

Evaluation of the Accuracy of Output Values of Torque Wrenches in Clinical Settings

Ayşegül ERTEN TAYŞI^{1*}  Nuri Mert TAYŞI²  Pınar ERCAL³ 

¹ Asst. Prof., Istanbul University-Cerrahpasa, Faculty of Dentistry, Department of Oral and Maxillofacial Surgery, Istanbul, Fatih, Türkiye, denterten@gmail.com

² Asst. Prof., Istanbul University-Cerrahpasa, Faculty of Dentistry, Department of Oral and Maxillofacial Surgery, Istanbul, Fatih, Türkiye, mtaysi23@hotmail.com

³ Assoc. Prof., Eastern Mediterranean University, Faculty of Dentistry, Famagusta, North Cyprus, Mersin-10-Türkiye, pinarercal@gmail.com

Article Info	ABSTRACT
Article History Received: 29.10.2024 Accepted: 15.04.2025 Published: 30.12.2025	Aim: The aim of this in vitro study was to determine and compare the accuracy of different types of mechanical torque limiting devices currently used in clinical settings. Materials and Methods: A total of 30 torque wrenches including both friction-style (n=17) and spring-style (n=13) instruments were evaluated in this study. A calibrated digital torque meter (Lutron TQ-8800; Lutron Electronic Enterprise Co., Ltd.; Taiwan) was used to measure the output torque values of the torque wrenches. Measurements were repeated 10 times for each wrench and reported in Ncm. The Shapiro-Wilk test was performed for mean torque measurement values followed by an independent t-test and the percentages of absolute deviation from target torque values were calculated. The results were evaluated at a 95% confidence interval with significance at p<0.05. Results: The mean torque measurement values of friction-style devices showed a statistically significant difference from target torque values (p<0.05), while the mean torque measurement values of spring-style devices did not differ significantly from target values (p>0.05). While the percentage deviation values ranged between 7.64 and 11.76 for friction-style devices, they were 1.79- 5.12 for spring-style devices. Conclusion: The accuracy of spring-type torque wrenches is better than that of friction-type torque wrenches, and the calibration of all wrenches should routinely be performed at the target torque value specified by the manufacturer to ensure optimum healthcare services.
Keywords: Dental implant, Dental restoration failure, Implant-supported denture, Mechanical stress, Torque.	

Kliniklerde Kullanılan Raşetlerin Çıkış Tork Değerlerinin Güvenilirliğinin Ölçülmesi

Makale Bilgisi	ÖZET
Makale Geçmişi Geliş Tarihi: 29.10.2024 Kabul Tarihi: 15.04.2025 Yayın Tarihi: 30.12.2025	Amaç: Bu in vitro çalışmanın amacı, kliniklerde halihazırda kullanılan farklı tipteki tork kontrol cihazlarının doğruluğunu belirlemek ve karşılaştırmaktır. Gereç ve Yöntemler: Kliniklerde kullanılan mekanik tork sınırlayıcı aletlerden (torklu raşet) sürtümlü tip (n=17) ve yaylı tip (n=13) olmak üzere toplamda 30 adet alet çalışmaya dahil edildi. Torklu raşetlerin çıkış tork değerlerinin ölçülmesi için kalibre edilmiş dijital bir tork ölçer (Lutron TQ-8800; Lutron Electronic Enterprise Co., Ltd.; Taiwan) kullanıldı. Her örnek için ölçümler 10 kez tekrarlandı ve Ncm cinsinden rapor edildi. Aletlerin ortalama tork değerleri ve hedef tork değerlerinden mutlak sapma yüzdesi üzerinden önce Shapiro Wilk testi ardından da bağımsız t testi yapıldı. Elde edilen sonuçlar %95 güven aralığında; p<0,05 anlamlılık düzeyinde değerlendirildi. Bulgular: Sürtümlü tipli aletlerin tork ölçüm ortalamalarının, hedef tork ölçüm değerlerinden istatistiksel olarak anlamlı bir farklılık gösterdiği görülürken (p<0,05), yaylı tipli aletlerin tork ölçüm ortalamalarının hedef tork ölçüm değerlerinden istatistiksel olarak anlamlı bir farklılık göstermediği anlaşılmıştır (p>0,05). Sapma yüzdesi sürtümlü tipteki aletlerde 7,64 ile 11,76 arasında hesaplanırken, yaylı tipteki aletler için 1,79 ile 5,12 olarak bulunmuştur. Sonuç: Torklu raşetlerden yaylı tipte olanların güvenilirliği sürtümlü tipte olan torklu raşetlere nazaran daha kabul edilebilir seviyede olup sağlık hizmetlerinin en doğru bir şekilde verilebilmesi için rutinde kullanılmakta olan tüm raşetlerin kalibrasyonunun düzenli olarak kontrol ettirilmesi gerekmektedir.
Anahtar Kelimeler: Dental implant, Dental restorasyon başarısızlığı, İmplant destekli protez, Mekanik stress, Tork.	

