The journal of
PROSTHETIC AND IMPLANT DENTISTRY
Official Publication of Indian Prosthodontic Society
Kerala State Branch

DOES TORQUE MAGNITUDE INFLUENCE DENTAL IMPLANT ABUTMENT SCREW? – A SEM ANALYSIS

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Abstract:

***Statement of problem:** Screw loosening of dental implants is one of the most common problems in prosthodontic practice. Despite known factors for screw loosening, the possible role of torque magnitude as a function of preload on the implant surface morphology must be explored to further understand the problem of screw loosening. **Purpose:** To evaluate the surface morphology of implant abutment screws under different torque magnitudes. **Materials and methodology:** Dental implant abutment screws of CMI, Neobiotech, South Korea were torqued to 15, 20, 35 and 45 Ncm on its corresponding laboratory implant analogue (3.5 X 11.5 mm). Using scanning electron microscopy (SEM) imaging, the torqued abutment screws were evaluated for any surface irregularities and thread wear. **Results:** SEM analysis of the torqued abutment screws revealed notching, stripping and wearing of the threads. The severity of altered surfaces increased with torque magnitude, compared to the absence of wear on the untorqued control abutment screws. **Conclusion:** Repeated tightening and loosening of titanium abutment screws can lead to thread wear and stripping. The chronic event of the above phenomenon can lead to screw loosening and further screw fracture. Studies on enhancing the abutment screw coatings with materials of reduced coefficient of friction can decrease the incidence of screw loosening and clinical adherence to replacing loosened abutment screws of implant patients with a new abutment screw is recommended to avoid screw fatigue and fracture.*

Key words: **Dental implants, Implant abutment screw, Screw loosening, Preload, Implant prosthetics**

1. Introduction

Though osseointegrated dental implants are the most predictable treatment of tooth replacement, long-term studies have shown presence of prosthetic complications, such as screw loosening and screw fracture. Problems associated with the integrity of implant –abutment screw joint assembly continue to be a perplexing clinical predicament for prosthodontists.[1,2] Abutment screw loosening is a recognized obstacles in successful prosthetic implant restorations and one of the common causes of restoration failures. In particular, the incidence of screw loosening of 33 % has been reported in single implant supported restorations.[3] Treatment of such prosthetic complications are further expensive and time consuming for both patient and the clinician. Concerted efforts by the implant manufacturers and clinicians are required to impact the above-mentioned complications. Factors such as preload, bending of screw joint, settling effect, coefficient of friction, screw material, connection geometry, implant number, implant diameter, restoration design and occlusal table influence the incidence of screw loosening. The influence of each of these factors is schematically illustrated in Fig. 1.

It is known that repeated tightening of the abutment screws can lead to the loss of the preload. The application of force while retightening could further

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lead to cold welding or fracture of the abutment screw. The surface changes on the abutment screw while torquing that occurs at a microscopic level are usually not evident clinically. Understanding wear of abutment screw at a microscopic level may help decipher the mechanism of screw loosening. Therefore, we aim to investigate the influence of torque magnitude on the surface morphology of abutment screw.

2. Methodology

A CMI Neo Biotech dental implant lab analogue (3.5X 11.5 mm, N2658-26, South Korea) was mounted in type III dental stone (Kalabhai, Mumbai, India). Five unused CMI Neo biotech implant abutment screws are manually torqued to the lab analogue to the values of 0 Ncm, 15 Ncm, 20 Ncm, 35 Ncm and 45 Ncm. With the control abutment screw, the experimentally torqued abutment screws to 15 , 20 , 35, and 45 Ncm are labeled as screw A, B, C, and D respectively. The torque screws were cleaned in ethyl alcohol in an ultrasonic bath to remove residues and impurities. The abutment screws were further subjected to scanning electron microscopy (COX IEM-30, South Korea) under magnifications, 75X and 250X to evaluate surface morphological changes of torque abutment screws such as surface irregularities, chipping, stripping and thread wear.

