

# The influence of clinical experience and gender in the manual application of torque on screws of implant-supported prosthesis

*A influência da experiência clínica e do gênero na aplicação manual de torque em parafusos de prótese suportada por implante*

*La influencia de la experiencia clínica y el género en la aplicación manual de torque en tornillos de prótesis sobre implantes*

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## Abstract

Compare with the torque value recommended by the manufacturer, the values of maximum closing torques generated by volunteers of the male and female gender, with and without experience in implant-prosthesis, for tightening the screw UCLA abutment retention. The hypotheses tested were that the greatest experience in the field would not influence the value of the applied torque, as there would be no difference between volunteers from different genders. In this way, 266 volunteers were classified according to their expertise in pre-clinical (PC), clinical (C) and professional (P). Were placed seated, simulating normal forward work position in front a digital torque meter. A specimen composed of an external hex implant embedded in modified polyester resin, a metal crown and its retaining screw was attached on torque meter. The participants were provided with directions to tighten the abutment retaining screw by using a manual torque driver and apply full force in one movement of rotation. The professional group achieved the highest mean manual torque (15.80 N / cm); males (14.96 N/cm) scores a higher than females (02.11 N/cm). They could not reach the torque value recommended by the manufacturer. Thus, the factors that influence the manual application of torque include the level of clinical experience and the physical strength of the operator. The conclusion is that the use of a calibrated mechanical driver torque is essential to apply a suitable and controlled torque value and capable of promoting a proper preload and maintaining the screwed joint for long periods.

**Descriptors:** Dental Implants; Dental Prosthesis, Implant-Supported; Stress, Mechanical.

## Resumo

Comparar com o valor de torque recomendado pelo fabricante, os valores dos binários máximos de fechamento gerados por voluntários do gênero masculino e feminino, com e sem experiência em implante/prótese, para apertar a retenção de pilar UCLA de parafuso. As hipóteses testadas foram que a maior experiência no campo não influenciaria o valor do torque aplicado, pois não haveria diferença entre voluntários de diferentes gêneros. Desta forma, 266 voluntários foram classificados de acordo com sua experiência em pré-clínica (PC), clínica (C) e profissional (P). Foram colocados sentados, simulando a posição normal de trabalho na frente de um medidor de torque digital. Um espécime composto por um implante hexadecimial externo incorporado em resina de poliéster modificada, uma coroa de metal e seu parafuso de retenção foi preso no medidor de torque. Os participantes receberam instruções para apertar o parafuso de retenção do pilar usando um excitador de torque manual e aplicar força total em um movimento de rotação. O grupo profissional alcançou o torque manual médio mais alto (15.80 N / cm); Os machos (14,96 N / cm) obtêm pontuação superior às do sexo feminino (02.11 N / cm). Eles não conseguiram alcançar o valor de torque recomendado pelo fabricante. Assim, os fatores que influenciam a aplicação manual do torque incluem o nível de experiência clínica e a força física do operador. A conclusão é que o uso de um torque de driver mecânico calibrado é essencial para aplicar um valor de torque adequado e controlado e capaz de promover uma pré-carga adequada e manter a junta parafusada por longos períodos.

**Descritores:** Prótese Dentária; Prótese Dentária Fixada por Implante; Estresse Mecânico.

## Resumen

Comparar con el valor de torsión recomendado por el fabricante, los valores de los pares máximos de cierre generados por voluntarios del género masculino y femenino, con y sin experiencia en implante-prótesis, para ajustar la retención del pilar UCLA con tornillo. La hipótesis probada fue que la mayor experiencia en el campo no influiría en el valor del torque aplicado, ya que no habría diferencias entre los voluntarios de diferentes géneros. De esta forma, 266 voluntarios se clasificaron de acuerdo con su experiencia en preclínicos (PC), clínicos (C) y profesionales (P). Se colocaron sentados, simulando la posición de trabajo hacia delante normal en frente de un medidor de par digital. Una muestra compuesta de un implante hexagonal externo incrustado en resina de poliéster modificada, una corona de metal y su tornillo de retención se adjuntaron en el medidor de par. A los participantes se les proporcionaron instrucciones para apretar el tornillo de retención del pilar utilizando un destornillador de torque manual y aplicar toda la fuerza en un solo movimiento de rotación. El grupo profesional logró el torque manual medio más alto (15.80 N / cm); los machos (14,96 N / cm) puntúan más que las hembras (02,11 N / cm). No pudieron alcanzar el valor de par recomendado por el fabricante. Por lo tanto, los factores que influyen en la aplicación manual del torque incluyen el nivel de experiencia clínica y la fortaleza física del operador. La conclusión es que el uso de un par motor mecánico calibrado es esencial para aplicar un valor de torque adecuado y controlado y capaz de promover una precarga adecuada y mantener la unión atornillada por largos períodos.