To cite this article: Erten-Tayşı A, Tayşı NM, Ercal P. Evaluation of the Accuracy of Output Values of Torque Wrenches in Clinical Settings. NEU DENT J. 2025;3:353-62. <https://doi.org/10.51122/neudentj.2025.169>

*Corresponding Author: Ayşegül ERTEN TAYŞI, denterten@gmail.com



INTRODUCTION

Dental implants are currently considered a standard treatment option that promises long-term success for partially and completely edentulous patients.¹ Recent studies emphasize a rapid decrease in the average age of patients receiving dental implants and a continuous increase in the number of these patients.¹ However, clinicians who apply this increasingly popular treatment option face a variety of biological and mechanical complications in clinic settings.²

One of the most common mechanical complications in dental implantology is the loosening of screws.^{3,4} There are many factors associated with this complication, including fatigue fracture, which might cause more serious outcomes and could even result in implant removal because of broken screw fragments.^{1,5} Other relevant factors include non-passively fitting substructures, contamination of the screw socket, inadequate final tightening, occlusal factors, restoration design and implant component design, and implant material.^{6,7}

Mechanical torque-limiting devices, known as torque wrenches or ratchets, are routinely used to place implants into bones or tighten the abutment screws during the fabrication of implant-supported prostheses.^{3,4} There are two types of mechanical torque-limiting devices commonly used in clinics: friction-type torque-limiting devices and spring-type torque-limiting devices. Friction-type devices are designed to stop the fracturing and additional bending motion by either shifting the drive shaft laterally to the axis of the rotating shaft or shifting the latching mechanism internally within the limits of the rotating drive head when a preset torque value is applied.⁸ If the torque value exceeds the set limit, the torque-limiting device breaks the handle head component. An arm that is attached to the wrench is bent in spring-type devices, and various torque values are transmitted depending on how much this arm is deflected. Torque is applied by deflection until the bending of the

arm coincides with a pre-determined mark on the surface of the rigid arm indicating that the appropriate torque value has been achieved.⁸

In preventing screw loosening and ensuring the adequate preloading of the screw connection the most important factor is the application of the appropriate torque, achieving the target value with the torque wrenches, as recommended by the implant company.⁹ Companies recommend that these torque wrenches, which are critical for applying sufficient torque, be recalibrated regularly, but there is limited information about the reliability of torque values that vary according to the frequency of the clinical use of these instruments or the regularity of their recalibration.^{3,4,10}

The primary aim of the present study was to examine the accuracy of the output torque values of friction-type and spring-type wrenches used in clinical settings. The secondary aim was to compare the accuracy of the output torque values of friction-type and spring-type wrenches. The null hypothesis of the study was that there would be no significant differences within or between the accuracies of the friction-type and spring-type mechanical torque-limiting devices currently used in dental clinics as determined by their ability to achieve target torque values.

