Comparison of the torque stability of Implant Torque Controllers

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• Abstract

Tightening of the screws in implant restorations should be accurate and precise. If applied torque is too low, screw loosening would be occurred. With too high torque, the screw fracture might take place. Various torque generating devices are developed and employed to apply a proper torque. The purpose of this investigation was to determine and compare the accuracy of the torque controllers.

In this study, 4 types of torque controllers were used; electronic torque controller, torque limiting device, torque indicating device and contra angle torque driver. Digital torque gauge was employed to measure the de-torque value. Thirty cycles of tightening and loosening were done with each torque controller.

All implant torque controllers have shown slight errors and deviations. The torque limiting device exhibited the most accurate data. No significant difference was found among the mean de-torque values of the electronic torque controller, torque indicating device and contra angle torque driver.

In the limitation of this study, it would be recommended that the implant torque controllers should be checked whether uniformed and precise torque can be generated and a measuring error should be corrected.

• Key word : de-torque, torque, torque controllers

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Introduction

Implant prostheses are available in 2 designs: screw- or cement-retained. The advantage of the screw-retained prosthesis is that it can be easily removed and reattached by the clinician and can be fabricated in areas with restricted space. The prosthesis can easily be repaired but it is hard to design contact points because of the screw hole on the occlusal surface. Loading along the long axis of the implant is problematic and the screw is not as aesthetically pleasing as the cement-retained type. Loosening can also occur. The occlusal stability of a cement-retained implant is superior and loading can easily be given along the long axis of the implant. The cement-retained prosthesis is relatively easy to fabricate and is quite aesthetic but it is difficult to apply in areas with restricted intermaxillary space. Removal of the subgingival cement the prosthesis repair are difficult.

Regardless of the implant type, the fixture and upper structure is designed to be connected by a screw. This design allows easy removal and functions as a stress breaker when loaded. However, loosening of the screw, screw fracture, and screw abrasion may occur.

When reviewing the literature for screw loosening frequency, Jemt et al.2) in 1991 reported that during 1 year after implant installation, 26% of gold retention screws and 43% of fixture screws were loosened; but as the fixture component was improved and by using an implant torque controller, loosening occurred much less frequently. Priest3) in 1999 reported 7.1% screw loosening in 10 years after implant installation and in 2008 Jung et al.4) reported 12.7% during 5 years after implant installation.

The cause of screw loosening has been observed to be related to mechanical tolerance5), screw material6,7), fatigue resistance of the metal8), micromovement on functioning, occlusal force out of the long axis9,10), applied torque and preloading11), elasticity and settling effect of the alveolar bone12). The settling effect is a phenomenon in which two surfaces with different micro-roughness are facing each other and the space is narrowed by abrasion caused by the rougher surface.12,13)

Screw loosening occurs in two steps. First, an external force such as masticatory force applied to the screw connection area causes preloading and decreases the tensile strength, which results in sliding between spirals. Secondarily, preloading decreases below the critical point and external forces and vibration cause rotation of the spirals resulting in screw loosening.14) Screw loosening such as this may cause screw fracture, prosthesis fracture, loss of osseointegration and implant fixture fracture. Screw loosening is caused by external reasons such as inadequate implant positioning, occlusal relationship, crown configuration, excessive masticatory force, insufficient tightening torque, and incongruity between fixture and implant, and internal reasons such as loss of preloading caused by decrease in tensile strength of the screw itself.15,16)

Jörnéus et al.17) reported that the main reason of screw loosening is inadequate tightening force. When the tightening force is less than adequate, screw loosening occurs and screw fracture occurs in the opposite situation. When the screw is tightened manually inadequate rotatory force is applied, resulting in inadequate preloading, which allows the screw to more easily loosen than a screw tightened with adequate torque. Jaarda et al.18) reported that the primary reason for screw loosening is inadequate torque and loss of preloading. When the fixture screw is manually locked, an error of 15-48% may occur, thus to gain the adequate torque recommended by the manufacturer, it is better to use a mechanical torque controller19). Goheen and Binon20,21) reported that a manual torque controller generally cannot produce a torque bigger than 20Ncm, and Delinges et al.22) reported that there was a difference in the torque applied by men and women underlining the importance of using a mechanical torque controller.

To prevent screw loosening along the screw length of the fixture, configuration of the spiral and groove, position of the spiral and numbers may be modified or the surface roughness of the screw may be changed.23) Also, the manual fitness of the prosthesis may be enhanced or the number of implants may be increased, the occlusal interference can be removed and the occlusal surface decreased, the contact surface with proximal teeth may be increased but above all, a torque controller should be applied to gain the torque recommended by the manufacturer.24)

Implant manufacture companies have developed various types of torque controllers and they are being used to apply adequate torque to implants. The electronic torque controller applies rotatory force by a mechanical torque producer, while the torque limiting device is designed so that the anterior part of the handle bends when the torque exceeds the prescribed level. The torque indicating device has a scale so the operator can set the amount of tightening force. The contra-angle torque device is able to attach controllers that
have fixed or controllable force to the contra-angle hand piece. But many studies report gaps between the force recommended by the manufacturer and the actual torque applied by the torque controller. Gutierrez et al. reported an error rate of 17.0%–58.6% depending on the service life of the controller. Standlee et al. reported that Nobel Biocare torque controller has an error rate of 8.0%–41.0%. The ITI and DynaTorq ITL torque controllers have an error rate around 10% while Dellinges et al. reported that the DynaTorq ITL torque controller delivers a reliable result.

