Influence of Transmucosal Height on Loss of Prosthetic Abutment Torque After Mechanical Cycling

Karla Regina Nogueira da Silva, DDS, MS[1]
Júlio Cesar Joly, DDS, PhD[1]
Daiane Cristina Peruzzo, DDS, PhD[1]
Marcelo Henrique Napimoga, DDS, PhD[2]
Elizabeth Ferreira Martinez, DDS, PhD[2]*

The aim of this study was to measure and record the universal transmucosal abutment height, and then evaluate whether it influenced loosening of the abutment screw by analyzing the torque and detorque values after mechanical cycling. Thirty-six implants, model CM Unitite, with internal conical connections (3.5×10 mm) and respective universal prosthetic abutments ($n = 36$, 3.25×6 mm), were divided into three groups ($n = 12$ each) with respective transmucosal heights of 0.8, 3.5, and 5.5 mm. Insertion torque of 20 Ncm was used in accordance with the manufacturer's specifications. Afterward, the samples were submitted to fatigue tests consisting of 500,000 cycles at a frequency of 2Hz, a dynamic compressive load of 120N, and an angle of 30°. The detorque values were measured with a digital torque meter and tabulated to perform statistical analyses; a level of significance of 5% was adopted. The mean detorque values (SD) obtained were 22.83 (6.30), 22.5 (5.45), and 19.41 (4.69) Ncm for transmucosal abutments with heights of 0.8, 3.5, and 5.5 mm, respectively, and showed no statistically significant difference ($P = .262$). The authors of this study concluded that the transmucosal height of prosthetic abutments submitted to mechanical fatigue did not influence the detorque values.

Key Words: torque, transmucosal, implant-prosthetic abutment

INTRODUCTION

The evolution in implants used to replace natural teeth has been one of the major achievements in dentistry over the last few years. Ever since the studies reported by Branemark,[1] this approach has proved successful in the solution of esthetic and functional implant-supported restorations.[2] Nevertheless, the volume of surgeries has also led to an elevated number of failures.

One of the main causes of failures in implant dentistry is related to biomechanical failures or intercurrences at the implant-abutment interface. This may affect the stability of the set and cause screw loosening or fracture, interfering directly in the longevity of prosthetic rehabilitation.[3–6]

The intermediate abutment is coupled to the implant by tightening of the torque, an action that generates so-called preload stress within the screw.[7] Should any biomechanical interference occur, this preload may drop below critical levels, resulting in compromising the stability of the implant-abutment complex and in the loosening or fracture of the abutment screw.[8]

Different connection systems have been developed to bypass potential biomechanical problems regarding the implant-abutment assembly, such as the internal tapered systems. This type of connection design creates an area of friction between the implant wall and the abutment, promoting retention between the parts, further reinforced by the abutment screw.[9,10]

However, additional factors may also influence the intensity of the mechanical load bearing on the restoration, such as the height of the crown, which may create a vertical cantilever and destabilize the assembly when submitted to external loads.[11] This may cause a leverage effect, since an elevation of 1 mm in crown height may mean an increase of up to 20% of force on the set, placing a significant load on the implant and around the bone crest, with possible loss of the abutment or even the implant itself.[12]

It is important to point out that the height of the crown is measured from the bone crest up to the occlusal plane in the posterior region and from this crest up to the incisal edge in the anterior region.[13] It is noteworthy to elucidate that there is a belt—the transmucosal abutment—between the implant platform and the gingival margin, which may vary in dimension and interfere in the final height of the implant-supported restoration.

The choice of height of this transmucosal abutment will depend on the level of the implant platform in relation to the edge of the gingival margin. It should be observed that the terminal of the crown must be at least 1 mm lower to obtain an esthetic result, particularly on the vestibular surface.[14] Therefore, the choice of the transmucosal abutment depends on the depth at which the implant is inserted and its relationship with the edge of the gingival margin. Accordingly, the abutment

[1] Department of Oral Implantology, São Leopoldo Mandic Institute and Research Center, Campinas, São Paulo, Brazil.
[2] Department of Cell Biology, São Leopoldo Mandic Institute and Research Center, Campinas, São Paulo, Brazil.
* *Corresponding author,* e-mail: dr.efmartinez@gmail.com; elizabeth.martinez@slmandic.edu.br
DOI: 10.1563/aaid-joi-D-17-00250

