Distribution Statement

Distribution A: Public Release.

UNIFORMED SERVICES UNIVERSITY OF THE HEALTH SCIENCES
POSTGRADUATE DENTAL COLLEGE
SOUTHERN REGION OFFICE
2787 WINFIELD SCOTT ROAD, SUITE 220
JBSA FORT SAM HOUSTON, TEXAS 78234-7510
https://www.usuhs.edu/pdc

THESIS APPROVAL PAGE FOR MASTER OF SCIENCE IN ORAL BIOLOGY

Title of Thesis: "Assessing Hand Torque Values for Dental Implants"

Name of Candidate: Dr. Jedidiah M. Allen
Master of Science Degree
Research defense date: June 1, 2022

THESIS/MANUSCRIPT APPROVED: DATE:

MASTERSON.ROBERT.EDWARD.1300590302 Digitally signed by MASTERSON.ROBERT.EDWARD.1300590302 Date: 2022.03.21 09:47:59 -05'00'

21 March 2022

Dr. Robert Masterson
PROGRAM DIRECTOR, FORT HOOD AEGD-2
Committee Chairperson

KREIDER.JOHN.KEITH.1152698816 Digitally signed by KREIDER.JOHN.KEITH.1152698816 Date: 2022.03.21 12:54:29 -05'00'

21 March 2022

Dr. John Kreider
ASSISTANT PROGRAM DIRECTOR- FACULTY MENTOR,
FORT HOOD AEGD-2

COLTHIRST.PAUL.1062710990 Digitally signed by COLTHIRST.PAUL.1062710990 Date: 2022.04.04 09:37:08 -05'00'

21 March 2022

COL Paul Colthirst
COMMANDER, US ARMY DENTAL HEALTH ACTIVITY, FORT HOOD
Dean, Fort Hood AEGD-2

Evaluation of hand torque application on dental implant healing abutments

Jedidiah Allen, DDS

CPT DC, USA

AEGD-II

Ft. Hood, TX

June 2022

Acknowledgements:

1. This research project would not have been possible without the support of Dr. John Kreider, Assistant Director, Fort Hood AEGD-II Residency, for mentoring and advising throughout the duration of this project.
2. Special thanks to Dr. John Decker, Periodontic Department Mentor, and Dr. Eric Hu, Prosthodontic Department Mentor, for the initial ideas for this project and continued support and mentorship.
3. Special thanks to Ms. Dawn Beaver, Dr. Matthew Frazier, and Dr. Karl Wenger for providing crucial support in navigation of the EIRB process, guidance for initial research design, statistical analysis, and Institutional Review. Additional thanks to both Dr. Frazier and Dr. Wenger for final data organization, data interpretation and analysis, and advice in final constructs for this project.

ALLEN.JEDIDIAH.M.1166431740 Digitally signed by ALLEN.JEDIDIAH.M.1166431740 Date: 2022.06.01 15:11:33 -05'00'

Jedidiah Allen, D.D.S.

CPT, DC, US Army

Fort Hood AEGD-II Residency

ABSTRACT & KEY WORDS

Loss of dental healing abutments can lead to excess cost, lost time, and additional surgeries. Achieving adequate tightening of these healing abutments can prevent this loss. Therefore, the purpose of this in vitro, pilot study, was to evaluate the ability of a single clinician to hand-tighten dental healing abutments of several types and collar heights. This study evaluated two types and two collar heights of dental healing abutments and the clinician's ability to hand tighten these abutments. A customized jig was utilized to stabilize four implants and the clinician hand tightened different healing abutments to each implant. A digital torque meter was utilized to obtain the reverse torque values for each sample in each group. Four healing abutments were evaluated: 3mm one-piece, 8mm one-piece, 3mm two-piece, 8mm two-piece. The mean torque values was calculated and analyzed using statistical software. The overall mean torque value was 13.42Ncm and a one-way analysis of variance showed statistically significant difference between the different healing abutment groups ($p<0.001$). The 8mm two-piece group had the greatest difference among all the groups. However, all torque values were below the target level of 20Ncm. Dental healing abutments, similar to prosthetic abutment screws, should be tightened to the manufacture's recommended values utilizing a calibrated torque wrench to ensure adequate tightening and prevent early loss of the dental healing abutment.