Various types of torque controllers are currently being used and differing error rates are being reported depending on the type of torque controllers. In this study, 4 types of torque controllers were used to measure the torque and de-torque value and compare it with the manufacturer’s recommended value. Differences between actual forces applied by the controller and recommended values were examined to compare and analyze the accuracy of the torque controllers.

Material and Method

1. Study Material

1) Implant fixture (Fig. 1)

Twenty fixtures of Pentaborn (Mediscitec, Incheon, Korea) implant with 4.0mm diameter and 12.0mm length were used.
2) Implant abutment (Fig. 2)
Twenty abutments of Pentaborn (Mediscitec, Incheon, Korea) implant with 4.5mm diameter and 3.0mm gingival height screw abutments were used.

3) Torque Controllers (Fig. 3)
One electronic torque controller and three manual torque controllers were used to apply the force recommended by the manufacturer to connect the implant fixture and abutment.
1) Electronic torque controller (Bränemark system DEA020 Torque Controller, Nobel Biocare AB, Göteborg, Sweden)
2) Torque limiting device (Pentaborn, Mediscitec, Incheon, Korea)
3) Torque indicating device (Straumann, Basel, Swiss)
4) Contra-angle torque device (Torq Control Ref. 15000, Anthogyr, Sallanches, France)

2. Study Method

1) Specimen fabrication
1) Implant fixation
To fabricate resin blocks of identical shape, a template was made with silicone impression material (EXAFINE PUTTY TYPE, GC Corporation, Tokyo, Japan). The implant was placed vertical to the ground on a dental surveyor and the implant fixture spirals were locked with PMMA self-curing resin (Ortho-jet. Lang Dental Manufacturing Co., Inc. Wheeling, U.S.A.). (Fig. 4)

The resin block was shaped into a 20mm × 20mm × 20mm regular hexahedron using a cutter with a diamond blade and abraser (Exakt-Cutting Grinding System Apparatebau, Norderstedt, Germany) then cut and ground with number 600, 800, and 1000 sandpaper and finally cleansed in a ultrasound washer for one minute.
2) Resin block fixation
To repeatedly attach and detach the fixture and abutment, the specimen was placed parallel to the ground using a custom made device. (Fig. 5)

2) Connecting the fixture and abutment
Each abutment was connected to the fixture. One type of electronic torque controller and three types of manual torque controllers were used with a force of 20 Ncm to connect the abutment.
3) Repeated tightening and loosening of the abutment and measurement of each de-torque value (Fig. 6, 7)

The de-torque value of abutments which were attached using 4 types of different torque controllers were measured with a custom device and torque measuring instrument (MGT12, Mark-10 Inc., New York, USA). A 10 second interval was given between tightening and loosening the abutment screw and this was repeated 30 times for de-torque value measurement of each specimen. Five implant specimens were prepared for each torque controller and the abutment screw tightening and loosening procedure was repeated.

3. Statistical Analysis

The SPSS 14.0K for Windows program was used to compare the de-torque value according to each torque controller. Repeated Measured ANOVA was conducted at 95% significance level to evaluate the relationship among each torque controller, measurement cycle, specimen and measurement cycle in each group. Post-hoc studies were done to evaluate the difference between groups with the Tukey test.

Results

The de-torque value of each torque controller from different manufacturers are presented in tables I and II. When the torque value is compared to the standard tightening torque of 20 Ncm, the error rate of each company was Brånemark 9.5%, Pentaborn 2.6%, ITI 7.1% and Anthogyr 12.5%, which shows that comparing the mean values the error rate of Pentaborn was lowest and Anthogyr was highest. The maximum measurement value was Brånemark 17.0%, Pentaborn 23.0%, ITI 5.0% and Anthogyr 12.5% and the minimum measurement value was Brånemark 24.0%, Pentaborn 14.5%, ITI 15.0% and Anthogyr 25.0%. At the maximum measurement value, the error rate of ITI was the lowest and Pentaborn was the highest while at the minimum measurement value the error rate of Pentaborn was the lowest and Anthogyr was the highest.

