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The effect of length and diameter of dental implants on primary stability (experimental study on tibia of the sheep)

Huda A. Salim, Alyaa I. Naser, Abdulhameed N. Aldabagh

ABSTRACT

Aims: The aim of this study was to assess the effect of different length and diameter of the implant on primary stability and was measured by Osstell mentor. Methods: Ten fresh natural tibia bones of sheep and fifty-five dental implants were used in this study. The sheep bones were divided into two groups. In one group the different length with the same diameter was considered, while in second group different diameter with the same length was included. An incision was made along the longitudinal axis of the lateral surface of the tibia. Drilling was accomplished in a sequence recommended by the system manufacturer. Thereafter, dental implants were carefully installed and fixed manually till implant bodies submerged in the bone. Osstell device was used to evaluate the resonance frequency after implant placement. Results: After statistical analysis obtained from the values of resonance frequency analysis (RFA), it was found that when implant length was increased, there was an increase in implant stability. There was increase in the primary stability with an increase in the implant diameter as well. Conclusion: Primary stability is the most important clinical goal to be achieved at the time of implant placement. RFA has great potential to predict implant stability while being noninvasive and reproducible.

Huda A. Salim[1], Alyaa I. Naser[1], Abdulhameed N. Aldabagh[2]

Affiliations: [1]MSc, Assistant Lecturer, Department of OMFS, College of Dentistry, University of Mosul, Nineveh, Iraq; [2]PhD, Lecturer, Department of OMFS, College of Dentistry, University of Mosul, Nineveh, Iraq.

Corresponding Author: Abdulhameed N. Aldabagh, Department of Max-Fax, College of Dentistry, University of Mosul, Iraq; Email: aaldabag@yahoo.com

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INTRODUCTION

Dental implants represent one of the most successful, principal, and established treatment modalities in modern medicine for replacement of missing teeth [1]. Primary stability defined as the biomechanical stability of the implant at the time of insertion within the bone, it plays an essential role and prerequisites for successful osseointegration of dental implant [2–4]. Implant stability is considered as a gauge of the clinical immobility of an implant through its indirect effect on the osseointegration process. Regarding the type of bone, implant stability can be classified into primary stability for cortical bone and secondary stability for cancellous bone [5]. The degree of primary stability depends on factors like morphology of implant, quality, and quantity of bone, surgical procedures, and skills of the surgeon, secondary implant stability depends on the response of tissue to surgery and implant material [6, 7]. An increase in implant stability was found with increasing levels of osseointegration [8]. RFA has been recognized as a non-aggressive, conservative, dependable, easily foreseeable, and objective method of quantifying implant stability by measuring the frequency of implant oscillation inside the bone [9, 10]. Osstell Mentor® (Osstell AB, Göteborg, Sweden) device used for assessing RFA and the unit for measurement is implanted stability quotient (ISQ) which converting kHz (3,500–8,500) unit to values scale vary from 1 to 100, the higher ISQ the higher of stability [11, 12]. In general, the preferred implant lengths was used range from 8 mm to 15 mm, which is approximately resemble the length of natural teeth roots [13].

