued after the initial screw insertion and periodically thereafter.^{5,17}

The same MTLD was used with all subjects, and the variation in the recorded values cannot be attributed to the fact that all subjects used only one MTLD. According to Goheen et al,¹¹ MTLDs can deliver the required torques in a consistent manner. Another study comparing three types of MTLDs found that the spring-type device provided torque values that were within 10% of the set target values.⁸

Periodic calibration and training on the use of MTLD might be necessary regardless of the practitioner's level of experience. The use of electronic torque controllers, typically in the form of a latch-type dental hand piece, might be advocated to deliver more consistent torque values.

CONCLUSION

The use of MTLDs to torque abutment screws did not always result in consistent torque values. The technique by which the operators use the MTLD might affect the obtained torque value, which is also the case for the ability to directly visualize the scale of the MTLD.

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