Original Article

Comparing Original and Universal Screwdrivers in Terms of Torque Loss in the Abutment Screw

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Abstract

Objective: The aim of this study was to examine whether tightening or loosening the abutment screw results in torque loss and whether there is a difference in this respect between original screwdrivers and universal screwdrivers. **Materials and Methods:** For the purpose of the study, two groups were formed, with the original screwdriver used in group 1 and the universal screwdriver used in group 2. One Straumann implant and one BEGO implant were each inserted into a stationary torque transducer. The next step was to screw 13 abutments into each implant with 13 original abutment screws, using the screwdriver assigned to the group with the torque specified by the manufacturer. To establish whether the torque transmitted to the abutment screw via the screwdriver is also transmitted to the implant rather than causing deformation of the screw head or being transmitted to the surrounding area, the actual torque transmitted from the screw to the implant was measured and recorded electronically during the experiment. **Results:** There was no loss of torque in the transmission of the tightening torque to the Straumann implant with either screwdriver ($P > 0.05$). There was a loss of torque in the transmission of the tightening torque to the BEGO implant when using the universal screwdriver but not with the original screwdriver ($P < 0.01$). Relative to the previously applied tightening torque, a loss of torque when loosening the screw was found with both screwdrivers, both Straumann ($P > 0.05$) and BEGO ($P < 0.05$). **Conclusion:** Using universal screwdrivers can result in loss of torque. The loosening torque is thus decreased, which in turn increases the likelihood of complications such as screw loosening.

Keywords: Abutment screw, implant, torque, universal screwdriver

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Introduction

Every year, about one million dental implants are inserted as part of oral rehabilitation in Germany.[1] In recent years, dental implantology has developed into a widely used and safe form of treatment and is currently a standard procedure in everyday dental practice.[2]

Dental prostheses are connected to the implant body via an abutment in the sensitive area between the soft tissue around the implant and the oral cavity. The abutment must, therefore, meet high requirements in terms of stability, fatigue strength, chemical resistance, biocompatibility, esthetics, and individual design.[3,4]

The contact surfaces of the matrix and patrix of the implant and abutment are pressed against each other by the abutment screw.[5]

At the same time, compression is caused between the abutment screw head and the abutment as well as between the thread of the abutment screw and the implant.[6] The resulting tensile force, or preload force, in the abutment screw, is reduced in the first three to four threads and transmitted to the thread of the implant.

Despite preventive measures, screw loosening is one of the more frequent complications in dental implantology.[7-9] The risk of screw loosening depends on a number of factors, with the correct application of tightening torque being crucial.[10] Torque systems are needed to achieve the correct tightening

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torque. Depending on the implant system, these can vary in terms of design and the way that the torque exerted on the screwdriver is transmitted to the screw.

Matching tools are available for every implant system to facilitate the treatment of the implant after insertion.[11]

Because of the congruent fit between the tip of the screwdriver and the recess in the screw head, friction is generated between the two components. In theory, this friction results in optimum positioning and a stable fit of the screwdriver in the screw head, thus reducing the risk of the screwdriver slipping from the screw inside the patient's mouth.

For some time now, suppliers have been marketing universal screwdrivers advertised as working with the screws of all conventional implant systems.

However, the universal shape of the screwdriver might not interlock perfectly or be congruent with the recess in the screw head. This bears the risk of loss of torque in transmission to the implant.

With these considerations in mind, the aim of this study was to determine the loss of torque, if any, when using original vs. universal screwdrivers.

Materials and Methods

We examined abutment screws manufactured by Straumann GmbH (Straumann) and by BEGO Implant Systems (BEGO). The experiment involved tightening and loosening the abutment screws produced by the two companies with the respective original screwdrivers and with the universal screwdriver distributed by bredent GmbH & Co. KG (referred to as bredent or universal screwdriver below).

The products of the two implant manufacturers were examined separately with the same set-up. Two groups were formed: group 1 to examine the original screwdrivers of both manufacturers and group 2 to examine the universal screwdriver.

In group 1, one implant of each manufacturer (Straumann and BEGO) was inserted into a static torque transducer (Stationary Torque Transducer MT TS, Microtec Systems, Freiburg, Germany). Then, 13 abutments were screwed into each implant with 13 abutment screws from the same manufacturer, using the original screwdriver with the torque specified by the manufacturer. The Straumann abutment screws were screwed in with a torque of 35 Ncm. This manufacturer's torque system consisted of a torque ratchet with a torque bar that indicates the correct torque of 35 Ncm. The BEGO abutment screws were screwed in with a torque ratchet set to 30 Ncm. We did not use a standardized contact force as that would have required inserting the screwdriver with a defined force while taking into account the flexibility of the different base materials (e.g., measuring device, table, implant). Because we could not guarantee this aspect of the set-up and because a defined contact force is not applied in everyday dental practice, we made the deliberate choice not to factor it in. Before each new measurement, repeated checks were carried out with a torque-measuring device to ensure that the settings on the torque ratchet corresponded to the actual torque.

