Journal of Dental and Oral Health

Scient Open Access
Exploring the World of Science

Open Access Full Text Article

Research Article

# Influence of Dimensions on the Primary Stability and Removal Torque of Short Dental Implants

This article was published in the following Scient Open Access Journal:
Journal of Dental and Oral Health
**Received** June 27, 2015; **Accepted** July 10, 2015; **Published** July 17, 2015

**Ali Alghamdi[1]*, Fayz Alshehri[1], Mariana Alghamdi[2] and Anil Sukumaran[1]**

[1]*King Saud University, Saudi Arabia*
[2]*King Abdulaziz University, Saudi Arabia*

## Abstract

**Background:** Reduced vertical bone level in the implantation area is often considered one of the limiting factors before implant insertion. Inserting implants of reduced length might be useful in order to avoid vertical bone augmentation prior to implantation. The uses of short implants in compromised sites are considered an alternative procedure to avoid extensive surgical procedures such as sinus lifting and grafting.

**Methods:** 40 short dental implants (4.8 and 6.2 mm diameter with 5 and 7 mm diameter) fixtures were installed on 20 bovine rib blocks. The primary stability of the implant was measured by the resonance frequency using an Osstel Mentor ® device. The removal torque values (RTV) of the implants were assessed using a Digital torque gauge instrument.

**Results:** Both 4.8 and 6.2 mm wider implants showed marginal increase in resonance frequency and removal torque values with 5 and 7 mm implants. However when the comparison was done between the two implants with different diameter a significantly higher primary stability was observed with 6.2 mm diameter implants.

**Conclusion:** From the observations of the study it can be concluded that short implants were able to achieve desirable primary stability. The primary stability substantially improved with short implants with wider diameter.

**Keywords:** Short implants, Removal torque, Primary stability, Resonance frequency analysis

## Introduction

Successful osseointegration has an important influence on the long term success of dental implant restorations. While primary implant stability and osseointegration can be predictably achieved in dense bone, it is often challenging to achieve the same in areas with poor bone quality [1]. Primary stability lowers the level of implant micromotion, which in turn allows uninhibited healing and osseointegration [2].

Studies have demonstrated that initial implant stability is influenced by factors such as the length and diameter of the implant, the implant design, the micro-morphology of the implant surface, the insertion technique, and the congruity between the implant and the surrounding bone [3-5]. Further important determinants are the quality and quantity of the bone. Low density bone implant sites have been pointed out as the greatest potential risk factor for implant loss when working with standard bone drilling protocols [6,7]. Clinical study with consecutively placed implants that were immediately loaded showed a higher failure rate in low density bone, reinforcing that primary stability is a major determinant in the success of immediately loaded implants [8,9]. Many reports have shown that it is a viable concept to use the short dental implants in both jaws [10].

Number methods are used to assess the primary stability of the dental implant [11]. Among these resonance frequency analysis has been revealed and widely used as the most successful method to assess primary stability because of its easiness, accuracy, and non-invasiveness [1,12]. The implant-bone interface is measured based by resonance frequency (RF)which is the reaction to oscillations exerted to the implant, and is expressed as implant stability quotient (ISQ) [13]. On the other hand mechanical test such as insertion torque and values of push-out test showed positive correlation to the primary stability [14,15].

Hence noninvasive measurement methods have also been introduced for the

***Corresponding author:** Ali Alghamdi, BDS, King Saud University, Saudi Arabia, Tel: 00966506595579, Email: ali.malghamdi@yahoo.com

diagnosis and prediction of immediate and the long-term implant stability. Studies have shown that the measurement of removal torque strength was a useful indirect biomechanical method to evaluate the bone and implant interface [16,17]. The purpose of this in vitro study was to compare the primary stability and removal torque measurements of short dental implants with different dimensions.

## Materials and Methods

Fresh bovine ribs procured from the butcher shop were used for the study. They were cut into 6 cm long pieces and a total of 20 bovine rib blocks were prepared. The cortical bone was removed until it was about 1 mm thick in order to make it mimic to type II bone [18]. 10 short implants with a diameter of 4.8 mm with two different lengths 5 mm and 7 mm were used to assess the **Resonance frequency (**RF) and **Removal torque values (**RTV). Similarly another set of short implants with 6.2x5 mm and 6.2x7 mm were used for comparison.

### Resonance frequency (RF)

After installation, the ISQ was measured by using resonance frequency analyzer (Osstell Mentor™). The osteotomy sites were prepared according to the manufacturer's guidelines. After implant insertion, the magnetic wireless RF analyzer was used for direct measurement of the endosseous implant stability. The RF analysis technique analyzes the RF of a smartpeg® which can be attached to the implant.

