Role of Clinician's Experience and Implant Design on Implant Stability. An Ex Vivo Study in Artificial Soft Bones

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ABSTRACT

Objectives: Clinical experience in implant placement is important in order to prevent implant failures. However, the implant design affects the primary implant stability (PS) especially in poor quality bones. Therefore, the aim of this study was to compare the effect of clinician surgical experience on PS, when placing different type of implant designs.

Methods: A total of 180 implants (90 parallel walled-P and 90 tapered-T) were placed in freshly slaughtered cow ribs. Bone quality was evaluated by two examiners during surgery and considered as 'type IV' bone. Implants (ø 5 mm, length: 15 mm, Osseotite, BIOMET 3i, Palm Beach Gardens, FL, USA) were placed by three different clinicians (master/I, good/II, non-experienced/III, under direct supervision of a manufacturer representative; 30 implants/group). An independent observer assessed the accuracy of placement by resonance frequency analysis (RFA) with implant stability quotient (ISQ) values. Two-way analysis of variance (ANOVA) and Tukey's post hoc test were used to detect the surgical experience of the clinicians and their interaction and effects of implant design on the PS.

Results: All implants were mechanically stable. The mean ISQ values were: 49.57(± 18.49) for the P-implants and 67.07(± 8.79) for the T-implants. The two-way ANOVA showed significant effects of implant design ($p < .0001$), clinician ($p < .0001$), and their interaction ($p < .0001$). The Tukey's multiple comparison test showed significant differences in RFA for the clinician group I/II ($p = .015$) and highly significant ($p < .0001$) between I/III and II/III. The P-implants presented (for I, II, and III) mean ISQ values 31.25/49.18/68.17 and the T-implants showed higher ISQ values, 70.15/62.08/68.98, respectively. Clinicians I and II did not show extreme differences for T-implants ($p = .016$). In contrast, clinician III achieved high ISQ values using P- and T-implants following the exact surgical protocol based on the manufacturer guidelines. T-implants provided high stability for experienced clinicians compared with P-implants.

Conclusion: T-implants achieved greater PS than the P-implants. All clinicians consistently achieved PS; however, experienced clinicians achieved higher ISQ values with T-implants in poor quality bone.

KEY WORDS: bone quality, clinician experience, implant stability

INTRODUCTION

Primary (initial) stability (PS) is related to the level of primary bone-implant contacts at the interface during implant placement. PS is an important determinant of implant survival.[1,2] PS is the absence of mobility in the bone bed upon insertion of the implant and depends on quantity and quality of bone, surgical technique, and implant design.[1] There are different scientific opinions on factors that influence PS. For example, according to different studies length, geometry and surface area of the implant and bone-to-implant contacts at the histologic level influence the PS,[3] while others[4] stated that primary implant stability is determined by the bone density, implant design, and surgical technique.

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Implant design and its association (or relationship) to the PS have been evaluated by many groups. Implants were placed in porcine iliac cancellous bones in order to evaluate the PS of hybrid self-tapping implants compared with cylindrical non-self-tapping implants. According to the results, the hybrid self-tapping implants could achieve high PS, which predicts them for use in low-density bone.[5] Another study showed results of placing implants on beagle dogs with no statistically significant difference in bone formation between the cylindrical and conical implant designs when placed using the non-submerged technique.[4]

Cylindrical and screw-shaped implants may cause less stress as compared with conical and stepped implants.[6] Implants with different geometric form, but similar diameters have shown no differences in strain levels on surrounding bone.[7] Improved stability with conical implant systems than cylindrical screw designs has also been demonstrated by another group.[8]

PS has also been shown to be influenced by bone quality and the technique used for insertion.[9] In a recent systematic review by Marquezan and colleagues,[10] the authors were able to establish a positive correlation between implant PS and bone mineral density of the receptor site. A study by Turkyilmaz and colleagues[11] suggested that use of thinner drills during implant placement in regions of poor bone quality may improve the primary implant stability, which again reiterates the significance of bone quality and mechanical interlocking with the surrounding bone.

The clinical assessment of implant stability is generally experiential and subjective observation.[12] Few objective methods for determining PS are Periotest value and resonance frequency analysis (RFA). The implant design in terms of geometrical shape (tapered vs non-tapered) was previously studied and PS was compared by RFA. O'Sullivan and colleagues[13] in a human cadaver study demonstrated higher PS (assessed by RFA values) for tapered designed implants than non-tapered and found similar RFA values for tapered implants irrespective of bone quality. Glauser and colleagues[14] found significantly higher RFA values for tapered implants than non-tapered in a comparative clinical study using RFA and insertion torques. Although the PS has been evaluated in vitro and in vivo in different models using various implant designs, there is no information today about the clinician's experience on the implant PS.

MATERIALS AND METHODS

A total of 180 implants (90 parallel walled-P and 90 tapered-T) were placed in freshly, slaughtered cow ribs (Figure 1). The bone quality was evaluated by two examiners during surgery and considered as 'type IV' bone.

The implants (ø 5 mm, length: 15 mm, Osseotite, BIOMET 3i, Palm Beach Gardens, FL, USA) were placed, by three different clinicians (master/I, good/II, non-experienced/III; 30 implants per group). 'Master' clinician had experience of more than 1,000 implants, 'good' clinician had placed up to 500 implants (but less than 1,000 implants), and the 'non-experienced' clinician had never placed implants. All implants were placed at the crestal bone level using the same sequence of drills and inserted by hand.