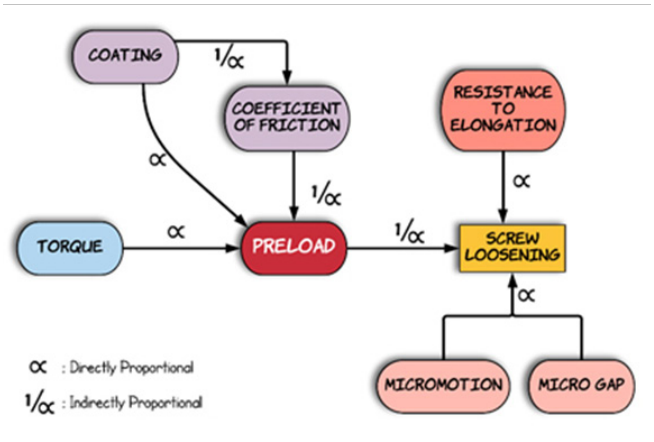

Fig.1 Flowchart representing factors influencing preload

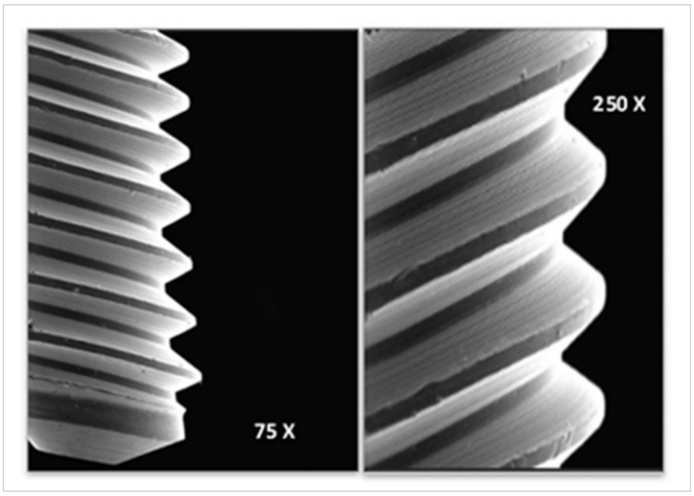

Fig.2 Scanning electron microscopic images of the control implant abutment screw at low magnification (75 X) and higher magnification (250X)

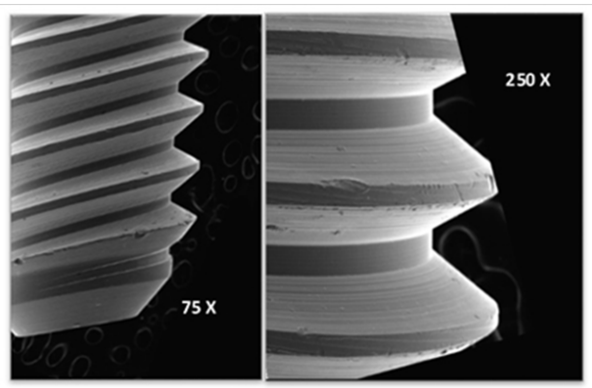

Fig.3 Scanning electron microscopic images of the implant abutment screw A torqued at 15 Ncm at low magnification (75 X) and higher magnification (250X)

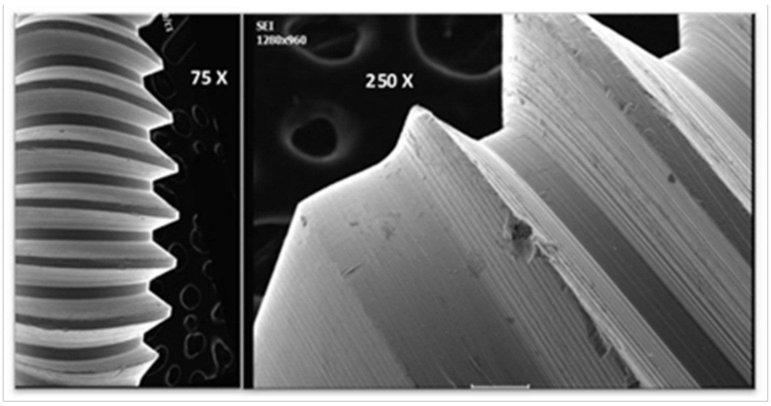

Fig.4 Scanning electron microscopic images of the implant abutment screw B torqued at 25 Ncm at low magnification (75 X) and higher magnification (250X)