**Descriptores:** Prótesis Dental; Prótesis Dental de Soporte Implantado; Estrés Mecánico.

## INTRODUCTION

The most common failure of implant-prostheses and restorations, loose retaining screws<sup>1-5</sup>, is mainly caused by applications of improper torque<sup>6-12</sup>. Other causes of loose

retaining screws include fatigue, excessive bending and micro movements<sup>2</sup>. When insufficient torque is applied, the preload compressive clamping force that keeps together the

components, decreases beyond a critical level. This allows external forces to cause sliding and vibrations of the screw threads which jeopardizes the stability of the bond and lead to unscrewing<sup>13,14</sup>.

It is difficult to eliminate the separation action that is generated since the prosthesis is subjected to multidirectional impact forces, such as those that occur during masticatory cycles. The only way to prevent loosening is to ensure that the forces required to separate them<sup>13</sup>. Therefore, the development of a proper preload is vital to preventing short-and long-term failure of the implant system/prostheses<sup>15</sup>. The greater the contact surface area between the abutment and the implant, the better the screw can tolerate external loads<sup>16</sup>. Thus, the higher the preload, the more is the resistance to loosening and stability of the screwed union<sup>17,18</sup>.

To prevent the loss of preload and reduce the potential for loosening of the retaining screw, the dentist must apply an appropriate amount of closing torque. Specific closing torques, ranging from 10 to 35 N/cm, are recommended for specific screws and depend on the type of implant systems, as well as, abutment screw design, diameter, material, and manufacturer<sup>6,19,20</sup>.

However, there is great variation in the ability of the professionals to discern whether they have applied the proper torque to the implant components<sup>21</sup>. One study, reported the results of a comparison of the manufactures' recommended closing torque values with the usual torque and closing maximum torque generated by experienced operators who used manual torque drivers during the placement of the abutment under simulated clinical conditions. The data showed that the usual closing torque of the operator was equal to or less than 50% the recommended maximum torque and the manual closing mean was less than 75% of the recommended torque values. Most believed that by applying a maximum clamping force, the torque recommended by manufacturers can be exceeded and promote damage at the bone-implant connection<sup>22</sup>. The aim of this study was to determine if the amount of torque generated manually by using a manual torque driver met the recommendations of the abutment screw manufacturers. It was measured the amount of maximum closing torque generated by experienced and inexperienced operators while using a manual torque driver to tighten the retaining screw a metal crown. This value was compared to the torque value recommended by the manufacturer to determine if the torque generated manually provided enough preload to maintain the stability of the screw union, thus lowering the incidence of screw loosening. Two test hypotheses were formulated; the first being that the most experience in the field would not influence the value of the applied torque, as there would be no difference in that respect between volunteers from different genders.

## MATERIAL AND METHOD

This research was approved by the Research Ethics Committee through the presentation of Certificate for Ethics Assessment No. 47897515.1.0000.5420 in 11/16/2015.

Two hundred and sixty-six volunteers participated in the study. After approval by ethics committee, we divided the volunteers into 3 groups according to their clinical experience with implant-supported prostheses: (1) pre-clinical stage (PC)- undergraduate dentistry students without prior clinical contact, (2) clinical stage (C) - dental students with prior clinical contact, but with only theoretical experience, (3) professional (P) - clinically experienced

with varying degrees of clinical experience. The groups also subdivided according to gender (Table 1), female (FPC) and male (MPC) students in the pre-clinical stage, female (FC) and male (MC) students in the clinical phase, female (FP) and male (MP) professionals.