MATERIALS AND METHODS

A total of 30 torque wrenches, including friction-type (n=17) and spring-type (n=13) wrenches, obtained from 8 clinics were evaluated in the present study, which aimed to determine the reliability of mechanical torque-limiting devices used in clinics (Table 1). The samples were comprised of wrenches from 8 different brands for friction-type and 6 different brands for spring-type mechanisms. The distribution of friction-type wrenches by manufacturer was as follows: Bego® (n=5), Detect® (n=1), Dentegris® (n=1), DTI® (n=3), Osstem® (n=1), Paltop® (n=3), Shinhung Implant® (n=1), and Trias (n=2). The

distribution of spring-type wrenches used were as follows: Dentium® (n=3), Implants® (n=2), Juyo® (n=1), Nobel Biocare® (n=1), Nucleoss® (n=3), and Straumann® (n=3).

Table 1: Brand distribution and target torque values of mechanical torque wrenches obtained from dental clinicals.

Type	Brand	Number	Target Value (Ncm)
Friction-type	Bego ¹	5	30
	DE Tech ²	1	30
	Dentegris ³	1	30
	DTI ⁴	3	30
	Osstem ⁵	1	30
	Paltop ⁶	3	30
	Shinhung ⁷	1	30
	Trias ⁸	2	30
Spring-type	Dentium ⁹	3	40
	Implance ¹⁰	2	35
	Juyo ¹¹	1	30
	Nobel Biocare ¹²	1	35
	Nucleoss ¹³	3	30
	Straumann ¹⁴	3	35

¹ Bego Implant System, GmbH & Co. KG, Bremen, Germany; ² DE|Tech Implant Technology, Ankara, Türkiye; ³ Dentegris Implant System, Dentegris, Münsterstraße, Germany; ⁴ DTI Implant System, Istanbul, Türkiye; ⁵ Osstem, Seoul, Korea; ⁶ Paltop, Keystone Dental Company, MA, USA; ⁷ Shinhung Implant System, Seoul, Korea; ⁸ Trias Implants; Servo-Dental GmbH & Co. KG, Hagen, Germany; ⁹ Dentium Co, Seoul, Korea; ¹⁰ Implants, Trabzon, Türkiye; ¹¹ Juyo Instruments (Pvt) Ltd, Sialkot, Pakistan; ¹² Nobel Biocare AB, Gothenburg, Sweden; ¹³ Nucleos, Izmir, Türkiye; ¹⁴ Straumann AG, Basel, Switzerland.

Previous studies were taken as the basis for the sample size of this the study.³ The following inclusion criteria were: torque wrenches should be sterilized following the recommendations of the manufacturer after each use, brand and/or company names should be clearly visible on the wrenches, they should be previously sterilized in an autoclave device at least 100 times,^{3,4} and they should be actively used on patients. At the beginning of the study, the operator performed calibration by practicing 100 repetitions on both types of torque wrenches. Torque ratchets used for this calibration were not included in the study.

A digital torque meter (Lutron TQ-8800, Lutron Electronic Enterprise Co., Ltd., Taiwan) was used to measure the output torque values of

the wrenches (Figure 1). The digital torque meter used was calibrated by the supplier (Netes Engineering and Foreign Trade Inc., Istanbul, Turkey) before the experimentation began. The accuracy of the meter was within $\pm 0.25\%$ of the full scale. The tip of the digital torque meter was firmly fixed on the test bench with a vise to prevent any movement (Wisent, Multifunktions Schraubstock, Bahag AG, Mannheim, Germany) (Figure 2).

Figure 1: Digital torque wrench



Figure 2: Multifunction vice



After the implant screwdriver was attached to its matching torque wrench, the screwdriver's tip was fixed to the gauge of the digital torque meter (Figure 3), the torque indicator on the meter was set to zero, and the calibrated operator (AET) applied force until

the target torque value was reached with stretching of the tool arm for spring-type wrenches, while the necessary force to release the arm for friction-type wrenches was slowly applied for 4 seconds.¹¹ The peak torque output value was recorded with the digital torque meter for each sample and the operator was blinded to these readings. This process was repeated 10 times for each torque wrench.^{3,8-10}

Figure 3: Experimental setup and attachment of the torque wrench to a screwdriver fixed to the digital torque wrench's gauge