### Removal torque values (RTV)

The RTV of each implant was measured using a digital torque MGT 50®digital torque gauge instrument (MARK-10 Corp., New York). A controlled, gradually increasing rotational force (displacement 0.5 mm $min^{-1}$) was applied to the implant until implant loosening. The peak force measured at implant loosening was scored as the torque-out value [19].

## Statistical Analysis

The statistical analysis will be performed with GraphPad® Instat 3.05 software (GraphPad Software Inc, San Diego, CA, USA) using analysis of variance (ANOVA). Tukey-Kramer multiple comparisons test was used to compare the ISQ values and RTV of the two types of implants with two different dimensions. p-value<0.05 were assumed to be statistically significant.

## Results

The mean values and standard deviations of resonance frequency measurements are shown in Table 1. The 4.8 implants showed ISQ values of 45.08 ± 2.29 and 46.45 ± 1.60 respectively for 5 mm and 7 mm respectively. For the 6.2 mm implants the ISQ values were 50.5 ± 1.05 and 51.57 ± 2.06 respectively for 5 mm and 7 mm implants. Even though the values were higher for 7 mm in both groups it was not significant. However when it showed significant difference (P<0.01) between the 4.8 mm and 6.2 mm diameter implants at both dimensions.

The removal torque values are depicted in Table 2. The removal torque measurements showed no significant differences between 4.8 and 6.2 mm implants with 5 mm and 7 mm length. The removal torque values showed significant difference with the different diameter of the implants used. The 6.2 mm implants showed significantly higher RTV compared to the 4.8 mm implants.

| 4.8X5 | 4.8x7 | 6.2X5 | 6.2X7 |
|---|---|---|---|
| 43.3 | 44.5 | 51 | 52 |
| 45.5 | 48.5 | 51 | 50.5 |
| 43.5 | 47.1 | 52 | 52.4 |
| 46.5 | 46.5 | 49 | 48.5 |
| 41.5 | 44.5 | 50 | 52 |
| 45.5 | 45.5 | 49.5 | 53.5 |
| 42.5 | 48.5 | 50 | 53 |
| 47.5 | 47.5 | 49.5 | 53.5 |
| 48.5 | 44.5 | 51 | 47.6 |
| 46.5 | 47.4 | 52 | 52.7 |
| **45.08** | **46.45** | **50.5** | **51.57** |
| **2.29** | **1.60** | **1.05** | **2.06** |

**Table 1:** The mean values and standard deviations of resonance frequency measurements.

| 4.8X5 | 4.8x7 | 6.2X5 | 6.2X7 |
|---|---|---|---|
| 24 | 26 | 27 | 27.4 |
| 26.5 | 25 | 28.2 | 29.5 |
| 24 | 24.5 | 26.5 | 30.2 |
| 25 | 27.2 | 29.4 | 28.5 |
| 23.4 | 27 | 25 | 25.4 |
| 26 | 26.4 | 28.4 | 31 |
| 25 | 28 | 29 | 27.6 |
| 24.4 | 25.6 | 28.2 | 30.4 |
| 25 | 26 | 29 | 28.8 |
| 26.6 | 24 | 27 | 31 |
| **24.99** | **25.97** | **27.77** | **28.98** |
| **1.09** | **1.25** | **1.37** | **1.81** |

**Table 2:** Values of removal torque.

## Discussion

Several critical factors are necessary for successful osseointegration of dental implants, including the primary stability and surface characteristics of the implant, anatomical conditions.

The primary stability of the implant, which results from the initial interlocking between alveolar bone and the body of the implant, affects the secondary stability of the implant because the latter results from subsequent contact osteogenesis and bone remodeling [20,21]. Implant stability is a prerequisite for the long-term clinical success of osseointegrated implants [22,23]. The stability of implants can be successfully assessed by the Osstel device which quantifies the RF. Resonance frequency is a noninvasive, objective method to evaluate implant stability and it has been validated through *in vitro* and *in vivo* studies [13,24]. The technique is based on the measurement of the RF of a small piezoelectric transducer attached to an implant or abutment [13,25].

As a consequence, a high degree of primary implant stability is a key prerequisite for immediate or early loading [26,27]. The primary determinants of the primary stability of an implant are the surgical technique used, the design of the implant, and the mechanical properties of the bone tissue [28]. Maintenance of low implant micro-movement, especially in the early healing phase is important to promote direct bone in growth to implant surface [29]. Earlier studies have shown a linear relationship between the exposed implant height and the corresponding ISQ values. Tozum TF, et al. [30], Sim CP and Lang NP [31] reported a correlation between the ISQ values and the bone structure and implant length. On the other hand O'Sullivan et al. [32] failed to report any correlation between the implant primary stability and the shape of the implant. In the present study a comparison was done between bone level implants and tissue level implants with similar dimensions. Bone level implants showed slightly higher but insignificant ISQ and removal torque values as compared to the tissue level implants.