MATERIALS AND METHODS

Fifty five dental implants, (Dentium Co. Ltd, Suwon, Korea) and ten fresh natural tibia bones of sheep procured from the butcher shop were used for this study. These bones were divided into two groups: one group had different length with the same diameter and second group had different diameter with the same length. A 3 cm skin incision was done parallel to the long axis of the lateral surface of the tibia. Afterward, dissection of fascia was started and full thickness flap was reflected (Figure 1). Serial drilling was accomplished following system manufacturer's references, i.e. preparation starts by Linderman guide 2.2 mm drill followed by Linderman first drill 2.6 mm then by final drill followed by countersink. Drilling was made in an intermittent manner. The osteotomy site was prepared according to standard drilling protocol, five dental implants (D3.6 L10 mm) insert in the tibia. At room temperature (25c) normal saline solution was used as irrigating the place and to preserve the continuity throughout drilling by using the cooling system and at a constant ratio (40 ml/minute). Drill speed is fixed at 1062 rpm and the torque maintained at 50 n\cm, (high dense bone) the gear ratio is 1:32. Subsequently, a dental implant was installed manually until implant bodies submerged in bone. After fixing a transducer to the fixture (smart pegTM) by hand and tightened, the resonance frequency amount was evaluated using the Osstell device. Then measurements probe was held close to the top of the smart peg. At distance about 2–3 mm, the smart peg is stimulated by a magnetic pulse from the measurement probe. On the Osstell mentor screen, the results are displayed. The ISQ is estimated from the response signal. It is scaled from 1 to 100, the higher the number the superior the stability. ISQ values were measured four times perpendicular to smart peg, and one time in parallel orientations to it i.e. (anterior, posterior, mesial, distal, and perpendicular). Moreover, the average was recorded as final reading (1 was considered as least stable to 100 most stable).

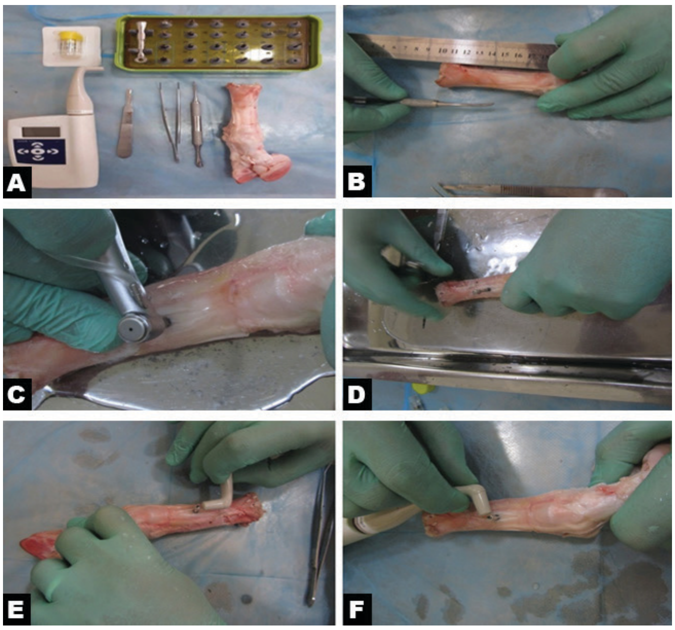

Figure 1: Preparation and implant placement. (A) Set used for implant. (B) Skin incision along the longitudinal axis. (C) preparation by Linderman drill. (D) Dental Implant installed manually. (E) Osstell mentor reading in the anterior direction. (F) Osstell mentor reading in a mesial direction.

Statistical analysis

The data were processed statistically using the SPSS version 21 for Windows 10 Pro, Lenovo laptop, think pad L460. The association between lengths at the same diameter was studied using Friedman Npar test. Wilcoxon signed ranks test was used in one hand for comparing between lengths at same diameters and in the other hand for comparing between diameters at same lengths.

RESULTS

Analysis between lengths at the same diameters (D1 = 3.6 mm, D2 = 4.5 mm) with Friedman test revealed a significant difference between them and P-values are 0.00 for both diameters as shown in Table 1. Wilcoxon signed rank test was used to evaluate the exact significant for difference between lengths. There were significant differences between lengths 10 mm–12 mm and between 7 mm–12 mm, while no significant difference between 7 mm – 10 mm in which p-value was 0.170 as shown in Table 2. For determining the significant diameter at same length Wilcoxon Signed Rank test clarified that difference appeared significant only at length 7 mm as shown in Table 3.