The repeated measured ANOVA results showed that in intra-subject effect analysis there was a difference according to repetition cycle and the measured value was affected by repetition number and torque controller. Inter-subject effect analysis results showed that the measured value was affected by the torque controller. (Tables III, IV)

The multiple regression analysis with post-hoc studies using the Tukey test show that there were no statistically significant differences among torque controllers from ITI, Brånemark and Anthogyr but the torque controller of Pentaborn showed statistically significant differences in accuracy with the other three types of torque controllers. (Table V) The Pentaborn torque controller demonstrated the best results compared to the standard value; and ITI, Brånemark and Anthogyr were next in order of similarity.
By presenting the mean value of each specimen according to repetition cycle in a graph that reveals the measurement value of each torque controller, it shows that the initial de-torque value is generally higher than standard and the value was uniform up to 15 cycles for Pentaborn and Branemark and then the value drastically decreases for every controller after about 15 to 20 repetitions. There is a general tendency of de-torque values decreasing as the number of repetitions increases. (Fig. 8)

**Discussion**

Many studies have reported a considerable difference between the actual value applied by a torque controller and the manufacturer’s recommended torque. Standlee et al.\(^{27,28}\) repeated measurements 10 times using 6 torque controllers from Nobel Biocare, 5 from ITI and 6 DynaTorq ITL torque controllers showing that the Nobel Biocare torque controller showed the largest error rate of 8.0% to 41.0% while the ITI and DynaTorq ITL torque controller showed errors within 10% of the adequate value. Dellinges et al.\(^{19,22}\) reported that the DynaTorq ITL torque controller showed a reliably low error rate before sterilization and the error rate generally rose after sterilization. At 10Ncm, the overall error rate before and after sterilization showed no statistically significant difference. Inaccurate and inadequate torque can be caused by frequency of controller use, foreign substances in the device, and corrosion of the spring.

In this study the comparison between the standard value with the standard.
This study shows that the initial de-torque value remained uniform for up to 15 cycles for the Pentaborn and ITI and then the value drastically decreases for every controller after about 15 to 20 repetitions. There is a general tendency for the de-torque value to decrease when the number of repetitions increases. These results are consistent with those of previous studies. Gutierrez et al.\textsuperscript{26} reported that when 35 torque controllers including 4 types, DynaTorq ITL, Steri-Oss, Lifecore, and Dentsply torque controller, were used for 1 to 42 months, the error rate ranged from 17% to 58.6%. The results show that the relation between usage duration, sterilization frequency, and torque controller did not show a statistical significance; but with corrosion of the internal device spring and aging and abrasion of the spring, errors up to 455.0% were found. In another study on the accuracy of torque controller and sterilization frequency, ßehreli et al.\textsuperscript{29} compared the accuracy of 15 unused ITI torque controllers and after 50 to 200 uses, 500 to 1000 uses. Accuracy was maintained but there was a tendency of the measured value to decrease as the usage frequency increased. There is a difference in standard value but the de-torque value remained uniform for up to 15 cycles for the Pentaborn and ITI units. Considering the importance of maintaining a certain level after repeated use, these two torque controllers will be able to show superior clinical results by decreasing the difference between standard value and actual torque through regular checkups.

Every torque controller showed a drastic decrease of de-torque value after 15 to 20 uses. Considering the fact that except for the first year, 1-2 applications of torque are made annually. It is recommended that the tightening and loosening procedure of the abutment screw intraorally be repeated 15 times. The decrease in preload caused by the decrease in coefficient of friction resulting from the friction between the two facing surfaces after repeated tightening and loosening of the screw is considered to be the reason why the de-torque value decreases after repeated tightening of the abutment screw.\textsuperscript{25} The limitation of this study is that the measurements were conducted on a laboratory model and not in the true intraoral environment, which may cause differences from the actual measurement values. Also, the torque controllers used in this experiment had been used in the clinic for a short while and the specific duration and number of uses for each controller are unable to be verified. This may contribute to errors in the results so additional experiments after grouping every torque controller according to usage
duration and number could result in a more objective comparison. The specimen number for each standard measurement value was 5 and the repeated measurement number was limited to 30 times, so it is necessary to diversify the standard measurement value for each implant system and increase the specimen and measurement number.

Conclusion

This study was designed to analyze the exactness and consistent readings of torque controllers from 4 different manufacturers and seek statistically significant differences between each device.

The below conclusions have been drawn.
1. From the comparison of the measured mean, maximum and minimum value, the Pentaborn torque controller had superior accuracy compared to the other three types of torque controllers.
2. When the measured values were analyzed after repeated use, the Pentaborn torque controller had the closest value to standard and ITI, Brånemark, and Anthogyr were next in order. But there were no statistically significant differences among ITI, Brånemark, and Anthogyr.
3. When comparing the accuracy according to torque controller type, a torque limiting device such as Pentaborn showed superior results but there were no statistically significant differences in accuracy among the electronic torque controller of Brånemark, the torque indicating device of ITI, and the contra-angle torque device of Anthogyr.

According to the results of this study a gap exists between the actual tightening forces applied by various torque controllers. This implies that it is difficult to apply exact tightening force so the clinician must use regular checkups and adjustments to his or her torque controller to obtain stable, accurate force values.

References

References