**Table 1.** Formation of groups: level of experience and gender of the participants

Level of experience	Gender	
	Female	Male
Pre-clinical (PC)	64	24
Clinical (C)	69	33
Professional (P)	32	44
<b>Total</b>	<b>165</b>	<b>101</b>

All volunteers were asked to tighten retaining screw (DSP Biomedical®, Campo Largo, Paraná, Brazil) of the metal crown on an external hexagon implant (4 x 13 mm) (DSP Biomedical®, Campo Largo, Paraná, Brazil) that was embedded in modified polyester resin (Technovit 4000-Heraeus Kilzer, Wehrheim, Germany).

They were seated, in a position that simulated their normal working positions, while in front of a digital torque meter (Torque Tool Tester, TST series 2 Norbar®, Navi, Mumbai, India) that was coupled the specimen, and were given a long digital key 24 mm (SIN - System implant, São Paulo - SP, Brazil) as the handheld-device of torque. Subsequently, we instructed them to use the manual torque driver to tighten the screw and apply maximum bi-digital force in one movement of rotation. Under supervision, they performed this procedure three times, with an interval of 3 minutes between each squeeze. The values recorded in the torque meter were registered. Individual and group means of the manual torque applied were calculated.

Data were analyzed using the Statal software R (Free Software Foundation, Viena, Áustria) with a 0.05 level of statistical significance. Since the torque values were not normally distributed ( $p < 0.05$ ), used the nonparametric Shapiro-Wilk-test.

## RESULTS

The overall mean torque obtained manually was 12.51 N/cm, which is 41.7% of the torque values recommended by the manufacturer. Table 2 presents the means and standard deviations of the manual torque according to gender. Men had a statistically significant ( $p < 0.05$ ) higher mean (14.96 N/cm) than women (11.02 N/cm).

**Table 2.** Manual torque values (N/cm) for the ender of participants, regardless of level of experience

Gender	Mean
Female	11.02 ± 3.87 <sup>a</sup>
Male	14.96 ± 4.68 <sup>b</sup>

As shown in Table 3, comparing the torque values by experience level, the highest value was found in P (15.80 N/cm) and the lowest in PC (9.89 N/cm). It found no statistically significant difference between the three levels of experience (PC, C and P). In multiple comparisons between the levels of experience. There was no statistically significant difference among all groups (PC and C, Pc and P, C and P).

**Table 3.** Mean and standard deviation of manual torque values (N/cm) for the level of experience of participants, regardless of gender

Level of experience	Mean
Pre-clinical (PC)	9.89 ± 3.36 <sup>a</sup>
Clinical (C)	12.34 ± 3.74 <sup>b</sup>
Professional (P)	15.80 ± 4.89 <sup>c</sup>

Table 4 presents the means and standard deviations of the manual torque according to gender and level of experience. The FPC group generated the lowest amount of torque (mean = 9.18 N/cm), while the MP group generated the greatest amount of torque (men = 17.05 N/cm). There was a significant differences existed between the groups FPC x FC; FPC x MC; FPC x FP; FPC x MP; MPC x MP; FC x MC; FC x MC.

**Table 4.** Mean and standard deviation of manual torque values (N/cm) for the level of experience and gender of participants

Level of experience	Gender	
	Female	Male
Pre-clinical (PC)	9.18 ± 3.31 <sup>Aa</sup>	11.78 ± 2.73 <sup>Aa</sup>
Clinical (C)	11.30 ± 3.16 <sup>Ab</sup>	14.48 ± 3.99 <sup>Bab</sup>
Professional (P)	14.07 ± 4.27 <sup>Ab</sup>	17.05 ± 4.97 <sup>Ab</sup>

The mean amount of torque generated manually by each group, ranging between 30.60 N/cm and 56.83% of the recommended torque, (Table 5) was significantly lower than that recommended by the manufacturer (30 N/cm).