Key Words: dental implants, healing abutments, torque, hand drivers

INTRODUCTION

Dental implants as a treatment option for replacing missing teeth is an increasing modality chosen by patients and dental clinicians. They have several benefits such as stability, durability, and are highly esthetic if done correctly[1]. However, current implant systems consist of multiple parts with a variety of designs to meet the needs of the clinician. These implant systems have various healing abutments (HEA) that attach to the implant body with the use of a separate screw or as a screw and abutment in one piece[2]. These HEA are used to preserve the soft tissue and may stimulate osseointegration around a successfully stabilized dental implant as well as to prepare the tissue for its final prosthesis.

Most implant manufactures recommend dental HEA to be “hand-tightened” or “finger-tightened”, whereas Biomet 3i implants (ZimVie Dental, Palm Beach Gardens, FL) have a specific torque value recommendation of 20 Newton centimeters (Ncm)[2]. HEA that have a torque recommendation of “hand-tighten” or “finger-tighten” have the potential to become loose, leading to HEA disconnection and reconnection. Frequent disconnection and reconnection of a dental HEA has been postulated to lead to changes in the mucosal barrier and increase marginal bone loss around an implant[3]. Along with biological changes, early loss or loosening of dental HEA can increase cost by increasing appointments, additional Stage II surgeries to re-expose the implant, and can also lead to mechanical problems with the implant body. By following recommended torque values and calibrating providers ability to hand-tighten HEA, prevention of early HEA loss can be avoided[4].

Several studies have identified wide ranges of clinicians’ ability to hand-tighten or hand torque various dental implant components[4-8]. According to one study, clinicians achieved torque values ranging from 11-38Ncm tightening HEA onto an implant secured in a typodont attached to a mannequin[7]. This study looked at inter-provider variance while tightening a HEA of the same height and type. Others researchers have compared various implant-abutment combinations with a final prosthesis and their associated prosthetic screws[8,9]. There are limited studies comparing clinician's ability to tighten various HEA and none that examine the torque achieved with different types of HEA. Therefore, we aim to compare the consistency of a single provider and potential variation of achieved torque values with different HEA by capturing and comparing Reverse Torque Values (RTV).

RTV have been utilized to compare clinician's ability to hand-tighten various abutments in several studies[1,4,6-8,10]. These values utilize both digital and manual means for capturing the RTV while unscrewing an abutment from a dental implant. However, several of these studies do not have repeat tests of the same clinicians and none compare the different types of HEA available.

The primary objective of this study is to compare RTV of different healing abutment types and collar heights by a single clinician. Our secondary objective is to evaluate the clinician's ability to consistently achieve the manufacture's recommended values for the dental HEA. Our null hypothesis is there will be no difference of the hand tightened RTV of the different HEA types or collar heights.

MATERIALS AND METHODS

Implant system and healing abutments

Four expired 4.1mmx11.5mm dental implants (Certain Internal Connection T3, ZimVie Dental, Palm Beach Gardens, FL) were selected (Figure 1). Four associated HEA were selected with two different collar heights and two distinct types of connections. These commercially available and packaged dental HEA were selected to match the emergence profile of the implant platform (4.1mm) and were stratified into four groups for testing: one-piece (OP) and two-piece (TP) HEA types (Figure 2,3), and 3mm and 8mm collar heights (Table 1). A new, previously unused manufacturer-compatible hand driver was utilized throughout the study.