Statistical Analysis

To evaluate the findings obtained in this study, IBM SPSS Statistics 26.0 (IBM Corp., Armonk, NY, USA) was used for statistical analyses. The mean difference between target torque and measured torque was evaluated. Furthermore, the percentage of deviation from target torque values [PerDev = (absolute difference/target torque) × 100] was calculated and compared with the target torque values specified by the manufacturers. Before comparing the quantitative data, the compliance of the variables to normal distribution was tested using the Shapiro-Wilk method and it was confirmed that the data were normally distributed ($p > 0.05$). Comparisons of these normally distributed variables were performed using parametric tests (one-sample t-test, independent t-test). Results were evaluated at a

95% confidence interval with a significance level of $p < 0.05$.

RESULTS

Comparisons of each measurement value to the target value for each tool type included in the study are given in Table 2. When all obtained measurements were compared regarding the target values for friction-type tools, the mean torque measurement values for each measurement were statistically significantly different from the target torque values ($p < 0.05$). In these cases, the mean torque values obtained from measurements were lower than the target torque values. The PerDev values of the friction-type wrenches were found to range between 7.64 and 11.76. On the other hand, when all measurements for each spring-type tool were compared regarding the target values, it was found that the mean values for torque measurements did not differ significantly from the target torque values ($p > 0.05$). The PerDev values of the spring-type wrenches were calculated as ranging between 1.79 and 5.12.

Comparisons of mean values and the torque values obtained for each measurement with the tools included in this study according to tool type are given in Table 3. The overall means and the torque values obtained for each measurement differed with statistical significance according to tool type ($p < 0.05$). The output torque values of the spring-type tools were higher than those of the friction-type tools for both mean values and all measurements.

Comparisons of the mean values obtained for each tool included in this study and their target values are given in Table 4. It was found that the mean torque values of the friction-type tools were statistically significantly different compared to the target torque values ($p < 0.05$). The mean torque values of these tools were lower than the target torque values and the PerDev value of the friction-type tools was found to be 1.29. However, the mean torque values of the spring-type tools did not differ significantly from the target torque values ($p > 0.05$). The PerDev value of the spring-type tools was calculated as 3.52.

Table 2: Comparison of measurements of torque values for friction-type and spring-type torque wrenches.

Type	Measurement	N	Mean ± S.D.	t	p	Mean difference	PerDev
Friction	1	17	27.71 ± 2.82	-3.350	0.000*	-2.294	7.647
	2	17	26.82 ± 1.98	-6.628	0.000*	-3.176	10.587
	3	17	27.06 ± 2.16	-5.603	0.000*	-2.941	9.803
	4	17	26.88 ± 2.06	-6.246	0.000*	-3.118	10.393
	5	17	26.82 ± 2.77	-4.734	0.000*	-3.176	10.587
	6	17	26.59 ± 2.50	-5.624	0.000*	-3.412	11.373
	7	17	26.82 ± 2.27	-5.769	0.000*	-3.176	10.587
	8	17	27.12 ± 2.60	-4.579	0.000*	-2.882	9.607
	9	17	26.47 ± 2.27	-6.419	0.000*	-3.529	11.763
	10	17	26.82 ± 2.01	-6.525	0.000*	-3.176	10.587
Spring	1	13	33.15 ± 4.43	-1.193	0.256	-1.466	4.235
	2	13	32.85 ± 4.76	-1.344	0.204	-1.774	5.124
	3	13	32.92 ± 4.13	-1.481	0.164	-1.697	4.902
	4	13	33.00 ± 4.14	-1.410	0.184	-1.620	4.679
	5	13	33.23 ± 4.53	-1.106	0.291	-1.389	4.012
	6	13	34.08 ± 5.02	-0.390	0.704	-0.543	1.568
	7	13	33.15 ± 4.78	-1.107	0.29	-1.466	4.235
	8	13	34.15 ± 4.54	-0.370	0.718	-0.466	1.346
	9	13	33.85 ± 4.91	-0.568	0.581	-0.774	2.236
	10	13	34.00 ± 5.45	-0.410	0.689	-0.620	1.791

*: p<0.05; One-sample t-test; PerDev: Percentage of deviation

Table 3: Comparison of each measurement according to torque type.