To determine whether the torque exerted via the screwdriver onto the abutment screw is also transmitted to the implant, rather than deforming the screw head or being transmitted to the surrounding area, the actual torque transmitted from the screw to the implant was measured and recorded electronically during the experiment.

To this end, the implant, with the abutment attached, was inserted into the torque-measuring device (Microtest Base Unit MTBU, Microtec Systems GmbH, Freiburg, Germany). The torque-measuring device was connected to a computer and linked with the compatible Torque Test Pro software (Version 3.1, Microtec Systems, Freiburg, Germany). With Torque Test Pro, the torque recorded by the torque-measuring device could be stored as a file and as a graph. The measurements are indicated as "torque [Ncm]" in a separate results table for each manufacturer in the results section.

As a next step, the torque-measuring device was then used to measure the torque needed to once more loosen the screw with the screwdriver. The acquired data were again recorded and stored with Torque Test Pro. The measurements were listed as "loosening torque [Ncm]" in the different results tables.

In the second group, the experiment was repeated for both implant manufacturers, except the 13 original abutment screws in the 13 abutments were tightened, loosened, and pulled off with a universal screwdriver. New abutment screws and abutments were used for group 2. The measurements are listed in separate results tables.

Statistical evaluation

Once the data had been collected, statistical evaluation was performed to compare the original screwdriver with the universal screwdrivers in combination with the products of the two manufacturers. This was done with the programs R (version 3.3.3, R Foundation, Boston, USA) and RStudio (version 1.0.136, RStudio, Inc., Boston, USA). The values were first checked for normal distribution using the Shapiro–Wilk test. Depending on the result, further statistical analyses using the *t*-test or the Wilcoxon signed-rank test followed.

Results

Straumann

Based on the data collected in the set-up using this manufacturer's original screwdriver, the Shapiro–Wilk test was used to calculate the following results. The data for both "tightening torque" and "loosening torque" showed a P value of $P < 0.05$ (not normally distributed), while the "pull-off force" showed a P value of $P > 0.05$ (normally distributed). In addition to the P values, Table 1 also lists skew, kurtosis, mean value, and standard deviation.

The data collected using the universal screwdriver produced the following results after calculation with the Shapiro–Wilk test. The data for both "tightening torque" and "loosening torque" showed a *P* value of $P > 0.05$ (normally distributed), while the *P* value of "pull-off force" was $P < 0.05$ (not normally distributed). In addition to the *P* values, Table 2 also summarizes other values.

Based on the calculated *P* values, the "tightening torque," "loosening torque" and "pull-off force" data of the original screwdriver and those of the universal screwdriver were compared using the Wilcoxon signed-rank test and further calculated.

The probability value calculated for tightening the screws and the corresponding torque transmission [Ncm] was $P = 0.27$ for both screwdrivers. In terms of transmission of tightening torque to the implant, there was no statistically significant difference. The mean value was 36.0 ± 2.9 Ncm with the original screwdriver and 36.1 ± 1.5 Ncm with the universal screwdriver.

There was no loss of torque in transmission to the implant when using the original screwdriver or the universal screwdriver. On an average, the recommended torque was exceeded by +2.8% (1.0 Ncm) with the original screwdriver and by +3% (1.1. Ncm) with the universal screwdriver.

The probability value of the torque used to loosen the screws was calculated as $P = 0.34$ for both screwdrivers.

The mean loosening torque was 32.9 ± 2.7 Ncm when using the original screwdriver and 34.0 ± 1.5 Ncm when using the universal screwdriver.

For both screwdrivers, a loss of torque was found when comparing the loosening torque with the torque previously transferred to the implant during the tightening of the screw. At −5.7% (2.1 Ncm), the loss of torque with the universal screwdriver was less than with the original screwdriver (−8.7% [3.1 Ncm]).

BEGO

Based on the data collected in the set-up using this manufacturer's original screwdriver, the Shapiro–Wilk test was used to calculate the following results.