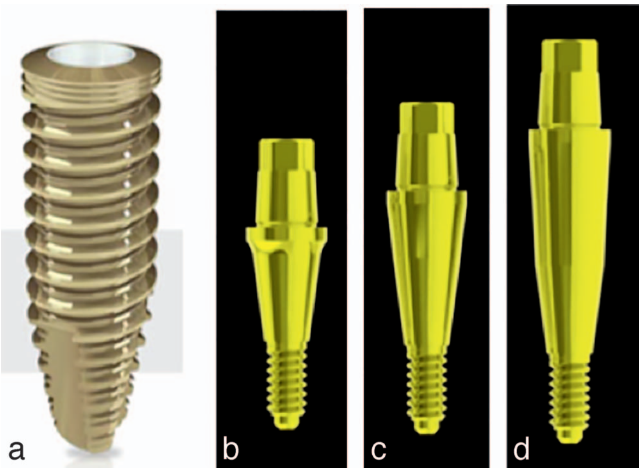

Figure 1. (a) Implant and (b) 0.8 mm, (c) 3.5 mm, (d) 5.5 mm prosthetic abutments.

may vary in centimeters and increase the vertical dimensions of the implant-supported dental prosthesis. This may cause a greater load on the abutment-implant set, a result of the possible effect of leverage.

The aim of this study was to evaluate whether different universal straight abutment transmucosal heights could interfere in the stability of the prosthetic implant-abutment set, causing preload loss of the abutment screw and consequent failure of the implant-supported prosthetic rehabilitation.

Materials and Methods

The implants used (n = 36) were model CM Unitite (SIN, São Paulo, SP, Brazil) with internal conical connections (3.5.5 × 10 mm) and with respective universal prosthetic straight abutments (n = 36), 3.25 mm in diameter and 6 mm high. They were divided into three groups (n = 12 each) with transmucosal abutment heights of 0.8, 3.5, and 5.5 mm (Figure 1).

The implants were fixed on a bench lathe (Premium Adjustable Vice 100 mm, Ningbo Genin Industrial Co, Ltd, Ningbo, China), with prosthetic straight abutments coupled to them with an insertion torque of 20 Ncm, as recommended by the manufacturer, using a hexagonal, 0.9 × 24.0 mm-long torque key (ref. CDHC-24, SIN) and digital Torque Meter TQ-8800 (Lutron, Taipei, Taiwan). The screws were retightened after 10 minutes to avoid the settling effect, as recommended by Winkler et al.[15]

The test specimens were fixed onto cylindrical bases made of tin, measuring 25 mm in diameter, with 20 mm on the highest side and 10 mm on the lowest; this provided the bases with a surface inclined at a 30° angle.[16]

The test sets were submitted to fatigue testing, consisting of 500 000 cycles at a frequency of 2Hz, with a compressive dynamic load of 120N in an electromechanical machine simulating 1 year's worth of fatigue by chewing, according to the protocol described in ISO 14.801.[17]

The number of cycles, frequency, and load force in the simulation were the same for the three groups, irrespective of the transmucosal straight abutment height. After mechanical cycling, the test specimens were once again fixed on the bench lathe, and the screws were submitted to detorque using a digital torque meter. The detorque values were measured and tabulated to perform statistical analyses.

Normal distribution of data was confirmed by Shapiro-Wilk test. The data were then subjected to the 1-way ANOVA test using SigmaPlot software for Windows, version 11 (Systat Software, Inc, San Jose, Calif). The level of significance was set at 5%.

Table

Different mean detorque values (SD), in Ncm, and respective transmucosal heights (mm)

Transmucosal Height	Mean (SD)
0.8 mm	22.83 (6.30)
3.5 mm	22.5 (5.45)
5.5 mm	19.41 (4.69)
$P = .262$	

Results

The mean detorque values obtained from the samples submitted to mechanical cycling are described in Table 1 and Figure 2. As shown, this procedure had no significant effect on the detorque values at the $P > .05$ level for the three different transmucosal heights evaluated ($P = .262$).

Discussion

When implant-supported dentures are used, loosening of the abutment screw is usually attributed to occlusal overload and maladjusted prosthetic abutments. However, internal conical connections have been found to be associated with a lower incidence of this problem because they provide an implant-prosthetic connection with pressure within the implant, thus making the connection safer.[18]

Abutment stability is directly related to the ability to maintain the preload, which is the tensional force accumulated within the screw as a result of its clamping function.[19] Clamping establishes firm contact between the abutment and the implant, keeping the screw from exceeding its elastic limit.[20] This avoids overload and consequent failure from screw loosening or fracture. In internal conical connections, the oblique and compressive forces generated by masticatory movements increase the preload of the screw, which reinforces retention of the screw because these forces act in the direction of the abutment insertion.[10]

In the present study, we proposed to evaluate whether different transmucosal universal straight abutment heights could interfere in the stability of the prosthetic implant-abutment set. This stability is important to avoid loss of screw preload and consequent failure of the implant-supported prosthetic rehabilitation. The results showed that there was no significant difference in the detorque values for the different transmucosal straight abutment heights evaluated ($P = .262$) in implants with internal conical connections.