**Table 5.** Means of comparison the manual torque values between the value recommended by the manufacturer (N/cm)

Groups	Recommended	Mean (N/cm)	Variation for the recommended value	Coefficient of variation (%)
FPC	30	9.18 *	30.60%	36.08
FC	30	11.30 *	37.66%	27.99
FP	30	14.07 *	46.90%	30.41
MPC	30	11.78 *	39.26%	23.22
MC	30	14.48 *	48.26%	27.55
MP	30	17.05 *	56.83%	29.18

## DISCUSSION

The two test hypotheses were rejected, since both clinical experience how gender influenced the torque values. By including volunteers of different experience levels, analyzed the amount of torque applied to an implant-supported prostheses when using a manual torque driver under experimental conditions that simulates the clinical working position. In summary, the data showed that the mean maximum manual closure torque achieved by any group was less than the value recommended by the manufacturer (30 N/cm). The male participants had a significantly higher mean than the female participants.

This data suggests that clinical experience influences the amount of torque generated manually. When it was compared torque only by level of experience, the group of professionals (P) were able to achieve higher torque values. However, only two men, of the 76 total participants in the P group generated the recommended amount of torque. The group of students who did not have clinical experience (PC) generated the lowest mean torque, which was less than one third of the manufacturer recommended torque. It was also noted that most subjects in PC group were not familiar with the components of the screwed joint and manual applicator torque, reinforcing the notion that clinical experience may influence the application of torque. This is also supported by comparison of experience levels by gender.

The FPC and MPC had the lowest mean torque, while the professional groups (FP and MP) had the highest mean. When comparing only the female participants there was no significant difference seen in the groups according to clinical experience FC and FP. However, the female participants in the pre-clinical stage (FPC), who had the lowest mean of whole study, were statistically different from the other female groups. When comparing the male participants, there was a difference between the

pre-clinical groups (MPC) and professional (MP), who achieved the lowest and highest mean torque, respectively, while the values from the MC group did not differ statistically from the other two.

When comparing according to gender, the pre-clinical stage groups (FPC x MPC) and professionals (FP x MP), did not differ significantly. However, there was a significant difference between the FC and MC groups. The MC group achieved the highest mean. In addition, the FPC group showed a statistically significant difference from the MC and MP groups. The MPC group showed no statistically significant difference when compared the FC and FP groups. These data support the notion that male physical strength produces higher torque values, despite having less clinical experience than the females. This reinforces the need to use mechanical torque drivers to achieve the recommended torque values, regardless of the gender of the participants.

When comparing the values obtained in this study with the value recommended by the manufacturer, no group reached a level of torque that was close to ideal. To evaluate the distribution of torque values within each group, was calculated the coefficient of variation and expressed it as a percentage. A lower percentage indicates a more homogeneous group. The most homogeneous group was the MPC, while the most heterogeneous group was the FPC group had the widest distribution of values (mean torque ranged between 3.77 and 18.39 N/cm), while the other groups showed less variation.

This study simulates conditions in which volunteers did not have to deal with saliva and restricted or poor visibility. These conditions can make it more difficult to perceive and apply proper torque using manual torque driver in real clinical conditions.

Knowing that few minutes after the application of torque there is a loss of preload and the masticatory load tends to further decrease this preload and even promotes screw loosening and fracture of the retaining screw<sup>16, 20, 23-29</sup>. [16,20,23-29] This study reaffirms the need to use a calibrated mechanical torque drivers to apply torque to screws of the abutments<sup>21</sup>, for using the manual torque driver (bidigital key), even if using the maximum force, are not achieved values torque appropriate to produce the ideal preload in screws which require greater than 20 N/cm. Which compromises the maintenance union of these screwed joint for long periods.

## CONCLUSION

Respecting the limitations of the study, we can conclude that the increased knowledge and clinical experience are important to achieve higher torque values when using bidigital manual torque driver, but not the only determinant, since the physical strength, presumed higher in males showed significantly influence the results obtained.

## ACKNOWLEDGMENTS

The authors are grateful to teacher Paulo Henrique dos Santos and Taciana Kasaki Oliveira Shimizu by statistical analysis (PhD student in the course of the Graduate Inter-Institutional Program in Statistics from the University of São Paulo (USP) and Federal University of São Carlos (UFSCar) and the volunteers of this study.

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## CONFLICTS OF INTERESTS

The authors declare no conflicts of interests.

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**Received** 14/11/2017

**Accepted** 09/01/2018