The data for both "tightening torque" and "loosening torque" showed a *P* value of $P > 0.05$ (normally distributed), while the "pull-off force" showed a *P* value of $P < 0.05$ (not normally distributed). In addition to the *P* values, Table 3 also lists skew, kurtosis, mean value, and standard deviation.

The data collected using the universal screwdriver produced the following results after calculation with the Shapiro–Wilk test.

The data for both "tightening torque" and "loosening torque" showed a *P* value of $P > 0.05$ (normally distributed) and those for "pull-off force" a *P* value of $P < 0.05$ (not normally distributed). In addition to the *P* values, Table 4 also lists other values.

The "tightening torque" and "loosening torque" data for the original screwdriver and the universal screwdriver were compared using the *t*-test

The probability value calculated for tightening the screws and the corresponding torque transmission to the implant [Ncm] was $P < 0.001$ for both screwdrivers. A statistically significant difference was found between the original screwdriver and the universal screwdriver in terms of transmission of tightening torque to the implant. The mean tightening torque was 30.8 ± 0.9 Ncm when using the original screwdriver and 28.8 ± 0.7 Ncm when using the universal screwdriver.

When using the original screwdriver, there was no torque loss in the transmission of tightening torque to the implant. On average, the recommended torque was exceeded by +2.7% (0.81 Ncm). When using the universal screwdriver, however, there as an average torque loss of −3.9% (1.2 Ncm).

The probability value of the torque used to loosen the screws was calculated as $P < 0.05$ for both screwdrivers. Using the original screwdriver to loosen the screw required a mean torque of 27.1 ± 0.9 Ncm while using the universal screwdriver required a mean torque of 26.2 ± 0.7 Ncm.

For both screwdrivers, a loss of torque was found when comparing the loosening torque with the torque previously transferred to the implant during the tightening of the screw. There was less torque loss when using the universal

Table 1: Descriptive statistics original screwdriver (Straumann)

Variables	Skew	Kurtosis	*P*	Mean value	SD
Tightening torque	2.1	3.8	<0.05	36.0	2.9
Loosening torque	−1.9	3.1	<0.05	32.9	2.7

SD: Standard deviation

Table 2: Descriptive statistics universal screwdriver (Straumann)

Variables	Skew	Kurtosis	*P*	Mean value	SD
Tightening torque	−0.01	−0.97	>0.05	36.1	1.5
Loosening torque	0.1	−1.6	>0.05	34.0	1.5

SD: Standard deviation

Table 3: Descriptive statistics original screwdriver (BEGO)

Variables	Skew	Kurtosis	*P*	Mean value	SD
Tightening torque	1.0	0.4	>0.05	30.8	0.9
Loosening torque	0.7	−0.2	>0.05	27.1	0.9

SD: Standard deviation

Table 4: Descriptive statistics universal screwdriver (BEGO)

Variables	Skew	Kurtosis	*P*	Mean value	SD
Tightening torque	−0.25	−1.5	>0.05	28.8	0.7
Loosening torque	−0.0	−1.5	>0.05	26.2	>0.7

SD: Standard deviation

screwdriver (9.1% [2.6 Ncm]) than when using the original screwdriver (12.1% [3.7 Ncm]).

Discussion

The objective of this study was to compare the original screwdrivers of two implant manufacturers with a universal screwdriver to establish any differences in terms of torque transmission to the implant when tightening and loosening the abutment screw as well as torque loss [Figures 1 and 2].

Discussion of materials and methods

For this study, Straumann and BEGO each provided 26 abutments with abutment screws and one implant, all unused and in their original packaging. The material was then divided between groups 1 and 2 (13 each) to carry out the experiment.

Each manufacturer also provided an original screwdriver with a corresponding torque system, a ratchet and a wrench. This set was also in its original packaging and unused.

An unused universal screwdriver set produced by bredent was also used.

Although repeated use of the same screwdriver will likely result in changed conditions for each measurement, we chose not to use a new screwdriver for every single measurement. The study was intended to reflect reality in that regard, as the same screwdrivers are also reused in everyday clinical practice.