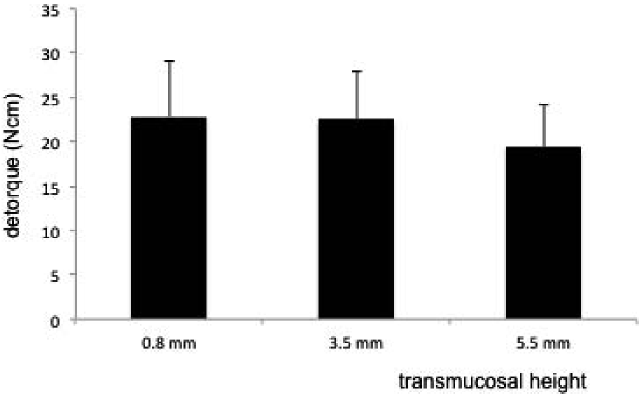

Figure 2. Mean detorque values (Ncm) at the different transmucosal abutment heights.

However, it was observed that the torque values were greater for the 0.8- and 3.5-mm high transmucosal straight abutments than the initial torque recommended by the manufacturer. In contrast, the lowest torque values were observed for the 5.5-mm high transmucosal straight abutment in comparison with the initial value. Although statistical analysis did not show a significant difference among the groups, this lower value from unstacking at the highest abutments may indicate a greater probability of screw loosening, as demonstrated in previous studies.[21,22]

Siadat et al[21] posited that transmucosal prosthetic abutment height could result in a leverage effect and overload the implant-abutment set. They evaluated different transmucosal heights (1.5, 3.5, and 5.5 mm) in implants with internal hexagon connections submitted to mechanical cycling and found that the screw torque loss was related directly to the transmucosal height. Ricardo Lillo et al[22] observed the internal conical connections submitted to mechanical cycling. They found that the lowest transmucosal height (2.5 mm) and the largest implant platform diameter (4.5 mm) presented the best mechanical behavior and resistance to compression of the set. Conversely, a greater height and a smaller diameter had the worst respective results.

Loosening of the prosthetic abutment screw is rare in single implant-supported dental prostheses, irrespective of the form or type of connection, provided the torque and anti-rotational features are put to use.[23] However, parafunctional habits may cause extremely critical conditions and cause failures due to loosening, or even loss, of the implant. This is especially the case when there is accentuated discrepancy in the implant-abutment-prosthesis proportion.[24] In addition to the role played by masticatory forces, the settling effect may occur and cause greater reduction in the screw preload. In the present study, implant screws were retightened 10 minutes after applying the initial torque, as recommended by Winkler et al,[15] as a routine clinical procedure to prevent the settling effect.

Internal connections of the conical type have reduced the incident of the leverage effect resulting from oblique forces. They distribute the forces homogeneously into the implant,[25] irrespective of the transmucosal height, as corroborated by the present study. The basic principles of an internal conical connection are locking and mechanical friction. Accordingly, the lateral loads prevent the prosthetic abutment from inclining. Consequently, the threads are protected from excessive functional loads,[26] and the prosthetic abutment undergoes a very low loss of preload. This diminishes the possibility of micromovements during occlusal function and avoids overload on the retention screw.[27] In this study, internal conical connections were used with 11° angulation of the walls and 3.7 mm internal height of the prosthetic abutment. This adaptation contributed to improving the load distribution, promoting greater contact pressure between the implant and the abutment for a cold-welding effect.

Conclusion

The differences between the initial torque and the detorque values were measured, revealing that the varying heights of prosthetic straight abutment belts of internal conical connections had no significant influence on the loss of screw preload. Therefore, the heights had no influence on screw loosening. This finding could prove to have a favorable clinical effect in regions of occlusal overload.

Acknowledgment

The authors wish to thank Prof Dr Lucas Novaes Teixeira, who performed an independent statistical analysis and confirmed the previous statistical results.

Note

The authors declare no conflicts of interest related to this study.