Measurements (m)	Type	N	Mean	S.D.	t	p
1	Spring	13	33.15	4.43	4.105	0.000*
	Friction	17	27.71	2.82		
2	Spring	13	32.85	4.76	4.290	0.001*
	Friction	17	26.82	1.98		
3	Spring	13	32.92	4.13	5.034	0.000*
	Friction	17	27.06	2.16		
4	Spring	13	33.00	4.14	4.883	0.000*
	Friction	17	26.88	2.06		
5	Spring	13	33.23	4.53	4.498	0.000*
	Friction	17	26.82	2.77		
6	Spring	13	34.08	5.02	5.357	0.000*
	Friction	17	26.59	2.50		
7	Spring	13	33.15	4.78	4.817	0.000*
	Friction	17	26.82	2.27		
8	Spring	13	34.15	4.54	5.360	0.000*
	Friction	17	27.12	2.60		
9	Spring	13	33.85	4.91	5.019	0.000*
	Friction	17	26.47	2.27		
10	Spring	13	34.00	5.45	4.522	0.000*
	Friction	17	26.82	2.01		
Generalized mean	Spring	13	33.40	4.33	5.054	0.000*
	Friction	17	26.91	1.87		

*: p<0.05; Two-samples independent t-test

Table 4: Comparison of measurements for each torque type according to target values. Negative mean difference values indicate lower values than target torque output on average.

Type	N	Mean ± S.D.	t	p	Mean difference	PerDev
Friction	17	26.91 ± 1.87	-6.818	0.000*	-3.088	10.294
Spring	13	33.4 ± 4.33	-1.016	0.330	-1.220	3.523975

*: p<0.05; One-sample t-test; PerDev: percentage of deviation

Table 5: Comparison of torque wrench brands according to target torque values

Brand	Friction-type			Brand	Spring-type		
	Mean	TV	PerDev		Mean	TV	PerDev
Bego ¹	27.34	30	8.867	Dentium ⁹	38.6	40	3.500
DE Tech ²	29.1	30	3.000	Implance ¹⁰	33.3	35	4.857
Dentegris ³	28.3	30	5.667	Juyo ¹¹	29.5	30	1.667
DTI ⁴	25.96	30	13.467	Nobel Biocare ¹²	35	35	0.000
Osstem ⁵	25.4	30	15.333	Nucleoss ¹³	27.67	30	7.767
Paltop ⁶	28.23	30	5.900	Straumann ¹⁴	34.76	35	0.686
Shinhung ⁷	23.5	30	21.667				
Trias ⁸	25.95	30	13.500				

TV: Target value; PerDev: Percentage of deviation; ¹Bego Implant System, GmbH & Co. KG, Bremen, Germany; ²DE|Tech Implant Technology, Ankara, Türkiye; ³Dentegris Implant System, Dentegris, Münsterstraße, Germany; ⁴DTI Implant System, Istanbul, Türkiye; ⁵Osstem, Seoul, Korea; ⁶Paltop, Keystone Dental Company, MA, USA; ⁷Shinhung Implant System, Seoul, Korea; ⁸Trias Implants; Servo-Dental GmbH & Co. KG, Hagen, Germany; ⁹Dentium Co, Seoul, Korea; ¹⁰Implance, Trabzon, Türkiye; ¹¹Juyo Instruments (Pvt) Ltd, Sialkot, Pakistan; ¹²Nobel Biocare AB, Gothenburg, Sweden; ¹³Nucleos, Izmir, Türkiye; ¹⁴Straumann AG, Basel, Switzerland.

The mean torque and PerDev values of the tools included in this study are given in Table 5 according to instrument types along with the target torque values of each brand. For friction-type instruments, the highest mean torque value was obtained for the DE|Tech brand, while the lowest was obtained for the Shinhung Implant brand. For spring-type instruments, the highest mean torque value was obtained for the Dentium brand and the lowest was obtained for the Nucleoss brand.

