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The Influence of Site Preparation (Countersinking) on Initial Dental Implant Stability. An *in vitro* Study Using Resonance Frequency Analysis

Linish Vidyasagar, Girts Salms, Peteris Apse, Uldis Teibe

SUMMARY

Primary implant stability is now generally accepted as an essential criterion for obtaining osseointegration. It is generally accepted that it is necessary to achieve good stability at the time of implant placement to achieve consistent osseointegration. However, this can be difficult in bone of low density. Consequently the question is how to improve implant stability in softer bone qualities. The present study is designed to test implant stability, using Resonance Frequency Analysis (RFA), in relation to surgical technique (countersinking of the implant site). The implant stabilities of 2 implants types (Biohorizon, D2 and D3) were studied after insertion into pig ribs. In all, the implants were divided into 4 groups. *Group A*: D2 implants placed with countersinking of the implant site, *Group B*: D3 implants placed with countersinking of the implant site, *Group C*: D2 implants placed without countersinking of the implant site, *Group D*: D3 implants placed without countersinking of the implant site. Higher primary stabilities were observed for the groups placed without countersinking of the implant site. Elimination of countersinking in low density bone should be considered to increase initial implant stability.

Key words: dental implant, stability, resonance frequency, surgical technique

INTRODUCTION

Primary implant stability is considered to be a critical factor for obtaining successful osseointegration [1]. Studies using Resonance Frequency Analysis (RFA) have demonstrated that initial implant stability is determined by the density of the bone, the surgical technique used, and the design of the implant [2, 3]. While different implant designs have shown similar results of higher stabilities in dense bone, initial stability can remarkably decrease in low density bone, and thereby jeopardize the osseointegration process [4]. Moreover, a recent clinical study with consecutively placed implants that were immediately loaded, showed a higher failure rate in low density bone, suggesting that primary stability is a major factor in the success of immediately loaded implants [5]. Consequently the question is how to improve implant stability in low density bone.

Local bone density of the site *via* compression may be increased by altering the surgical technique. A recent study demonstrated that a modified surgical technique (less bone preparation) may influence primary implant stability in soft bone [6]. It has been suggested that countersinking (cervical flaring) of the implant site in type 3 and 4 bone may jeopardize the cortical bone anchorage and consequently affect primary implant stability [7]. However little has been published to date correlating primary implant stability to countersinking of the implant site. The purpose of the study is to test implant stability, using Resonance Frequency Analysis (RFA), in relation to surgical technique (countersinking of the implant site).

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MATERIALS AND METHODS

The study was conducted at the ARK private dental clinic (Skanstes iela 13, Riga, Latvia). The pig ribs used in the study were obtained from a retail meat market. The implant stabilities of 2 implants types (Biohorizon, D2 and D3) were studied after insertion into ethanol-treated [8] pig ribs. In a previous study by the same group [9], the surgeon's evaluation of bone density of the pig rib was of medium-dense bone (equivalent to Type 1/ 2 of Lekholm and Zarb classification). This was thought to be in part due to fairly dense cortical layer. In order to simulate softer bone quality in the present study, the pig rib was decorticated at the site of implant placement (Figure1). The bone density of the ribs were then assessed by surgeon by drilling a particular sequence of drills at the end of each rib, and classified as soft, medium, or dense (equivalent to Type I/ II (medium-dense), and Type III/ IV (soft) of Lekholm and Zarb classification). One implant of each group was placed in a pig rib (4 implants in a 50 mm pig rib). The implants were placed approximately 8 mm apart from each other and 10 mm from each end of the rib using preparation techniques recommended by the manufacturer (Figure 2, Figure 3).

The two implant designs used in this study include

-10 implants of Biohorizon Implant system (D2 thread profile) (Maestro, Biohorizons Implant Systems, Birmingham, AL, North America).

-10 implants of Biohorizon Implant system (D3 thread profile) (Maestro, Biohorizons Implant Systems, Birmingham, AL, North America).

In all, the implants were divided into 4 groups.