References

1. Brånemark PI, Hansson BO, Adell R, et al. Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10-year period. *Scand J Plast Reconstr Surg Suppl*. 1977;11:1–132.
2. Pietrabissa R, Gionso L, Quaglini V, Di Martino E, Simion M. An in vitro study on compensation of mismatch of screw versus cement-retained implant supported fixed prostheses. *Clin Oral Implants Res*. 2000;11:448–457.
3. Schwarz MS. Mechanical complications of dental implants. *Clin Oral Implants Res*. 2000;11:156–158.
4. Pjetursson BE, Tan K, Lang NP, Bragger U, Egger M, Zwahlen M. A systematic review of the survival and complication rates of fixed partial dentures (FPDs) after an observation period of at least 5 years. *Clin Oral Implants Res*. 2004;15:625–642.
5. Urdaneta RA, Rodriguez S, McNeil DC, Weed M, Chuang SK. The effect of increased crown-to-implant ratio on single-tooth locking-taper implants. *Int J Oral Maxillofac Implants*. 2010;25:729–743.
6. Goodacre CJ, Bernal G, Runcharassaeng K, Kan JYK. Clinical complications with implants and implant prostheses. *J Prosthet Dent*. 2003;90:121–132.
7. Alkan I, Sertgöz A, Ekici B. Influence of occlusal forces on stress distribution in preloaded dental implant screws. *J Prosthet Dent*. 2004;91: 319–325.
8. Steinebrunner L, Wolfart S, Ludwig K, Kern M. Implant-abutment interface design affects fatigue and fracture strength of implants. *Clin Oral Implants Res*. 2008;19:1276–1284.
9. Norton MR. An in vitro evaluation of the strength of a 1-piece and 2-piece conical abutment joint in implant design. *Clin Oral Implants Res*. 2000;11:458–464.

10. Bozkaya D, Müftü S. Mechanics of the tapered interference fit in dental implants. *J Biomech*. 2003;36:1646–1658.

11. Misch CE, Goodacre CJ, Finley JM, et al. Consensus conference panel report: crown-height space guidelines for implant dentistry—part 1. *Implant Dent*. 2005;14:312–318.

12. Bidez MW, Misch CE. Clinical biomechanics in implant dentistry. In: Misch CE, ed. *Contemporary Implant Dentistry*. 3rd ed. St Louis, MO: Mosby; 2008:543–555.

13. Misch CE, Bidez MW. Implant protected occlusion, a biomechanical rationale. *Compendium*. 1994;15:1330,1332,1334, quiz 1344.

14. Abichandani SJ, Nadiger R, Kavlekar AS. Abutment selection, designing, and its influence on the emergence profile: a comprehensive review. *Eur J Prosthodont*. 2013;1:1–10.

15. Winkler S, Ring K, Ring JD, Boberick KG. Implant screw mechanics and the settling effect: overview. *J Oral Implantol*. 2003;29:242–245.

16. Alves DCC, Carvalho PSP, Elias CN, Vedovatto E, Martinez EF. In vitro analysis of the microbiological sealing of tapered implants after mechanical cycling. *Clin Oral Investig*. 2016;20:2437–2445.

17. ISSO 14.801:2007 – dentistry – implants – dynamic fatigue test for endosseous dental implants. Geneva, Switzerland: *The International Organization for Standardization*.

18. Zipprich H, Weigl P, Lange B, Lauer HC. Micromovements at the implant-abutment interface: measurement, causes and consequences. *Implantologie*. 2007;15:31–46.

19. Jornéus L, Jemt T, Carlsson L. Loads and design of screw joints for single crowns supported by osseointegrated implants. *Int J Oral Maxillofac Implants*. 1992;7:353–359.

20. Patterson EA, Johns RB. Theoretical analysis of the fatigue life of fixture screws in osseointegrated dental implants. *Int J Oral Maxillofac Implants*. 1992;7;26–34.

21. Siadat H, Pirmoazen S, Beyabanaki E, Alikhasi M. Does abutment collar length affect abutment screw loosening after cyclic loading? *J Oral Implantol*. 2015;41(spec no.):346–351.

22. Lillo R, Parra C, Fuentes R, Borie E, Engelke W, Beltrán V. Compressive resistance of abutments with different diameters and transmucosal heights in Morse-taper implants. *Braz Dent J*. 2015;26:156–159.

23. Theoharidou A, Petridis HP, Tzannas K, Garefis P. Abutment screw loosening in single-implant restorations: a systematic review. *Int J Oral Maxilofac Implants*. 2008;23:681–690.

24. Fugazzotto PA, Beagle JR, Ganeles J, Jaffin R, Vlassis J, Kumar A. Success and failure rates of 9 mm or shorter implants in the replacement of missing maxillary molars when restored with individual crowns: preliminary results 0 to 84 months in function: a retrospective study. *J Periodontol*. 2004; 75:327–332.

25. Maeda Y, Satoh T, Sogo M. In vitro differences of stress concentrations for internal and external hex implant-abutment connections: a short communication. *J Oral Rehabil*. 2006;33:75–78.

26. Merz BR, Hunenbart S, Belser UC. Mechanics of the implant-abutment connection: an 8-degree taper compared to a butt joint connection. *Int J Oral Maxillofac Implants*. 2000;15:519–526.

27. Fortes RP, Kobayashi WC, Sendyk WR, Romão-Junior W. Comparative analysis of the abutment loosening torque connected to Morse taper implants, after cyclic loading. *Implant News*. 2008;5:639–645.