Experimental design

A 3D software application (Meshmixer, Autodesk Inc., San Rafael, CA) was utilized to design a custom jig to hold the four implants. The custom jig was then printed utilizing a FormLabs 3 printer and Dental LT V1 Clear Resin (Formlabs Inc., Somerville, MA). Utilizing a ultra-violet light curable resin material (Triad Gel Clear Colorless, DENTSPLY International Inc., York, PA) the implants were securely fixed to the four wells (Figure 4). The implant jig was then held with a tabletop vice for stability. A single investigator hand tightened a HEA utilizing the manufacturer's hand driver to the perceived value of 20Ncm. The investigator then utilized a digital torque gauge (BTGE50CN, Tohnichi America Corporation, Buffalo Grove, IL) and the same hand driver to record the Reverse Torque Values (RTV) achieved to an accuracy of 0.05Ncm (Figure 5). This process was repeated 5 times for each group giving a total of twenty recorded RTV. During the testing process, the digital readout on the gauge was blocked out. This blinded the investigator to the achieved value. The disconnection-reconnection process number was chosen to be 5 times to simulate a clinical scenario. Data was stored on the digital torque gauge and then transferred to a Microsoft Excel worksheet for analysis.

Statistical analysis

The methodology was reviewed by an independent statistician. Statistical analysis was performed using Microsoft Excel's integrated data Analysis ToolPak (Microsoft Corporation, Redmond, WA). Graphical and descriptive statistics were utilized to confirm normal distribution and homogeneity of variance. A one-way analysis of variance (ANOVA) was utilized to determine if there was a significant difference among the groups and paired *t*-tests were utilized to determine where the difference was among the groups. The statistical significance was set to $\alpha=0.05$.

FIGURE 1. Implant body

FIGURE 2. One-piece healing abutment design with 3mm (left) and 8mm (right) collar heights

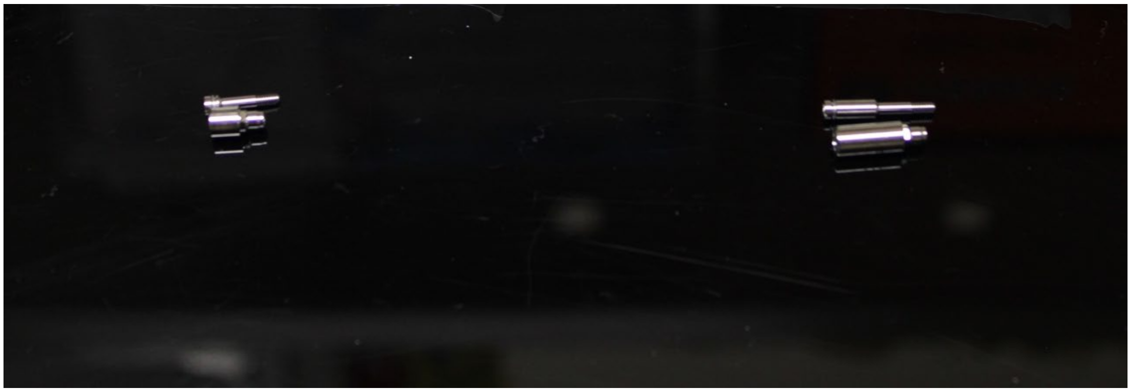

FIGURE 3. Two-piece healing abutment design with 3mm (left) and 8mm (right) collar heights

Table 1			
List of tested healing abutments (HEA)			
Manufacturer/Ref No.	**HEA types**	**HEA collar height**	**Recommended tightening torque, Ncm**
Zimmer Biomet 3i IEHA443	TP	3mm	20
Zimmer Biomet 3i IEHA448	TP	8mm	20
Zimmer Biomet 3i ISHA43	OP	3mm	20
Zimmer Biomet 3i ISHA48	OP	8mm	20

