Does Countersinking Improve Implant Primary Stability in Low Density Bone?

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ABSTRACT
*In order to evaluate the effect of countersinking on dental implants primary stability installed in low density bones, thirty dental implants were installed in the most proximal region of oxen ribs and grouped as follow: **Group1:** Fifteen implants installed by standard drilling with countersinking, **Group2:** Fifteen implants installed by standard drilling without countersinking. The graduated manual torque wrench and wireless resonance frequency analyzer were used to record the peak insertion torque (IT) and implant stability quotient (ISQ) values respectively. The results revealed a significant difference in IT and ISQ values between the two groups of study with higher values recorded in group two. From these findings and with the limitation of this study, it was concluded that in low density bones, the avoidance of countersinking during implant bed preparation will significantly increases implant primary stability.*

KEYWORDS
Countersink, Implant primary stability, Insertion torque, Resonance frequency analysis.

INTRODUCTION
Human beings lose their teeth duo to many causes like advanced caries, periodontal disease, and trauma make the replacement of teeth an important concern. Different methods had been used to replace the missing teeth including fixed and removable bridges and conventional complete dentures but they have drawbacks whether in esthetic, function, or conservation of adjacent structures. Dental implant is the latest modality which provides better comfort.[1] Although the current implant survival rate has reached more than 95% in sites like the anterior region of the mandible, implant loss is still considerable in other locations of poor bone quality.[2] This difference may be explained by variations in the local anatomy and histology of bone. For example, the mandible shows a higher ratio of compact to cancellus bone than the maxilla.[3-5]

The process of implant osseointegration involves a series of physiological processes of bone resorption and apposition, in which bone formation around the implant takes place, allowing better bone-implant joint. In order to make this process take place, it is necessary to achieve appropriate initial implant stability and control loadings acting on the implant with the aim of avoiding failure. Such stability is known as primary stability, which is defined as the a lack of implant movement immediately after placement and is mainly determined by initial bone-implant contact.[6] Primary stability is prerequisite for osseointegration process and implant survival.[7] This stability depends on many factors, among these factors are the bone quality which can determine the type of surgical procedure and the type of the implant that to be considered in the treatment.[8]

Several tests are available to assess implant stability. Among these tests are the insertion torque measurement (IT) and the resonance frequency analysis (RFA). Insertion torque measurement is one of the quantitative methods of assessing implant stability and bone quality which was described by Johansson and Strid in 1994[9] and has been still considered as useful when deciding the timing of loading of dental implants.[10] These values range between 5 and 40 N.cm. For statistical analysis, the maximum values for each procedure is used. In cases where the maximum value exceeds 40 N.cm, the value of 40 N.cm is considered for calculation.[11]

Meredith in 1996 developed an easy, noninvasive and reproducible method to measure implant stability. It can be used immediately after implant placement and during the osseointegration process, offering the possibility to know implant stability at any time during the healing process. This method is known as resonance frequency analysis. This measurement is carried out with a machine named Osstell® Mentor which is considered as a type of electronic tuning fork that automatically converts kilohertz (kHz) to implant Stability Quotient (ISQ) values on a scale of 1 to 100, with high values indicating high stability. Osstell® Mentor is a portable, hand-held device that emits signals repeated by a transducer that is screwed directly into the implant and the probe should hold in two directions (perpendicular and parallel) to the alveolar crest and calculating the resonance frequency (in ISQ values) from the response signal.[12,13]

An optimal implant stability is especially essential in bone of low density.[14] Several modifications of surgical technique have been described to increase the primary stability of implant in bone of low density. Some authors suggest the use of a smaller final drill diameter than the diameter of the implant,[15,16] whereas others propose the technique of bone condensation as it increases the density of the surrounding bone.[17,18] Also the use of self-tapping implants to avoid tapping of implant bed prior to implant placement was found to increase implant primary stability.[7] The countersinking of the implant bed will facilitate seating of implant collar within the cortical bone specially when a dense bone is encountered, but researchers showed that countersinking decreases the implant primary stability in low density bone.[19] Therefore, the aim of the present study was to evaluate the effect of countersinking on the primary stability of dental implant installed in bones of low density.

MATERIAL & METHODS

Fifteen ribs of freshly slaughtered oxen of 2 - 2.5 years old were used in the present research. All of the animals were taken from the same farm to ensure that all animals were bred in the same environment. Oxen ribs were used as a model for the human edentulous jaw bones as their density is comparable to that of human jaw bones of low density. In addition, they are available and cheep **(Fig 1)**.

Thirty tapered, sand blasted acid etched (SLA) dental implants (*Superline, Dentium, Korea*) were used and measured 4mm in diameter and 10mm in length **(Fig 2)**.