Group A: D2 Biohorizon implants placed with countersinking of the implant site.

Group B: D3 Biohorizon implants placed with countersinking of the implant site.

Group C: D2 Biohorizon implants placed without countersinking of the implant site.

Group D: D3 Biohorizon implants placed without countersinking of the implant site.

The resonance frequency measurements were then performed by attaching the transducer and securing with a

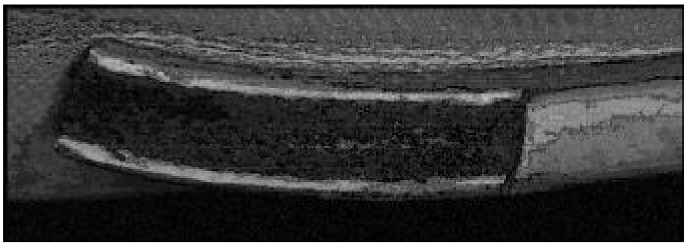

Figure 1. Decorticated pig rib.

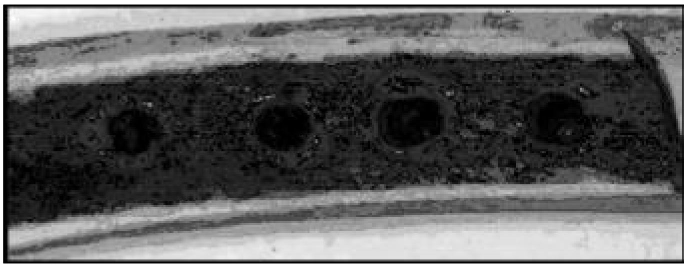

Figure 2. Implant site preparation for the 4 groups.

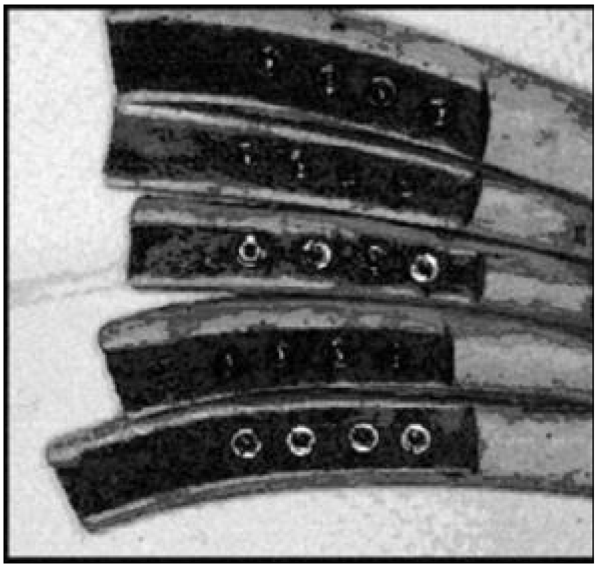

Figure 3. Ribs with implants in place.

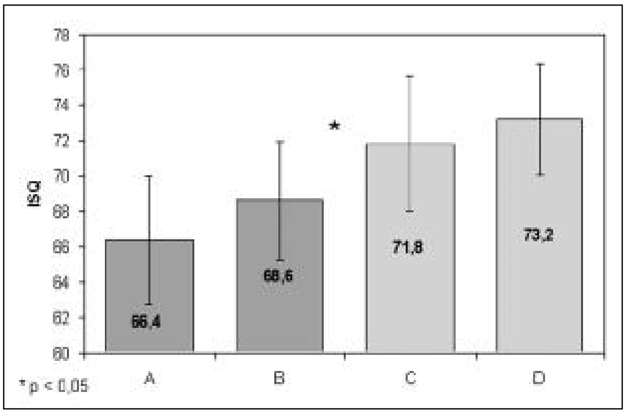

Figure 4. ISQ levels set against the different groups. There was significant difference between Groups (A+B) and Groups (C+D)

Table 1. Stability measurements using RFA. The values are expressed in ISQ (Implant Stability Quotient) units (M = Mean; SD = Standard Deviation)