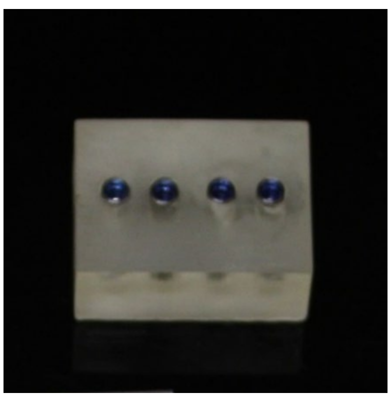

FIGURE 4. 3D printed jig with resin fixated implant bodies

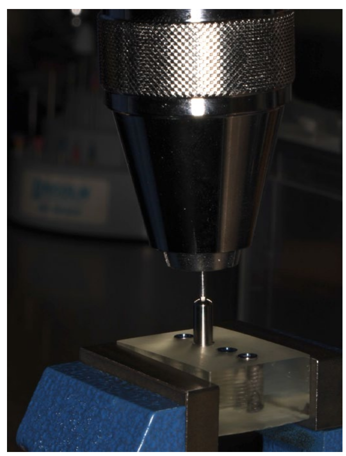

FIGURE 5. Reverse torque value measured with digital torque gauge for 8mm, one-piece healing abutment stabilized with tabletop vice

RESULTS

The total captured RTV are shown in Table 2 and the mean values calculated are shown in Figure 6. In this study, the mean of all twenty samples was 13.42Ncm. The highest mean was found in the 8mm TP group with 15.89±0.99 and the lowest mean was in the 3mm OP group at 12.06±0.90. The one-way ANOVA showed significant differences between HEA groups ($p<0.001$). Paired t-tests comparing HEA groups showed significant differences between the 3mm vs. 8mm TP HEA ($p=0.02$) and between the 8mm OP vs. TP HEA ($p=0.01$). There was no significant difference identified between the 3mm vs. 8mm OP HEA ($p=0.38$) or between the 3mm OP vs. TP HEA ($p=0.37$). The highest overall RTV was 17.10Ncm and the lowest was 10.50Ncm. All values were below the recommended target insertion torque of 20Ncm.

Table 2

Individual and mean reverse torque values (RTV) of HEA type and collar height

	RTV (Ncm) - 3mm, OP	RTV (Ncm) - 8mm, OP	RTV (Ncm) - 3mm, TP	RTV (Ncm) - 8mm, TP
Test #1	12.60	11.10	10.75	16.05
Test #2	12.45	12.40	14.15	17.10
Test #3	12.65	13.80	12.10	16.10
Test #4	12.10	13.30	15.20	15.85
Test #5	10.50	13.00	12.75	14.35
Mean	**12.06±0.90**	**12.72±1.04**	**12.99±1.74**	**15.89±0.99**