Preparation of the Study Samples

After slaughtering, the selected ribs had been carefully separated from the sternum, then all of the soft tissues, cartilage, and the periosteum were gently removed from the ribs by a knife.

Evaluation of Bone Density at Different Areas of the Rib

The most proximal region of the rib which has a minor portion of cortical bone and greater medullar proportion was selected since it resembles human edentulous jaw bone of low density i.e. D3 and D4 bone quality. To confirm that, two ribs were selected randomly and fixed by a parallel vise and ten parallel lines were mapped on each by a permanent marker. The rib was cut by a hand saw at the marked lines producing ten bony pieces each of one cm in width **(Fig 3)**.

The density of each piece was measured by Archimedes' principle as follows, the bone specimens were weighed out of water then weighed submerged in distilled water. The density was calculated using the following formula:

$$Density = (A/A - B) \times P$$

Where A is the weight of the bone specimen out of water, B is the weight of the bone specimen submerged in water, P is the density of distilled water at a given temperature, and A–B is the difference in weight, which is equivalent to the volume.

(Fig. 1)

(Fig. 2)

(Fig. 3)

(Fig. 4)

Sample Grouping

Two different surgical techniques for implant bed preparation (standard drilling with countersinking, standard drilling without counter-sinking) were tested using fifteen oxen ribs. The selected ribs were numbered from one to fifteen. A total of thirty dental implants were used, two dental implants were installed in the proximal portion of each rib using the surgical techniques mentioned above. A distance of two cm was left between

(Table 1) *The density of different areas of the rib (g/cm3)*										
RIB NO.	**Piece 1**	**Piece 2**	**Piece 3**	**Piece 4**	**Piece 5**	**Piece 6**	**Piece 7**	**Piece 8**	**Piece 9**	**Piece 10**
ONE	0.93	0.96	0.98	1.03	1.19	1.22	1.28	1.33	1.36	1.38
TWO	0.96	0.97	1.01	1.05	1.17	1.19	1.25	1.26	1.30	1.39

(Table 2) *Insertion torque values (N.cm) of the two groups of study*															
SC	25	15	29	19	30	18	28	11	6	6	10	11	10	20	7
SW	31	33	28	32	31	30	34	38	26	31	24	18	21	29	28

(Table 3) *Descriptive statistics of insertion torque values (N.cm) of the two groups of study*						
Surgical Technique	**Implant Primary Stability**	**Number of Implants**	**Minimum**	**Maximum**	**Mean**	**Standard Deviation**
SC	IT	15	6	30	16.33	8.541
SW	IT	15	18	38	28.93	5.106

(Table 4) *Implant stability quotient values (ISQ) of the two groups of study*															
SC	71	69.2	70	60.2	72	68.2	68.2	68.4	62.4	63.8	63.4	71.2	66.6	70.2	63
SW	73.4	73	66.6	69.2	69.6	73.8	70.6	72.8	66.4	74	71.2	71.2	66	70.4	73.2

(Table 5) *Descriptive statistics of implant stability quotient values of the two groups of study*						
Surgical Technique	**Implant Primary Stability**	**Number of Implants**	**Minimum**	**Maximum**	**Mean**	**Standard Deviation**
SC	ISQ	15	60.20	72.00	67.213	3.6851
SW	ISQ	15	66.00	74.00	70.760	2.7404

SC*= Standard drilling with countersink* ***SW****= Standard drilling without countersink*

each dental implant bed and another **(Fig 4)**. The implants grouped as follow:

Group I: Consist of fifteen dental implants where the standard drilling with countersinking (FC) was used for installation.
Group II: Consist of fifteen dental implants where the standard drilling without countersinking (FW) was used for installation.

Description of the Surgical Procedures

The surgical procedure were scheduled for three consecutive days, on each day, surgery was curried out on five ribs. Each rib was fixed by a parallel vise then the following surgical techniques were performed:

a. *Standard drilling with countersinking:* The following sequence of drills were used: starting with a pilot drill (Lindermann guide) of 2.2mm in diameter, then the Lindermenn first drill of 2.6mm in diameter after that the 3.6mm drill then the 4.0mm drill diameter were used. Finally, the countersink drill of 4mm in diameter was used for cortical preparation. At completion of drilling, the final implant bed diameter was equal to that of implant diameter i.e. 4mm in diameter.

b. *Standard drilling without countersinking:* The same sequence of drills that were used in the above technique but the countersink drill was not used.

For all implants, the speed of handpiece that was used during drilling was fixed at 1900 RPM and the drilling performed under sufficient normal saline irrigation as a coolant agent.

