Original Research

# Torque Removal Evaluation of Screw in One-Piece and Two-Piece Abutments Tightened with a Handheld screwdriver

**Jalil Ghanbarzadeh[1], Mahboobeh Rajabzadeh[2], Mohammadreza Nakhaei[3], Hamidreza Rajatihaghi[4], Niloufar Tayarani Najjaran[1]**

[1]Department of Prosthodontics, Faculty of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran
[2] Departments of Periodontics, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran
[3] Dental Research Center, Faculty of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran
[4] Dental Material Research Center, Faculty of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran

***Received 16 July 2013 and Accepted 8 November 2013***

## Abstract

**Introduction:** Some clinicians use a handheld screw driver instead of a torque wrench to definitively tighten abutment screws. The aim of this study was to compare the removal torque of one-piece and two-piece abutments tightened with a handheld driver and a torque control ratchet. **Methods:** 40 ITI implants were placed in acrylic blocks and divided into 4 groups. In groups one and two, 10 ITI one-piece abutments (Solid®) and in groups three and four, 10 ITI two-piece abutments (Synocta®) were placed on the implants. In groups one and three abutments were tightened by 5 experienced males and 5 experienced females using a handheld driver. In groups two and four abutments were tightened using a torque wrench with torque values of 10, 20 and 35 N.cm. Insertion torque and removal torque values of the abutments were measured with a digital torque meter. **Results:** The insertion torque values (ITVs) of males in both abutments were significantly higher than those of females. ITVs in both Solid® and Synocta® abutments tightened with a handheld screwdriver were similar to the torque of 20 N.cm in the torque wrench. Removal torque values (RTVs) of solid® abutments were higher than those of synocta® abutments. **Conclusion:** The one- piece abutments (solid®) showed higher RTVs than the two-piece abutments (synocta®). Hand driver does not produce sufficient preload force for the final tightening of the abutment.

**Key words:** Hand driver, one-piece abutment, removal torque, torque wrench, two-piece abutment.

-----------------------------------------------------------

Ghanbarzadeh J, Rajabzadeh M, Nakhaei M, Rajatihaghi H, Tayarani Najjaran N. Torque Removal Evaluation of Screw in One-piece and Two-piece Abutments Tightened with a Handheld screwdriver. J Dent Mater Tech 2014; 3(1): 11-5.

## Introduction

Screw loosening is one of the most common complications in implant-supported restorations (1-3). Several factors have a role in screw loosening, which include tightening torque, settling effect, metal fatigue, abutment misfit, and occlusal loading (4,5). Tightening of the screw results in elongation which in turn leads to tension in the screw, referred to as preload. Preload is transformed to a clamping force that is necessary to maintain the abutment united to the implant. Preload is directly proportional to the torque applied and the higher the preload, within a certain limit, the lower probability of screw loosening (4,6-8). Although the application of a low torque increases the odds of screw loosening, excessive torque also leads to permanent deformation of the screw and loss of its proper mechanical properties.

Tightening of the screw with an appropriate torque is controlled by the clinician and can decrease the odds of screw loosening. It has been emphasized that manufacturer's instructions should be followed in order to achieve a proper preload in abutment screws with the use of a torque limiting device (9-12). However, as for various reasons, some clinicians use a handheld screw driver instead of a torque wrench; the efficacy of the torque applied with the handheld wrench should be evaluated and ensured.

Previous studies have evaluated the torque applied by handheld screw driver during tightening of the abutment screw (9,10,13,14). However, no studies are available, in which the removal torque has been evaluated in one-piece abutments tightened using a handheld screw driver. The aim of the present study was to compare the removal torque of one-piece and two-piece abutments tightened with a handheld driver and a torque wrench.

## Materials and Methods

40 ITI fixtures (Regular Neck, Straumann, Basel, Switzerland) measuring 4.1 mm in diameter and 10 mm in length were placed in acrylic blocks. The fixtures were divided into 4 groups of 10 with simple randomize.