3. Results

Scanning electron microscopy of the control abutment screw, reveals smooth threads under low magnification and minor notches under high magnification as seen in Fig.2. Further, screw A (torqued to 15Ncm) shows uniform thread surface at low magnification with minor notching at higher magnification as seen in Fig.3. Screw B (torqued to 25Ncm) also shows uniform thread surface at low magnification with marked notching at the apical threads as shown in Fig.4. Screw C (35Ncm) revealed surface irregularities which were more pronounced and were present along the entire length of the screw as can be deciphered from Fig.5. Furthermore, with increase of torque, screw D (torqued to 45Ncm) shows extensive stripping at low magnification and at higher magnification showed severe wear of threads all along the length of the abutment screw as seen from Fig.6.

4. Discussion

The secure connection of the implant-abutment surfaces often depends on the preload applied by a predetermined amount of torque during abutment placement on the dental implant. Clinically, decrease in the torque value has been reported when the implant system is in function over occlusal load.[4] Preload of an abutment or prosthetic screw is the initial load created by the application of a torque on the screw that results further in its elongation. Preload places the screw in tension and leads to an over-clamping force between the parts of the implant system. The aim of tightening a screw using preload stress is to maximize the fatigue life of the screw yet provide satisfactory resistance to loosening. There are factors that influence the preload such as the torque magnitude, screw head design, thread design, composition of metal, component fit, surface condition, and diameter of the screw.[5]

It can be deciphered from Fig.2-6, that an increase in insertion torque results in greater wearing of the abutment screw threads. The surface irregularities and notching appear to start from the leading edge of the apical section of the screw with the torques of 15Ncm and 25Ncm and seem to progress along the entire length of the abutment screw at 35Ncm. The abutment screw torqued at 45Ncm showed extensive stripping. Increased torque magnitude can damage the abutment threads, reduce the preload over a period of time and further lead to screw loosening and under constant load, lead to fatigue and fracture. The results of the study are further confirmed by the incidence of higher preload resulting in reduced micromotion with a more stable joint assembly.[2]

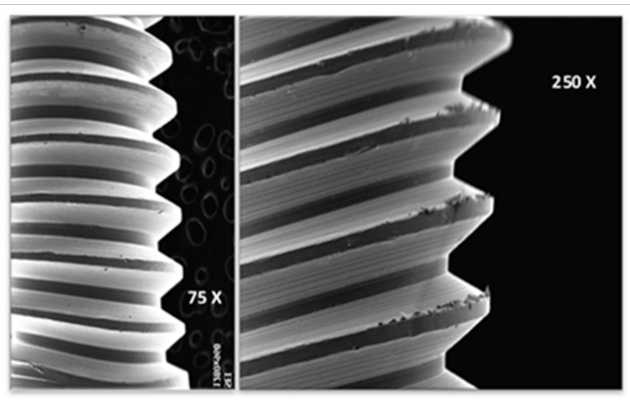

Fig.5 Scanning electron microscopic images of the implant abutment screw C torqued at 35 Ncm at low magnification (75 X) and higher magnification (250X)

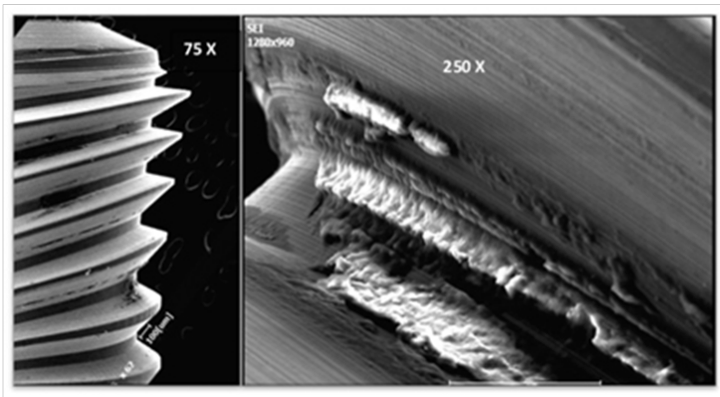

Fig. 6. Scanning electron microscopic images of the implant abutment screw D torqued at45 Ncm at low magnification (75 X) and higher magnification (250X)