Registration of Implant Primary Stability

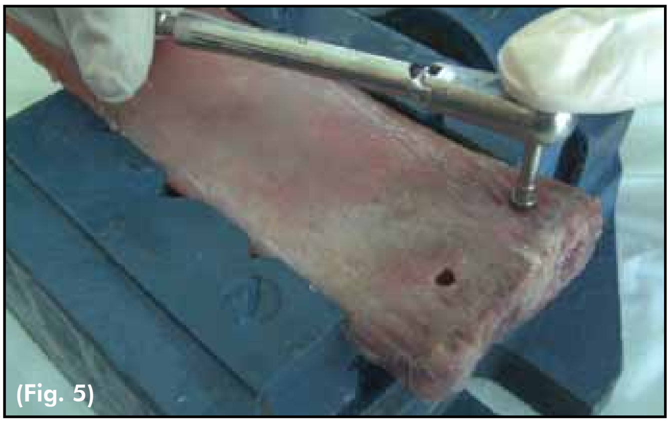
Two methods were used to evaluate implant primary stability:

a. *Insertion Torque Measurement (IT)*
Each implant was seated in its bed via the use special adapter which is mounted through the implant and then rotated by graduated manual torque wrench which records the torque required to seat the implant **(Fig 5)**. These records ranged between 5 and 40 N.cm. In cases where the maximum value exceeds 40 N.cm, the value of 40 N.cm was used for calculation.

b. *Resonance Frequency Analysis (RFA)*
Following installation of dental implant in its bed, the smart peg was screwed to the implant manually **(Fig 6a)** and primary implant stability was recorded by Osstell® mentor bearing in mind that the probe tip of the device does not directly contact the smart peg surface **(Fig 6b)**. Five records (superior, anterior, posterior, medial, and lateral) were taken for each implant and their mean was to be considered for statistical analysis.

Statistical Analysis

The insertion torque and implant stability quotient values



(Fig. 5)

(Fig. 6)

(Fig. 7)

for each dental implant were recorded. The results were loaded on SPSS under windows program in Pentium IV computer. The following statistical analysis were used:

1. Descriptive statistic (Minimum, Maximum, Mean, Standard deviation).
2. t- test at a=0.01 to test the difference between independent groups.

RESULTS

Evaluation of Bone Density at Different Areas of the Rib

The density of the different areas of two ribs were measured and the assumed data illustrated in **table 1**.

In both samples, the lowest rib density was recorded in its most proximal region and the density was gradually increased as directed distally.

Implant Primary Stability

a. *Insertion Torque Measurement*
The collected data illustrated in **table 2** and they showed that insertion torque was greater using the standard drilling without countersinking (28.93 N.cm) compared with the standard drilling with countersinking (16.33 N.cm) as illustrated in **table 3**.

Using t- test at a=0.01, a significant difference (P=0.000) was shown between the two groups of study.

b. *Resonance Frequency Analysis of Implant Stability*
The assumed data **(table 4)** revealed higher ISQ values using the standard drilling without countersinking (70.760) than the ISQ values in the other group (67.213) as shown in **table 5**.

Using t- test at a=0.01, a significant difference (P=0.006) was found between the two groups of study.

DISCUSSION & CONCLUSION

Endosseous implants are successful treatment options for the replacement of missing dentition. It is apparent that primary stability is a pivotal factor at the time of insertion (which depends on the surface geometry of the dental implant, local bone quantity and quality, and surgical technique used) and for the long-term success of endosseous dental implants.[20]

The density of rib bones that were used in this study had been evaluated by Archimedes' principle to confirm that the bone was of low density and comparable to posterior maxilla as illustrated by different researchers.[13,21] Such a principle is considered as standard procedure for density determination in vitro studies, since it is precise, cheep, and available.[22] Other methods of assessing bone density like computed tomography scans (CT) and dual energy x-ray absorptiometry (DXA) are expensive and only available at specialized centers.[23] Therefore, the latter two methods were put aside.

In the current study, the wireless generation of magnetic resonance frequency analyzer had been chosen since it is the new version and more sensitive and predictable device to quantify implant stability.[24] Moreover very limited number of studies had been implemented with the wireless version.[25]

Few studies had been conducted to demonstrate the effect of countersinking of implant bed on implant primary stability.[19,26,27,28] So, the present study focused on the influence of site preparation on the primary stability of dental implant in case of low density bone.

Regarding the groups of study, the insertion torque and the implant stability quotient (ISQ) values obtained were significantly higher for implants installed by standard drilling without countersink technique than those installed by standard drilling with countersink technique. These results demonstrate the influence of absence of countersinking on increasing the implant primary stability. The rationale behind these results was the increased osteocompression effect due to blockage of the implant collar resulting in higher primary stability. The obtained results were in agreement with previous studies.[19,26,27,28]

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