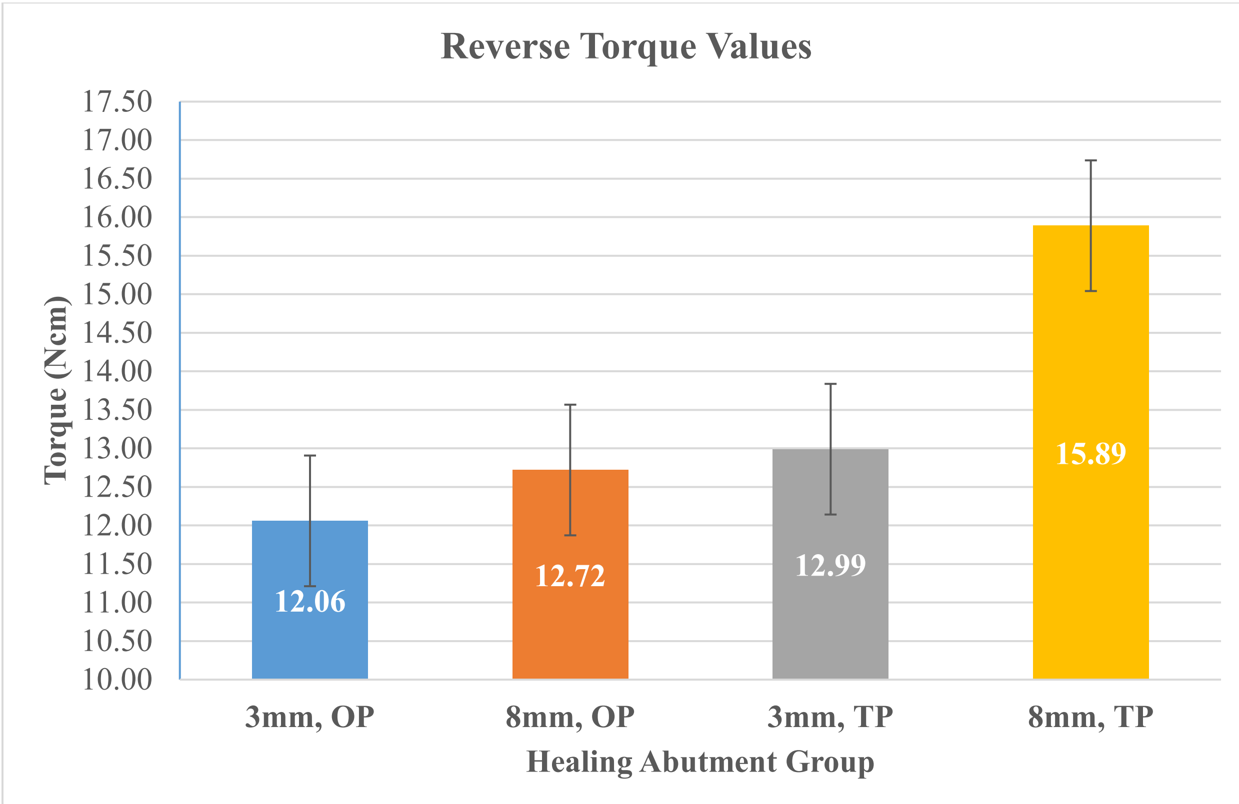

FIGURE 6. Mean reverse torque values for four separate groups

DISCUSSION

Previous studies comparing RTV on dental HEA are extremely limited. Most studies look at prosthetic screw tightening of different abutments, but none were found to examine the differences between dental HEA specifically. This study investigated a single clinician's ability to consistently hand-tighten different HEA and the potential differences between the RTV of different healing abutment types and collar heights. The results indicate that the mean torque, measured in RTV, achieved by hand-tightening various HEA types and collar heights was statistically significantly different, thereby, rejecting the null hypothesis.

Several studies have evaluated practitioner's ability to hand-tighten various abutments achieving results with wide variability. One of the earliest studies by Dellinges et al found that the average torque value of sixty second-year dental students was 11.55Ncm[5]. Other studies have found different mean values of 24.02Ncm[7] and 12.9Ncm[6] for clinicians' ability to hand-tighten HEA and prosthetic screws. Our mean RTV was consistent with these previous studies at 13.42Ncm. However, this value and all achieved values throughout this study were lower than the manufacture's recommended tightening value for 3i implants. A study by Bousquet et. al looked at the influence of bacteria proliferation with various clinicians' ability to hand-tighten and found that a torque $\geq$20Ncm decreased the gap connection between abutment-implant interface[11]. The study also identified that only 1.2% of the 54 clinicians were able to achieve torque >20Ncm[11]. This leads to continued recommendations to standardize and utilize torque wrenches when applying specific tightening values to dental implant abutments.

In this study, the significant difference noted between the first three groups and the final HEA group is difficult to ascertain. The investigator was blinded to the achieved values and therefore would not have increased the lower torque value based on the digital readout of the first groups. Also, one would assume that the learned feeling of being "fully tightened" should decrease based on finger fatigue compared to the initial values. One explanation could be the positioning of the dental implant in the jig and vise leading to an increase in clinician ability to tighten as the distance decreased. Another explanation could be length of the abutment screw and its ability to have a higher preload. One way to evaluate this would be to randomize the location of the healing abutments and then blind the clinician to which HEA is being tightened.