The abutment screws were tightened with the exact torque specified by the manufacturer, as inaccurate torque settings would result in damage to the abutment screw.[12]

Since screw loosening is one of the most common complications in implant treatment,[7-9] secure retention of the abutment screw is essential for clinical success.[13]

In order to reduce the risk of screw loosening, it is crucial to achieve the correct preload between the abutment screw and the implant through the accurate application of tightening torque.[10,13] If the torque used to tighten the screw is too low, the screw can become loose.[12] Strong external forces such as masticatory stress can cause radial and tangential sliding motion on the thread flank of the abutment or implant, or between the surfaces of the screw head and the implant.[14,15] This process can trigger a loosening motion and thus reduce the loosening torque. This results in a drop in preload and may even lead to complete loss of loosening torque, which increases the risk of the screw breaking due to the severe stress it is subjected to under in these circumstances.[15]

Straumann offers torque ratchets fitted with a torque arm that only serves as a visual indicator of the torque necessary to tighten the screw. Both the BEGO screwdriver and the universal one, on the other hand, include the option to preset the torque specified by the manufacturer on the torque ratchet. This way, the preset torque cannot be exceeded even if the screw is overtightened. Straumann screwdrivers do not include such a presetting option. This means that there is a risk of the torque specified by the manufacturer being exceeded if the screw is overtightened.

Measurement deviations

One result in the test series – obtained with the original screwdriver – considerably exceeded the torque of 35 Ncm specified by Straumann. The torque transmission measured for the S10 abutment screw to the implant was 44.7 Ncm. This abutment screw was loosened with a loosening torque of 25 Ncm, which is 55.9% of the tightening torque and thus below the average loosening torque, which should normally be 80%–85% of the original tightening torque.[16]

We conclude that exceeding the recommended tightening torque of 35 Ncm caused a decrease in preload and thus a decrease in loosening torque. One reason for this deviating measurement could be that, as outlined above, the Straumann torque ratchet only features a torque bar to indicate the torque currently applied and no way to set a maximum level of torque. We can thus assume that even brief distractions during treatment can result in torque levels that exceed or fall below those specified by the manufacturer.

No such deviations were found with BEGO products as they include the option of setting a maximum torque on the torque ratchet.

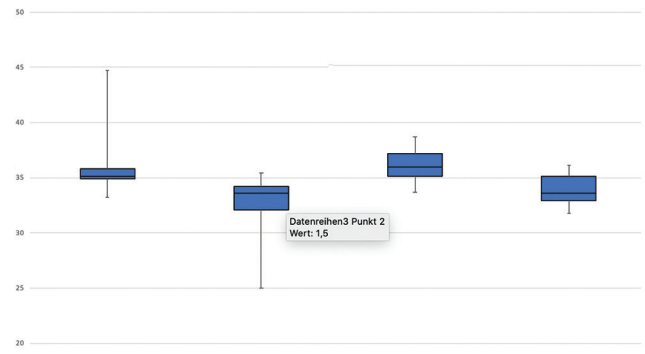

Figure 1: Box plot of tightening and loosening torque (Ncm). Box plot of torque measurements (Straumann). From left to right: Tightening torque original, loosening torque original, tightening torque universal, loosening torque universal

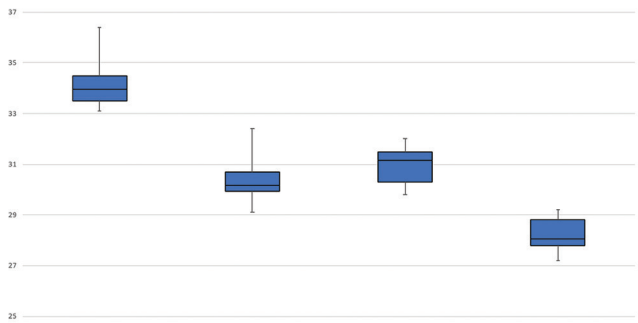

Figure 2: Box plot of tightening and loosening torque (Ncm). Box plot of torque measurements (BEGO). From left to right: Tightening torque original, loosening torque original, tightening torque universal, loosening torque universal

Although the universal screwdriver also included the option of specifying a maximum torque, 4 of the 13 results obtained with Straumann screws (US 10-US 13) exceeded the recommended tightening torque of 35 Ncm by at least 2–3.7 Ncm. The settings were not changed during the experiment. In these cases, we suspect technical inaccuracies in setting the torque on the universal screwdriver's torque ratchet.

However, since the loosening torque associated with these measurements was not reduced to below average, we can assume that when using the universal screwdriver, exceeding the recommended tightening torque by 2–3.7 Ncm and the resulting deviations would not result in a reduction in preload. As a result, these deviations would not be relevant to treatment success in implantology.

Discussion of Results

Torque loss in transmission to the implant

Straumann

With the original Straumann screwdriver, the torque of 35 Ncm specified by the manufacturer was achieved with a torque arm fitted as standard on the torque ratchet. Presetting the recommended torque, an option offered by other manufacturers, was not possible.