DISCUSSION

Previous studies conducted on mechanical torque-limiting devices reported that the observed output torque values tended to differ to variable extents,¹⁰ being either lower than the target value¹² or higher.¹³ The results of the present study are consistent with the results reported by Vallee et al.,¹² who found that all evaluated torque wrenches, whether friction-type or spring-type, had output torque values lower than the target torque value in each measurement. These findings support the rejection of the present study's hypothesis because a statistically significant difference ($p < 0.05$) and was obtained with lower accuracy in reaching the target torque values observed for friction-type torque wrenches compared to spring-type torque wrenches.

There are many studies in the literature evaluating the accuracy of mechanical torque-limiting devices with different methods and results. Many different methods have been used to evaluate and compare the accuracy of these devices.^{3,4,8,9,12,14-16} These methodological differences arise from the fact that the torque values recommended by implant and screw manufacturers vary between 18 and 45 Ncm and a consensus has not yet been reached on the best approach in studies comparing torque values.⁶

Previous studies compared performances between devices using mean absolute torque values, percentage deviation from target torque values (PerDev), or percentage differences from target torque values (PerDif) because the recommended torque values of different implant and screw manufacturers differ from each other.^{8,9,12} Some studies reported that the output torque value must be within the approximate range of $\pm 10\%$ of the value recommended by the manufacturer to provide adequate preloading successfully, while other studies based their evaluations on combinations of absolute differences and percentage differences. Although percentage deviation and mean absolute torque differences may be preferred to compare the accuracy of torque-limiting devices when the mean output torque values are lower than the target torque values, it was reported that using percentage differences from target torque values is a more appropriate

choice when the output values are both higher and lower than the target torque values.⁶ In the present study, the absolute percentage deviations from target torque values and mean torque values were analyzed to compare the accuracy of the tested devices because the measured torque values were lower than the target torque values recommended by the manufacturers.

The findings of the present study revealed that spring-type torque wrenches had statistically significantly lower percentage deviations and mean differences from target torque values compared to friction-type torque wrenches. Although these findings are in line with those reported by Vallee et al.,¹² there are also studies in the literature in which no statistically significant differences were reported between the output torque values of spring-type and friction-type torque wrenches.^{6,9} Moreover, there is another fundamental aspect that requires careful consideration in this study is related to the safe range of the PerDev measurements, as this directly impacts the interpretation of our findings. In general, the scientific literature establishes that mechanical torque-limiting devices should perform within $\pm 10\%$ their target values for clinical reliability.^{3,6} However, Goldstein et al.¹⁷ emphasized that there is an unclear point on how much difference would be clinically significant. Yilmaz et al.³ revealed that despite spring-style torque-limiting devices demonstrating superior accuracy compared to friction-style devices, all instruments performed within the manufacturer's established $\pm 10\%$ target torque parameters. In contrast, Vallee et al.¹² reported PerDev values of 13.74% and 2.36% for friction-type and spring-type devices, respectively. Consistent with the latter study, our findings indicate that spring-type wrenches (PerDev = 3.52%) performed well within this acceptable range, while friction-type wrenches (PerDev = 10.294%) slightly exceeded this threshold. It is noteworthy that the findings of the present study do not allow us to conclude

whether the PerDev values of the friction-type and spring-type torque wrenches would increase the probability of clinical complications such as implant loss or screw loosening. Moreover, if clinicians prefer to use the electronic torque-limiting devices that manufacturers have recently developed with innovative applications in light of technological advances instead of manual torque wrenches with less certain calibration, it must be taken into consideration that these electronic devices might also have limitations.¹⁸