DISCUSSION

Primary stability is the most important clinical goal to be achieved at the time of implant placement. Regarding implant parameters, diameter and length play crucial roles in implant success. Since they straightway influenced the primary stability [4]. RFA has great potential to predict implant stability while being noninvasive and reproducible. These devices could be useful in evaluating the status of bone – implant healing process associated with a recently placed implant [2, 14]. Kokovic et al. found that the primary stability of the implant with 10 mm length higher than implants with a length of 8 mm. The result of the present study coincided with these findings; in comparison, no difference was found when

Table 1: Mean ranks and p-values for resonance frequency analysis of different lengths at same diameter (D1 & D2) by Friedman test.

Length	D1	D2
7 mm	1.75	1.03
10 mm	1.45	1.98
12 mm	2.80	3.00
p-value	0.00	0.00

(D1: Diameter 3.6 mm, D2: Diameter 4.5 mm, p-value significance at ≤ 0.05)

Table 2: P-values at different implant lengths in diameter 1 and diameter 2 by Wilcoxon signed rank test.

	Lengths		
	7 mm–10 mm	10 mm–12 mm	7 mm–12 mm
P-value in D1	0.170	0.002	0.00
P-value in D2	0.00	0.00	0.00

(D1: Diameter 3.6 mm, D2: Diameter 4.5 mm, p-value significance at ≤ 0.05)

Table 3: Wilcoxon signed rank test for comparison between D1 and D2 at same implant length

	At 7 mm	At 10 mm	At 12 mm
P-value D1-D2	0.00	0.466	0.729

(D1: Diameter 3.6 mm, D2: Diameter 4.5 mm, p-value significance at ≤ 0.05)

the primary stability positioned in different sites in the posterior aspect of the mandible, however, another factor like the roughness and surface texture of implant should be considered [14]. Ostman et al., found that primary stability decreased with increased implant length, other factors like bone density and implant diameter/length possibly impact the degree of primary stability [7], while the bone quality and implant length and diameter are supposed to be influential on the contact between bone and implant and thus on implant primary stability [15]. Ostman et al. reported that the use of longer implants resulted in lower primary stability. They found that implants 15 mm and 18 mm in length resulted in lower primary stability compared to implants 13 mm in length, mainly because they were more heat generated due to the long bone drilling [7], while in our study the increase of implant length up to 12 mm resulted in increased primary stability. Li et al. found that implant diameter had extra significant roles in reducing cortical bone stress and enhancing implant stability, whereas the implant length was more effective in reducing cancellous bone stress under both AX and BL load [16]. This result agreed with the result of the current study. Conceding with results of the Barikani et al study, the length of the implant did not have any significant effect on primary stability when there was a good bone quality on the implant side. However, in cases of inadequate bone quality, an increase in implant length give rise to an increase in implant primary stability [15]. Generally, the basic technique did not prejudice either early or late formation of bone for any tested implant diameter; nevertheless, wider diameters were associated with less bone formation at longer healing times for both techniques [17]. It was observed that the early loss of implant associated with short length design implants. While there was no relation found between early loss of implants and the osseous quality or diameter of implants. These findings might be attributed to the operator's experience with different implant designs, learning curves, or changes in technique and indications for the use of short implants from 1996 to 2004 [18]. Implants of higher length provide better contact surface between bone and implant compared with implants with smaller length [4].

CONCLUSION

Increase in implant length was directly proportional to increase in the implant stability, also when the implant diameter increased with implant length the primary stability increased.

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Huda A. Salim – Conception of the work, Design of the work, Acquisition of data, Analysis of data, Interpretation of data, Drafting the work, Revising the work critically for important intellectual content, Final approval of the version to be published, Agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

Alyaa I. Naser – Conception of the work, Design of the work, Acquisition of data, Analysis of data, Interpretation of data, Drafting the work, Revising the work critically for important intellectual content, Final approval of the version to be published, Agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

Abdulhameed N. Aldabagh – Conception of the work, Design of the work, Acquisition of data, Analysis of data, Interpretation of data, Drafting the work, Revising the work critically for important intellectual content, Final approval of the version to be published, Agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

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Authors declare no conflict of interest.

Data Availability
All relevant data are within the paper and its Supporting Information files.

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