It was thus impossible to determine with absolute certainty whether the screw was actually tightened with the specified torque of 35 Ncm. The mean torque transmitted to the implant, however, was 36 ± 2.9 Ncm. There was thus no loss of torque in the transmission of the tightening torque to the implant. On the contrary, the specified torque was exceeded by 1 Ncm (2.8%). The deviations are likely due to the recommended torque of 35 Ncm only being achieved through visual inspection and manual movement of the torque bar.

Although the torque ratchet of the universal screwdriver could be preset to the 35 Ncm specified by Straumann, the recommended tightening torque was nevertheless exceeded by 1.1 Ncm (3%). Possible causes could be user inaccuracy in presetting the ratchet to 35 Ncm as well as technical flaws in the torque ratchet itself. There could also be inaccuracies in the transmission of measurements to the Torque Test Pro software.

Statistical evaluation to compare the two screwdrivers showed no significant difference ($P = 0.27$) between the original and the universal screwdriver.

BEGO

When using the original BEGO screwdriver, the specified torque of 30 Ncm was preset on the manufacturer's torque ratchet. As with Straumann, there was no loss of torque in the transmission of the tightening torque to the implant rthrough the abutment screw. On the contrary, the specified torque was exceeded by 0.81 Ncm (2.7%).

With the universal screwdriver, however, the actual torque fell short of the manufacturer recommendation by 1.2 Ncm (3.9%). As previously explained, when tightening the screw with too little torque, there is a risk that masticatory stress could cause a loosening motion in the abutment screw, causing the screw to become loose. The drop in preload and loss of loosening torque increase the risk of screw and implant fracture.[12,14,15,17]

The deviations in torque with both screwdrivers may be due to user inaccuracy in setting the torque to 30 Ncm, technical inaccuracies in the torque ratchet itself, or inaccuracies in the electronic transmission of results to the Torque Test Pro software.

Statistical evaluation to compare the two screwdrivers showed a probability value of $P < 0.001$, which means there was a difference depending on whether the original or the universal screwdriver was used to tighten the screw.

Loss of torque when loosening the screw (loosening torque)

Straumann

The average loosening torque with the original Straumann screwdriver was 32.9 ± 2.7 Ncm – a torque loss of 8.7% compared with the tightening torque (36 ± 2.9 Ncm). The average loosening torque with the universal screwdriver was 34 ± 1.5 Ncm – a torque loss of 5.7% compared with the tightening torque (36.1 ± 1.5Ncm).

With the BEGO screwdriver, the average loosening torque with the original screwdriver was found to be 27.1 ± 0.9 Ncm – a torque loss of 12.1% compared with the tightening torque (30.8 ± 0.9 Ncm). With the universal screwdriver, the average loosening torque was found to be 26.2 ± 0.7 Ncm – a torque loss of 9.1% compared with the tightening torque of 28.8 ± 0.7 Ncm.

According to the relevant literature, at 80-85%, the torque required to loosen a screw is usually less than that used to previously tighten it.[15,16,18] This is because when the abutment screw is tightened, a high level of preload is built up in the screw and causes the implant components to interlock. To achieve this preload, however, friction torque on the surface of the screw head and on the inner thread of the implant must be overcome, which means that the original tightening torque loses some of its force, causing the loosening torque to decrease.[14,15]

In our statistical evaluation, we found no significant difference ($P = 0.34$) between the original screwdriver and the universal screwdriver in terms of the torque required to loosen the screw.

BEGO

With the BEGO screwdriver, the average loosening torque was 87.9% after 12.1% torque loss. With the universal screwdriver, the average loosening torque was 90.9% after 9.1% torque loss.

Although at 90.9%, the average loosening torque measured when using the universal screwdriver is both within the recommended range and greater than that measured with original screwdrivers, another aspect must be taken into account here. The recommended torque was never achieved with the universal screwdriver, neither in the individual

measurements nor on average. The actual torque always fell short of the recommended torque. When the loosening torque of 26.2 ± 0.7 Ncm is considered relative to the recommended tightening torque of 30 Ncm, it mathematically decreases to 87.9%, i.e., just over the reference value of 80%–85%.

The statistical evaluation of the results achieved for BEGO showed a probability value of $P = 0.016$, which means that there is a difference depending on whether the screw was loosened with an original or with a universal screwdriver.

Conclusion

In this study, a loss of torque was only found when the BEGO abutment screw was tightened with the universal screwdriver.

We conclude that original screwdrivers should be favored in dental treatment to minimize as much as possible the risk of complications such as screw loosening.

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Conflicts of interest

There are no conflicts of interest.

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