The removal torque is defined as the amount of torque required to unscrew an implant from bone and is determined by the total degree of contact between the implant surface and bone. The greater removal torque values may be interpreted as the higher stability of the implants [33].

Bovine rib was used in this study and is classified as type II bone in other studies since contains thick compact bone and dense trabecular bone [34].

From the observed primary stability it can be concluded that short implants were able to achieve desired primary stability in areas with good bone quality. The use of small diameter implants can prevent the need for bone reconstruction like bone grafting or other augmentation procedures [35,36].

Within the limitations of the study, it can be assumed that implant dimension is an important factor in establishing primary stability than the implant dimension from the biomechanical point.

## Conclusion

From the observed primary stability it can be concluded that short implants were able to achieve desired primary stability in areas with good bone quality. The use of small diameter implants can prevent the need for bone reconstruction like bone grafting or other augmentation procedures [35,36].

Within the limitations of the study, it can be assumed that implant dimension is an important factor in establishing primary stability than the implant dimension from the biomechanical point.

### References

1. Yoon HG, Heo SJ, Koak JY, Kim SK, Lee SY. Effect of bone quality and implant surgical technique on implant stability quotient (ISQ) value. *J Advanced Prosthodont.* 2011;3(1):10-15.
2. Traini T, Assenza B, Roman F, Thams U, Caputi S, Piattelli A. Bone microvascular pattern around loaded dental implants in a canine model. *Clin Oral Investig.* 2006;10(2):151-156.
3. Büchter A, Kleinheinz J, Joos U, Meyer U. Primary implant stability with different bone surgery techniques. An in vitro study of the mandible of the minipig. *Mund Kiefer Gesichtschir.* 2003;7(6):351-355.
4. O'Sullivan D, Sennerby L, Jagger D, Meredith N. A comparison of two methods of enhancing implant primary stability. *Clin Implant Dent Relat Res.* 2004;6(1):48-57.
5. Abrahamsson I, Linder E, Lang NP. Implant stability in relation to osseointegration: an experimental study. *Clin Oral Implants Res.* 2009;20(3):313-318.
6. Garg AK. Success of dental implants in the geriatric patient. *Dent Implantol Update.* 2004;13(4):25-31.
7. Jacobs R. Preoperative radiologic planning of implant surgery in compromised patients. *Periodontol.* 2003;33:12-25.
8. Glauser R, Ree A, Lundgren A, Gottlow J, Hammerle CH, Scharer P. Immediate occlusal loading of Branemark implants applied in various jawbone regions: a prospective, 1-year clinical study. *Clin Implant Dent Relat Res.* 2001;3(4):204-213.
9. Molly L. Bone density and primary stability in implant therapy. *Clin Oral Implants Res.* 2006;17 Suppl 2:124-135.
10. Malo P, de Araujo Nobre M, Rangert B. Short implants placed one-stage in maxillae and mandibles: a retrospective clinical study with 1 to 9 years of follow-up. *Clin Implant Dent Relat Res.* 2007;9(1):15-21.
11. Lachmann S, Jager B, Axmann D, Gomez-Roman G, Groten M, Weber H. Resonance frequency analysis and damping capacity assessment. Part I: an in vitro study on measurement reliability and a method of comparison in the determination of primary dental implant stability. *Clin Oral Implants Res.* 2006;17(1):75-79.
12. Balleri P, Cozzolino A, Ghelli L, Momicchioli G, Varriale A. Stability measurements of osseointegrated implants using Osstell in partially edentulous jaws after 1 year of loading: a pilot study. *Clinical Implant Dent Relat Res.* 2002;4(3):128-132.
13. Meredith N. A review of nondestructive test methods and their application to measure the stability and osseointegration of bone anchored endosseous implants. *Critical Rev Biomed Eng.* 1998;26(4):275-291.
14. Degidi M, Perrotti V, Strocchi R, Piattelli A, Iezzi G. Is insertion torque correlated to bone-implant contact percentage in the early healing period? A histological and histomorphometrical evaluation of 17 human-retrieved dental implants. *Clin Oral Implants Res.* 2009;20(8):778-781.
15. Turkyilmaz I, Sennerby L, McGlumphy EA, Tozum TF. Biomechanical aspects of primary implant stability: a human cadaver study. *Clin Implant Dent Relat Res.* 2009;11(2):113-119.
16. Carlsson L, Rostlund T, Albrektsson B, Albrektsson T. Removal torques for polished and rough titanium implants. *Int J Oral Maxillofac Implants.* 1988;3(1):21-24.
17. Motoyoshi M, Hirabayashi M, Uemura M, Shimizu N. Recommended placement torque when tightening an orthodontic mini-implant. *Clinical Oral Implants Res.* 2006;17(1):109-114.
18. Lekholm U, Zarb G, Branemark P, Zarb G. Tissue integrated prostheses Osseointegration in clinical dentistry. Chicago: Quintenssence. 1985;199-209.
19. Schouten C, Meijer GJ, van den Beucken JJ, Leeuwenburgh SC, de Jonge LT, Wolke JG, et al. In vivo bone response and mechanical evaluation of electrosprayed CaP nanoparticle coatings using the iliac crest of goats as an implantation model. *Acta Biomater.* 2010;6(6):2227-2236.
20. Berglundh T, Abrahamsson I, Lang NP, Lindhe J. De novo alveolar bone formation adjacent to endosseous implants. *Clin Oral Implants Res.* 2003;14(3):251-262.
21. Esposito M, Grusovin MG, Willings M, Coulthard P, Worthington HV. Interventions for replacing missing teeth: different times for loading dental implants. *Cochrane Database Syst Rev.* 2013;3:CD003878.
22. Dilek O, Tezulas E, Dincel M. Required minimum primary stability and torque values for immediate loading of mini dental implants: an experimental study in nonviable bovine femoral bone. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2008;105(2):e20-27.
23. Seong WJ, Kim UK, Swift JQ, Hodges JS, Ko CC. Correlations between physical properties of jawbone and dental implant initial stability. *J Prosthet Dent.* 2009;101(5):306-318.
24. Veltri M, Balleri P, Ferrari M. Influence of transducer orientation on Osstell stability measurements of osseointegrated implants. *Clin Implant Dent Relat Res.* 2007;9(1):60-64.
25. Meredith N, Alleyne D, Cawley P. Quantitative determination of the stability of the implant-tissue interface using resonance frequency analysis. *Clin Oral Implants Res.* 1996;7(3):261-267.
26. Kim SK, Lee HN, Choi YC, Heo SJ, Lee CW, Choie MK. Effects of anodized oxidation or turned implants on bone healing after using conventional drilling or trabecular compaction technique: histomorphometric analysis and RFA. *Clin Oral Implants Res.* 2006;17(6):644-650.