Although a limited number of previous studies have contributed important information in the field of implantology about the accuracy of mechanical torque-limiting devices, to the best of our knowledge, the present study is the first to comprehensively evaluate and address the importance of regular calibration control to ensure the accuracy of torque wrenches currently used in clinical settings in Türkiye. At this point, one of the fundamental aspects should be stated as the importance of knowledge of International Organization of Standardization (ISO) recommendations which mandate that mechanical torque-limiting devices should be routinely tested for defining the difference of torque values and re-calibrated at either 5000 cycles or 12 months, whichever comes first.¹⁸ Additionally, when similar studies^{3,4} conducted on torque wrenches currently used in clinics were evaluated, it was seen that the present study shares some common limitations with previous studies. Manufacturers generally recommend that the bent arm of friction-type wrenches be lubricated and sterilized after each use while in the bent position. The instruments tested in the present study were obtained from 8 different clinics that sterilized their instruments after each use, and although the same sterilization protocols were applied in all clinics, it was observed that the recommendation to lubricate the bent arm was not followed in any of the clinics. In their research, Yilmaz et al.^{3,4} reported that some

torque wrenches could give output values higher than the target torque value as a result of heating processes coagulating the lubricant inside friction-style torque-limiting devices, thereby inhibiting their functioning and increasing the applied torque. In the present study, each instrument yielded either the target torque value or a torque value lower than the target value in each measurement, regardless of the type of instrument. This finding, in line with the explanation provided by Yilmaz et al.,^{3,4} was attributed to the lack of use of lubricating oil before sterilization in the clinics. It must also be noted as a limitation that the presence of many different variables related to sterilization, maintenance, calibration, and use prevents the results of this study from being generalized to every clinical situation. The lack of information on the duration of use, frequency of use, and number of sterilization cycles for the tested instruments is the most important limitation of the present study. While a minimum criterion of having undergone 100 sterilization cycles was established for the torque wrenches in our methodology according to the previous studies,^{3,4} no upper limit was specified or recorded, which could potentially impact the results due to material fatigue with increasing sterilization-usage cycles, especially when the calibration of the wrenches were neglected. Moreover, the lack of any information on whether the torque wrenches currently being used in these clinics were recalibrated at any time after their purchase was a dramatic finding in this study. Finally, the differences in force application procedures also constituted a limitation. It must be noted that the arm is bent to one side while using friction-style torque wrenches, objectively limiting the torque applied by the operator, whereas operators using spring-style torque wrenches apply force to an arm that can be bent until it aligns with the marked indicator at the desired torque value. Therefore, the spring-type procedure is more subjective and sensitive to manual dexterity.

Considering the limitations of the present study, although the authors of the study had initial concerns about using brand-based findings as definitive scientific data, it is not possible to entirely avoid discussing the brands in the process of providing the data, as was also recognized in previous studies. In a study¹⁹ conducted with torque wrenches from the Implant KA, Impliance, and Nucleoss brands that had never previously been used, it was reported that Nucleoss torque wrenches achieved higher output values than the target torque values. Erdem et al.²⁰ examined torque wrenches from the Straumann, Zimmer, Implant KA, Bredent, and Biohorizon brands that had been used for approximately 1 year. The brand that yielded the most stable output torque values was found to be Bredent. In the present study, the most stable brands in terms of output peak torque values were Nobel Biocare and Straumann, respectively, for spring-type wrenches and DE|Tech, Dentegris, and Paltop, respectively, for the friction-type wrenches.

CONCLUSION

The findings of this study demonstrate that spring-type torque wrenches exhibited superior accuracy compared to friction-type wrenches, with significantly lower percentage deviations from target torque values. The PerDev values of the friction-type wrenches were found to be slightly exceeding the acceptable threshold range. Both dentists and manufacturers should be aware of the calibration needs of manual torque limiting devices. It would be valuable for future researchers to evaluate the accuracy of the mechanical torque-limiting devices currently used in clinics while controlling for confounding variables such as device sterilization, aging, and maintenance. Furthermore, future studies must be aimed at developing comprehensive clinical guidelines or flow charts for calibration to ensure that these devices are used more effectively and safely.

Ethical Approval

This in-vitro study does not require ethics committee approval.

Financial Support

The authors declare that this study received no financial support

Conflict of Interest

The authors deny any conflicts of interest related to this study.