This investigation serves as a pilot study in the materials and methods utilized for evaluating dental HEA utilizing a high accuracy digital torque gauge. Due to this, several limitations are noted. A lack of randomization in the HEA groups evaluated could lead to skewed or inaccurate results. Utilizing a single clinician limited the sample size and ability to extrapolate to a larger population. Healing abutments were chosen based off expired parts to prevent excess cost which limited the number of groups. Future studies should consider these issues and account for them in order to enhance the validity of the findings.

CONCLUSION

Within the limitations of this pilot study, our results lead to the following conclusions:

- Length of the abutment screw may play a role in the ability to hand-tighten two-piece healing abutments.
- Clinicians are frequently unable to achieve recommended torque values for dental healing abutments.
- Use of torque wrenches to tighten dental healing abutments should be considered the standard rather than finger or hand-tightening (20Ncm).

ABBREVIATIONS

HEA: healing abutments

Ncm: Newton centimeters

RTV: reverse torque values

ANOVA: analysis of variance

OP: one-piece

TP: two-piece

REFERENCES

1. Alikhasi M, Kazemi M, Jalali H, Hashemzadeh S, Dodangeh H, Yilmaz B. Clinician-generated torque on abutment screws using different hand screwdrivers. *J Prosthet Dent*. Oct 2017;118(4):488-492. doi:10.1016/j.prosdent.2016.12.004
2. Zimmer. Certain Implant System Product Catalog. REV E ed2021.
3. Ríos-Santos JV, Tello-González G, Lázaro-Calvo P, et al. One Abutment One Time: A Multicenter, Prospective, Controlled, Randomized Study. *Int J Environ Res Public Health*. Dec 17 2020;17(24)doi:10.3390/ijerph17249453
4. 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*. Mar-Apr 1994;9(2):149-55.
5. Dellinges MA, Tebrock OC. A measurement of torque values obtained with hand-held drivers in a simulated clinical setting. *J Prosthodont*. Dec 1993;2(4):212-4. doi:10.1111/j.1532-849x.1993.tb00411.x
6. Hill EE, Phillips SM, Breeding LC. Implant abutment screw torque generated by general dentists using a hand driver in a limited access space simulating the mouth. *J Oral Implantol*. 2007;33(5):277-9. doi:10.1563/1548-1336(2007)33[277:Iastgb]2.0.Co;2
7. Kanawati A, Richards MW, Becker JJ, Monaco NE. Measurement of clinicians' ability to hand torque dental implant components. *J Oral Implantol*. 2009;35(4):185-8. doi:10.1563/1548-1336-35.4.185
8. Dincer Kose O, Karatasli B, Demircan S, et al. In Vitro Evaluation of Manual Torque Values Applied to Implant-Abutment Complex by Different Clinicians and Abutment Screw Loosening. *Biomed Res Int*. 2017;2017:7376261. doi:10.1155/2017/7376261
9. Hu E, Petrich A, Imamura G, Hamlin C. Effect of Screw Channel Angulation on Reverse Torque Values of Dental Implant Abutment Screws. *J Prosthodont*. Dec 2019;28(9):969-972. doi:10.1111/jopr.13111
10. Parnia F, Yazdani J, Fakour P, Mahboub F, Vahid Pakdel SM. Comparison of the maximum hand-generated torque by professors and postgraduate dental students for tightening the abutment screws of dental implants. *J Dent Res Dent Clin Dent Prospects*. Summer 2018;12(3):190-195. doi:10.15171/joddd.2018.029
11. Bousquet P, Bennasar IC, Tramini P, Jacquemot M, Cuisinier F. Tightening of healing abutments: influence of torque on bacterial proliferation risk, an in vitro investigation. *Biomed Tech (Berl)*. Dec 2014;59(6):495-500. doi:10.1515/bmt-2013-0142