In groups one and two, 10 ITI one-piece abutments (Solid®, Strauman, Basel, Switzerland) and in groups three and four, 10 ITI two-piece abutments (Synocta®, Strauman, Basel, Switzerland) were placed on the implants. The acrylic blocks were fixed on the three-jaw chuck of a digital torque meter. In order to simulate a clinical setting, this assembly was adjusted in a head phantom in the first molar area. The maximum anterior opening of the mouth in the head phantom was approximately 42 mm and the head phantom was placed in a reclined position. A total of 10 prosthodontists, 5 males and 5 females, with at least 5 years of clinical experience, were asked to participate in the study. All the participants were right-hand dominant and 30 to 40 years of age. In order to better simulate clinical conditions, the participants were asked to sit in an appropriate position and use moistened gloves to tighten the abutments. The participants were asked to tighten Solid® and Synocta® abutments in groups one and three, respectively, using the hand driver. In each of these groups, five abutments were tightened by male participants and five others were tightened by female participants. The maximum force applied to tighten each abutment and the torque necessary to remove the abutment were recorded by the digital torque meter.

In groups two and four (control groups), the abutments were tightened with an ITI torque wrench. In group two, the 10 Solid® abutments, and in group four, the 10 Synocta® abutments were tightened with 10, 20 and 35 Ncm torque and the force needed to remove each abutment was recorded by the digital torque meter. The process was repeated 10 times for each abutment and the mean removal torque values (RTVs) was calculated for 10, 20 and 35 N.cm torques. Data were analyzed using t-test and P-value of less than 0.05 was considered to be statistically significant.

## Results

The insertion torque values (ITVs) of males in both abutments were significantly higher than those of females ($P<0.05$). The male participants tightened the RTVs of solid abutments significantly higher than the females. However, no significant difference was observed in RTVs of Synocta® abutments between the males and the females (Table 1).

In the abutments tightened using a handheld screw driver, the mean ITVs in both Solid and Synocta abutments were similar to the torque of 20 N.cm in torque wrench ($P>0.05$). The mean RTVs of Solid® abutments were significantly higher than those of Synocta® abutments ($P<0.05$) (Table 2).

In Solid® abutments, there were no significant differences between RTVs of samples tightened with a hand driver and those tightened using a torque wrench with 20 N.cm ($P>0.05$). However, in Synocta® abutments, there were significant differences between RTVs of samples tightened with a handheld wrench and those tightened with 10, 20 and 35 N.cm torques ($P<0.05$) (Table 2).

**Table 1.** The mean tightening and removal torque values of abutments tightened using a handheld driver

| Abutment type | Tightening torque | | | Removal torque | | |
|---|---|---|---|---|---|---|
| | Male | Female | *P*-value | Male | Female | *P*-value |
| One-piece (solid®) | 28.8±4.61 | 16.8±1.73 | 0.001 | 20.25±4.46 | 13.16±2.18 | 0.013 |
| Two-piece (synocta®) | 23.31±5.29 | 14.94±2.4 | 0.013 | 14.42±4.46 | 10.34±3.4 | 0.143 |

$P<0.05$ is considered as significant

**Table 2.** The mean tightening torque and removal torque values of abutments tightened with handheld driver and torque wrench

| Abutment type | Handheld driver | | Torque wrench | |
|---|---|---|---|---|
| | Tightening torque | Removal torque | Tightening torque | Removal torque |
| One-piece (solid®) | 22.8±7.12$^{b}$ | 16.71±4.9$^{B}$ | 10$^{a}$ | 9.18±0.32$^{A}$ |
| | | | 20$^{bd}$ | 19.47±1.09$^{B}$ |
| | | | 35$^{c}$ | 34.76±1.13$^{C}$ |
| Two-piece (synocta®) | 19.12±5.89$^{d}$ | 12.38±4.3$^{D}$ | 10$^{a}$ | 7.35±0.32$^{E}$ |
| | | | 20$^{bd}$ | 16.5±0.87$^{F}$ |
| | | | 35$^{c}$ | 30.38±1.46$^{G}$ |

Different lowercase letters indicate significant difference in tightening torque values (P<0.05)

Different uppercase letters indicate significant difference in removal torque values (P<0.05)

## Discussion

The results of this study showed that RTVs of one-piece (Solid®) abutments were higher than that of two-piece abutment (Synocta®). The RTVs of Solid® abutments tightened with a handheld driver were similar to the 20 N.cm tightening force applied by the torque control ratchet.