Author Contributions

Design: AET, PE, Data collection or data entry: AET, NMT, Analysis and interpretation: AET, PE, Literature search: AET, Writing: AET.

REFERENCES

1. Szajek K, Wierszycki M. Screw preload loss under occlusal load as a predictor of loosening risk in varying dental implant designs. *J Mech Behav Biomed Mater.* 2023;148:106165.
2. Bardis D, Agop-Forna D, Pelekanos S, Chele N, et al. Assessment of Various Risk Factors for Biological and Mechanical/Technical Complications in Fixed Implant Prosthetic Therapy: A Retrospective Study. *Diagnostics (Basel).* 2023;13:2341.
3. Yilmaz B, L'Homme-Langlois E, Beck FM, McGlumphy E. Accuracy of mechanical torque-limiting devices for dental implants after clinical service. *J Prosthet Dent.* 2015;114:378-82.
4. Yilmaz B, L'Homme-Langlois E, Beck FM, McGlumphy E. Effect of long-term steam autoclaving on changes in torque delivery of spring- and friction-type torque wrenches. *J Prosthet Dent.* 2016;115:718-21.
5. Schwarz MS. Mechanical complications of dental implants. *Clin Oral Implants Res.* 2000;11:156-8.
6. Albayrak H, Gumus HO, Tursun F, Kocaagaoglu HH, Kilinc HI. Accuracy of torque-limiting devices: A comparative evaluation. *J Prosthet Dent.* 2017;117:81-6.
7. Gumus HO, Zortuk M, Albayrak H, Dincel M, et al. Effect of fluid contamination on reverse torque values in bone-level implants. *Implant Dent.* 2014;23:582-7.
8. Britton-Vidal E, Baker P, Mettenburg D, Pannu DS, et al. Accuracy and precision of as-received implant torque wrenches. *J Prosthet Dent.* 2014;112:811-6.
9. L'Homme-Langlois E, Yilmaz B, Chien HH, McGlumphy E. Accuracy of mechanical torque-limiting devices for dental implants. *J Prosthet Dent.* 2015;114:524-8.
10. Gutierrez J, Nicholls JI, Libman WJ, Butson TJ. Accuracy of the implant torque wrench following time in clinical service. *Int J Prosthodont.* 1997;10:562-7.
11. McCracken MS, Mitchell L, Hegde R, Mavalli MD. Variability of mechanical torque-limiting devices in clinical service at a US dental school. *J Prosthodont.* 2010;19:20-4.
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. Cehreli MC, Akça K, Tönük E. Accuracy of a manual torque application device for morse-taper implants: a technical note. *Int J Oral Maxillofac Implants.* 2004;19:743-8.
15. Standlee JP, Caputo AA, Chwu MY, Sun TT. Accuracy of mechanical torque-limiting devices for implants. *Int J Oral Maxillofac Implants.* 2002;17:220-4.
16. Steinebrunner L, Harder S, Wolfart S, Freitag-Wolf S, Kern M. The Precision of Mechanical Torque Wrenches Used for Implants in Dental Offices. *Int J Prosthodont.* 2015;28:527-30.
17. Goldstein G, Ghoujal B, Abdullah S. An in vitro assessment of the accuracy of new and in-use torque-limiting devices. *J Prosthet Dent.* 2020;124:716-9.

18. Faraj MA, Bidra AS, Taylor TD, Kuo CL. Comparison of electronic versus mechanical torque-limiting devices for dental implants: An in vitro study. *J Prosthodont.* 2024;33:663–9.
19. Kılınç Hİ, Albayrak H, Tursun F, Gümüş HÖ. Accuracy of different types of wrenches fabricated by different implant manufacturers. *Clin Dent Res.* 2015;39:95-100.
20. Erdem MA, Karatasli B, Dinçer Köse O, Köse T, et al. The Accuracy of New and Aged Mechanical Torque Devices Employed in Five Dental Implant Systems. *Biomed Res Int.* 2017;2017:8652720.