Groups	A	B	C	D
1	72	70	75	78
2	61	67	68	68
3	65	69	73	70
4	77	79	83	83
5	57	58	60	67
M	**66,4**	**68,6**	**71,8**	**73,2**
SD	**8,11**	**7,50**	**8,53**	**6,98**
	3,6	3,4	3,8	3,1

Table 2. Statistical analysis (t-test) correlating mean stabilities of Groups (A+B) and Groups (C+D) (df = degree of freedom; p = Statistical significance)

t-Test: Paired Two Sample for Means			
	A&B	*C&D*	
Mean	67,5	72,5	
Variance	55,611111	54,5	
Observations	10	10	
Pearson Correlation	0,9193203		
Hypothesized Mean Difference	0		
Df	9		
t Stat	-5,3033009		
P(T<=t) one-tail	0,0002459		
t Critical one-tail	1,8331139		
P(T<=t) two-tail	0,0004917	<0,05	
t Critical two-tail	2,2621589		

torque of 10 Ncm (Osstell, Integration Diagnostics AB, Göteborgsvägen, Sweden). In order to standardize the procedure, the measurements were made with the transducer at right angles to the long axis of the pig rib. The measurements were expressed in Implant Stability Quotients (ISQ) that ranges in a scale from 1 to 100. A higher ISQ value corresponds to a higher stability. The data is analyzed for statistical significance between independent samples using t-test, and statistical significance established at P = 0.05.

RESULTS

In general, Groups C and D exhibited higher mean stabilities than Groups A and B (Table 1).

The statistical analysis showed higher implant stabilities for Groups C and D, with p= 0.00049 (statistically significant) (Table 2, Figure 4).

DISCUSSION

Dental implants have become a predictable method of tooth replacement in prosthodontic treatment [10, 11, 12, 13]. However, implants tend to have a lower survival rate in softer bones characterized by Lekholm and Zarb [14] as type 4 bone [15, 16, 17, 18, 19]. Most of the implants placed in the above studies had been placed in type 4 bone according to a standard surgical protocol as of implants placed in type 1/2 bone. However, initial implant stability has not been found to be critical in bones of high density. Primary implant stability in dense mandibular bone, measured with resonance frequency analysis, was similar to the secondary implant stability measured after 3-4 months [20, 21]. However, initial stability can significantly decrease in bones of low density and thereby jeopardize osseointegration [4].

While bone quality and quantity are set factors, primary implant stability may be influenced by the implant design and surgical technique. Sennerby [22] suggested that omission of tapping in low density bone would improve primary implant stability. Other authors have proposed bone condensation using osteotomes [7], using a final drill size smaller than recommended [3], or even placing a submerged implant with its collar in a supra-crestal position [23, 24, 25] to increase local compression of bone at the implant site.

The present study reports on the influence of countersinking on primary implant stability. It has been suggested that countersinking (cervical flaring) of the implant site may optimize the primary implant stability due to blockage of the implant collar in the bone site [7]. The resonance frequency values obtained in this study were significantly higher for groups C and D than of implants used in groups A and B. This difference may be explained by the increased osteocompression effect due to blockage of the implant collar resulting in higher primary stability. Whether such a modification in surgical technique is advantageous to osseointegration because of heat generation and decreased friction is unknown, and has to be investigated in future studies. Futhermore, Group D (D3 which has increased thread pitch) showed a tendency towards higher RFA values; however this was not statisticallly significant. It is plausible that the altered thread profile of the D3 Biohorizon implant further improved the osteocompression effect at the implant site.

CONCLUSION

Implant stability is more difficult to attain in bone of low density. Efforts to improve immediate stability are being investigated using modified surgical techniques. This study investigated the effect of countersinking on implant stability in decorticated pig ribs simulating low density bone. It may be concluded that avoiding cervical flaring at the preparation site for a dental implant placed in soft bone may increase primary implant stability. However, there exists limited information on the effect of osteocompression on the osseointegration process. Future studies are necessary to evaluate the influence of osteocompression on bone healing.

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