The results of the present study are consistent with those of other studies which have indicated a wide range of torque ability with the use of a handheld driver (9,10,15). It has been demonstrated that experienced operators applied more consistent compressive axial force during screw tightening and loosening (16).

Hill et al. evaluated the ability of general dentists to apply torque using a handheld driver and showed that the experience is not an important factor in the ability to tighten abutment screws. It should be noted that in this study, the experience was defined as the number of years of clinical practice or the years elapsed since graduation from university (9). However, this conclusion might be questionable because general dentists with long clinical experience might still not have enough experience with implant tools.

Kanawati et al. (10) reported an average torque ability of 24 N.cm for the dentists and dental students. Hill et al. (9) reported a mean torque value of 12.9 N.cm for the general dentists. The corresponding values recorded in the present study were 22.8 and 19.1 N.cm for Solid® and Synocta® abutments, respectively. This variation in the results might be attributed to differences in age, clinical experience and dexterity of participants.

In the groups in which the abutments had been tightened with a hand driver, the RTVs of Solid® abutments were higher than Synocta® abutments. This result was predictable and could be attributed to a higher tightening torque of Solid® abutments. Nevertheless, in the abutments tightened using a torque wrench with equal torques of 10, 20 and 35 N.cm (control groups), Solid® abutments exhibited higher RTVs compared to Synocta® abutments. This finding is consistent with the results of Cehreli et al. (17) who placed crowns on abutments and subjected them to mechanical loading cycles.

A higher removal torque value (RTV) in Solid® abutments compared to Synocta® abutments might be attributed to the fact that Synocta® abutments are predominantly retained by the preload of the screw. However, in addition to preload, the friction at the Morse taper interface also plays a crucial role in the maintenance of solid abutments.

Unlike Solid® abutments, Synocta® abutments have octagon anti-rotational features. It is believed that anti-rotational features result in a better transfer of forces to the implant and bone and reduce the potential for abutment screw loosening. The following studies confirm that the anti-rotational feature only helps the position of the abutment in the implant and has no effect on the stability of the abutment screw. Cardoso et al. (6) used external hexagon implants and reported that removal of hexagon from the abutment has no effect on the RTV of the screw. Cibrika et al. (5) showed that lack of a precise fit between the implant external hexagon and abutment internal hexagon or even elimination of the external hexagon has no adverse effect on RTV. Tusgat et al. (18) showed that the anti-rotational features – whether external or internal – have no effect on RTV.

It has been claimed that Morse taper interface provides a mechanical locking friction without rotation, referred to as cold weld. A higher removal torque value compared to insertion torque value is an indication of the presence of cold weld. Sutter et al. (19) showed that even under mechanical loads, Morse taper results in a higher RTV compared to insertion torque value.

However, Michael et al. (20) evaluated RTVs of ITI and Astra implants and reported that at clinical tightening levels, RTV is 80–90% of the ITVs and showed absence of cold welding. Cehreli et al. (17) also reported an 8% decrease in RTV for Solid® abutments and concluded that cold welding does not occur. Based on the results of the present study, with the 35 N.cm torque, which is recommended by the manufacturer, RTVs was less than the ITVs, which is an indication that cold weld had not occurred.

In the present study, the prosthodontists in a certain age range were asked to participate to minimize the effect of factors such as age, clinical experience and dexterity. The participants had limited access to the abutment screw in order to simulate the oral cavity environment. Presence of saliva, poor visibility and lack of patient cooperation which have a negative effect on applying torque in clinical conditions could not be simulated in this study. Another limitation of this study was the evaluation of a specific brand. It is also a fact that different results would have been obtained with regard to RTVs if the abutments had received crowns and had been subjected to cyclic dynamic loads. Thus further studies are recommended with other implant abutment connections and under dynamic loads to confirm the results of the present study.

## Conclusion

Considering the limitations of the present study, the following conclusions were drawn:

1. One-piece abutments display higher RTVs than two-piece abutments.
2. Handheld driver does not produce sufficient preload force for the final tightening of the abutment.


## Acknowledgement

This study was supported by a grant (No. 900077) from the Vice Chancellor for Research of Mashhad University of Medical Sciences. The results presented here are based on an undergraduate thesis (No. 2545) submitted to Mashhad Faculty of Dentistry and Dental Research Center.


