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

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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
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 (Ostell 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.

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 Ossstell 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

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