27. Roccuzzo M, Aglietta M, Cordaro L. Implant loading protocols for partially edentulous maxillary posterior sites. *Int J Oral Maxillofac Implants.* 2009;24 Suppl:147-157.

28. Sennerby L, Meredith N. Implant stability measurements using resonance frequency analysis: biological and biomechanical aspects and clinical implications. *Periodontol 2000*. 2008;47:51-66.

29. Szmukler-Moncler S, Salama H, Reingewirtz Y, Dubruille JH. Timing of loading and effect of micromotion on bone-dental implant interface: review of experimental literature. *J Biomed Mater Res.* 1998;43(2):192-203.

30. Tozum TF, Turkyilmaz I, McGlumphy EA. Relationship between dental implant stability determined by resonance frequency analysis measurements and peri-implant vertical defects: an in vitro study. *J Oral Rehabil.* 2008;35(10):739-744.

31. Sim CP, Lang NP. Factors influencing resonance frequency analysis assessed by Osstell mentor during implant tissue integration: I. Instrument positioning, bone structure, implant length. *Clinical Oral Implants Res.* 2010;21(6):598-604.

32. O'Sullivan D, Sennerby L, Meredith N. Measurements comparing the initial stability of five designs of dental implants: a human cadaver study. *Clin Implant Dent Relat Res.* 2000;2(2):85-92.

33. Cho SA, Park KT. The removal torque of titanium screw inserted in rabbit tibia treated by dual acid etching. *Biomaterials*. 2003;24(20):3611-3617.

34. Trisi P, Perfetti G, Baldoni E, Berardi D, Colagiovanni M, Scogna G. Implant micromotion is related to peak insertion torque and bone density. *Clin Oral Implants Res.* 2009;20(5):467-471.

35. Hallman M. A prospective study of treatment of severely resorbed maxillae with narrow nonsubmerged implants: results after 1 year of loading. *Int J Oral Maxillofac Implants.* 2001;16(5):731-736.

36. Comfort MB, Chu FC, Chai J, Wat PY, Chow TW. A 5-year prospective study on small diameter screw-shaped oral implants. *J Oral Rehabil.* 2005;32(5):341-345.