## References


1. Wittneben JG, Buser D, Salvi GE, Bürgin W, Hicklin S, Brägger U. Complication and failure rates with implant-supported fixed dental prostheses and single crowns: A 10-year retrospective study. Clin Implant Dent Relat Res 2013 (In Press).
2. PjeturssonBE, Thoma D, Jung R, Zwahlen M, Zembic A. A systematic review of the survival and complication rates of implant-supported fixed dental prostheses (FDPs) after a mean observation period of at least 5 years. Clin Oral Implants Res 2012;23:22-38.
3. Romeo E, Storelli S. Systematic review of the survival rate and the biological, technical, and aesthetic complications of fixed dental prostheses with cantilevers on implants reported in longitudinal studies with a mean of 5 years follow-up. Clin Oral Implants Res 2012;23:39-49.
4. Yao KT, Kao HC, Cheng CK, Fang HW, Yip SW, Hsu ML. The effect of clockwise and counterclockwise twisting moments on abutment screw loosening. Clin Oral Implants Res 2012;23:1181-6.
5. Cibirka RM, Nelson SK, Lang BR, Rueggeberg FA. Examination of the implant-abutment interface after fatigue testing. J Prosthet Dent 2001;85: 268-75.
6. Cardoso M, Torres MF, Lourenço EJ, de Moraes Telles D, Rodrigues RC, Ribeiro RF. Torque removal evaluation of prosthetic screws after tightening and loosening cycles: an in vitro study. Clin Oral Implants Res 2012;23:475-80.
7. Byrne D, Jacobs S, O'Connell B, Houston F, Claffey N. Preloads generated with repeated tightening in three types of screws used in dental implant assemblies. J Prosthodont 2006;15:164-71.
8. Winkler S, Ring K, Ring JD, Boberick KG. Implant screw mechanics and the settling effect: overview. J Oral Implantol 2003;29:242-5.
9. Hill EE, Phillips SM, Breeding LC. Implant abutment screw torque generated by general dentists using a hand driver in a limited access space simulating the mouth. J Oral Implantol 2007;33:277-9.
10. Kanawati A, Richards MW, Becker JJ, Monaco NE. Measurement of clinicians' ability to hand torque dental implant components. J Oral Implantol 2009;35:185-8.

11. Quek HC, Tan KB, Nicholls JI. Load fatigue performance of four implant-abutment interface designs: effect of torque level and implant system. Int J Oral Maxillofac Implants 2008;23:253-62.
12. Vallee MC, Conrad HJ, Basu S, Seong WJ. Accuracy of friction-style and spring-style mechanical torque limiting devices for dental implants. J Prosthet Dent 2008;100:86-92.
13. 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;9:149-55.
14. Dellinges MA, Tebrock OC. A measurement of torque values obtained with hand-held drivers in a simulated clinical setting. J Prosthodont 1993;2:212-4.
15. Stüker RA, Teixeira ER, Beck JC, da Costa NP. Preload and torque removal evaluation of three different abutment screws for single standing implant restorations. J Appl Oral Sci 2008;16:55-8.
16. Pesun IJ, Brosky ME, Korioth TW, Hodges J, Devoe BJ. Operator-induced compressive axial forces during implant gold screw fastening. J Prosthet Dent 2001;86:15-9.
17. Cehreli MC, Akça K, Iplikçioğlu H, Sahin S. Dynamic fatigue resistance of implant-abutment junction in an internally notched morse-taper oral implant: influence of abutment design. Clin Oral Implants Res 2004;15:459-65.
18. Tsuge T, Hagiwara Y. Influence of lateral-oblique cyclic loading on abutment screw loosening of internal and external hexagon implants. Dent Mater J 2009;28:373-81.
19. Sutter F, Weber HP, Sorensen J, Belser U. The new restorative concept of the ITI dental implant system: design and engineering. Int J Periodont Rest Dent 1993;13:409-31.
20. Norton MR. Assessment of cold welding properties of the internal conical interface of two commercially available implant systems. J Prosthet Dent 1999;81:159-66.

**Corresponding Author:**
Mohammadreza Nakhaei
Faculty of Dentistry and Dental Research Center
Vakilabad Blvd, Mashhad, Iran
P. O. Box: 91735-984
Tel: +98-511-8829501
Fax: +98-511-8829500
E-mail: mrn_nakhaei@yahoo.com