To overcome the above stated problem of preload loss and prosthetic complications of screw loosening and fracture, abutment screws with modified or enhanced surfaces have been promoted to help reduce the coefficient of friction and generate greater rotational angles and preload values.[6–8] Several implant manufacturers attempted to lessen the incidence of screw loosenings through coatings on the abutment screws. Implant Innovations Inc (3i, West Palm Beach, Fla.) tailored the palladium-gold abutment screw surface with a solid gold lubricant with 0.76 μ thickness to decrease the coefficient of friction and increase preload by 24%. Further, Steri-Oss (Nobel BioCare USA, Yorba Linda, Calif.) modified the surface of its titanium abutment screw through a polytetra fluoroethylene polymer (Teflon) spray coating to decrease friction by 60% and increase fatigue strength.7–9 When titanium slides in contact with other metals of similar hardness, the coefficient of friction is initially low; however, with repeated tightening and loosening, the values of coefficient friction gradually increases to that of titanium implant against titanium abutment surfaces.[7,9] This increase in the friction coefficient to galling (wear caused by adhesion between two sliding surfaces) and seizing (cold welding-actual freezing together of the threads) tendency of titanium alloys. Reducing the coefficient of friction and enhancing the tightening speed, increases the angle of turn of the coated abutment screw at the target torque. As the angle of turn increases, the elastic energy and preload also increases. Additionally, an increase in the coefficient of friction, increases the frictional dissipation energy leading to a decrease in preload.[7]

Limitations of the study are that the cyclic loading was not used as it could have simulated the masticatory cycles, use of manual torque wrench instead of digital torque wrench, use of single implant manufacturer and using torque magnitude as a function of preload. The results can further be validated through evaluation of surface roughness parameters such as Ra, Rq with Optical Profilometer and Atomic Force Microscopy.

5. Conclusion

Repeated tightening and loosening of titanium abutment screws lead to thread wear, stripping and eventually screw fracture. Understanding the effect of the coefficient of friction and tightening speed on preload can improve the stability of joint surface characteristics, tightening speed and reduce the incidence of screw loosening. Clinically replacing the loosened abutment screw in a patient with a new abutment screw is recommended and a safer choice to prevent prosthetic complications.

6. References

1. Byrne D et al. Preloads generated with repeated tightening in three types of screws used in dental implant assemblies. J Prosthodont 2006; 15(3): 164–171. doi:10.1111/j.1532-849X.2006.00096.x.
2. Gratton DG et al. Micromotion and dynamic fatigue properties of the dental implant-abutment interface. J Prosthet Dent 2001; 85(1): 47–52. doi:10.1067/mpr.2001.112796.
3. Theoharidou A et al. Abutment screw loosening in single-implant restorations: a systematic review. Int J Oral Maxillofac Implants 23(4): 681–90. Available at: http://www.ncbi.nlm.nih.gov/pubmed/18807565. Accessed March 25, 2017.
4. Silva F et al. Preload Loss and Bacterial Penetration on Different Implant-Abutment Connection Systems. 2010; 21: 123–129.
5. Misch CE. Dental Implant Prosthetics. 2nd edition. St.Louis/Elsevier. 2015.pp 725-752.
6. Kim SK et al. An abutment screw loosening study of a Diamond Like Carbon-coated CP titanium implant. J Oral Rehabil 2005; 32(5): 346–50. doi:10.1111/j.1365-2842.2004.01475.x.
7. Martin WC et al. Materials and Surfaces. J Prosthet Dent 2001; 86(6): 24–32.
8. Park C et al. Effects of Surface Coating on the Screw Loosening of Dental Abutment Screws. Met Mater Int 2004; 10(6): 6–10.
9. Kim H-J et al. Abrasion of abutment screw coated with TiN. J Adv Prosthodont 2009; 1(2): 102--106. doi:10.4047/jap.2009.1.2.102.