The master/I and good/II investigators placed their implants according to their own surgical experience using the entire sequence of the drills from the surgical kit; however, the non-experienced clinician/III placed the implants strictly according to manufacturer protocol under direct supervision by an experienced company representative, as following:

- Master/I: A 2 mm twist drill was used to prepare the osteotomy for the sequential Quad Shaping Drills (QSDs) with speed 1,500 rpm, and the implants were placed with motor under torque 45 rpm.
- Good/II: A 2 mm twist drill was used to prepare the osteotomy for the sequential QSDs with speed 1,200 rpm. In prepared site, the implant was placed under torque 40 rpm.

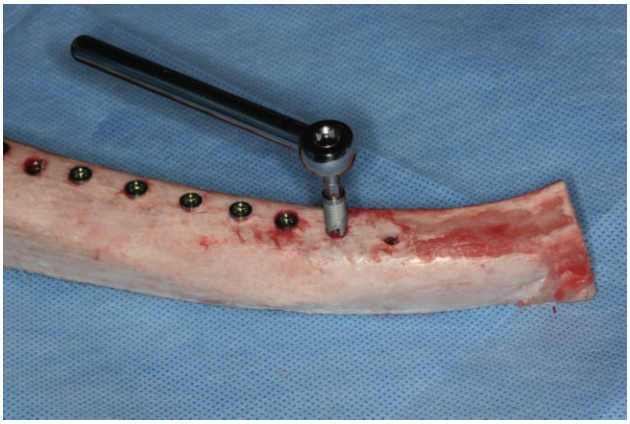

Figure 1 Implants placed in fresh bovine ribs containing soft bone by the 'master'-clinician.

TABLE 1 ISQ Values on Parallel- and Tapered-Designed Implants Placed by Different Experience Level Clinicians

Osstell	Parallel	Tapered
Operator I	31.25	70.15
Operator II	49.18	62.08
Operator III	68.17	68.98

- Non-experienced/III: Followed exactly the surgical protocol under guiding and supervision by manufacturer representative. Special guidance for soft bones was performed by the manufacturer representative.

An independent calibrated examiner assessed and measured the accuracy of placement and evaluated implant stability quotient (ISQ) values in a blinded method of assessment using the Osstell device according to the manufacturer guidelines. Specifically, two measurements were performed in different directions and the mean value was used as a final measurement for each value.

Two-way analysis of variance (ANOVA) and Tukey's post hoc test were used to analyze the main effects of clinicians and implant designs and their interaction effect using the SPSS statistical software (IBM, Armonk, NY, USA).

TABLE 2 Distribution of the Values of ISQ and Periotest for the Three Clinicians Using P-Implants

	P-Implants								
	Osstell						Periotest		
Implant #	Investigator I		Investigator II		Investigator III		I	II	III
1	22	22	64	38	56	62	−6	−5	−6
2	20	22	35	48	76	70	−7	−4	−7
3	22	22	61	46	77	77	−7	−4	−7
4	25	22	25	25	75	75	−5	−5	−7
5	22	22	25	25	80	78	−7	−5	−7
6	22	22	37	32	75	77	−7	−4	−7
7	22	20	46	63	70	70	−7	−5	−7
8	22	22	60	61	79	77	−7	−1	−7
9	43	44	62	44	75	70	−6	−5	−7
10	46	35	58	44	80	82	−6	−5	−7
11	22	25	61	44	80	82	−7	−7	−6
12	25	25	25	25	77	77	−6	−5	−5
13	25	25	61	41	70	76	−7	−6	−6
14	25	25	62	44	68	69	−7	−8	−6
15	25	25	37	52	74	74	−7	−7	−7
16	28	28	60	41	70	76	−7	−6	−6
17	25	25	62	55	80	79	−4	−4	−7
18	25	25	61	41	60	60	−5	−5	−4
19	25	25	59	39	75	72	−6	−3	−3
20	25	25	46	46	76	69	−6	−8	−4
21	25	25	61	41	69	59	−7	−8	−5
22	25	20	64	48	46	61	−7	−7	−4
23	59	59	41	61	50	72	−7	−4	−4
24	25	25	64	49	53	69	−6	−2	−5
25	61	43	55	65	52	60	−6	−2	−6
26	49	65	61	43	53	59	−7	−3	−1
27	41	39	57	42	53	58	−6	−4	−1
28	63	46	59	43	61	58	−7	−4	−1
29	43	30	60	61	50	56	−6	−4	−7
30	65	51	55	60	50	56	−7	−3	−7

RESULTS

All implants were mechanically stable. Tables 1–3 shows the mean values for the three clinicians using the Osstell device in type IV bone quality. There is significant difference between clinicians ($p < .0001$) and between implant designs ($p < .0001$). The effects of clinicians significantly depend on implant design (interaction effect, $p < .0001$). Tukey's multiple comparison test showed significant differences in RFA for the clinician group I/II ($p = .015$) and highly significant ($p < .0001$) between I/III and II/III. Clinicians I and II showed significant differences for T-implants ($p = .016$). In contrast to that, clinician III achieved high ISQ values using P- and T-implants following strictly the exact surgical protocol according to the manufacturer's guidelines. T-implants provided high stability for experienced clinicians compared with P-implants.

DISCUSSION

This is the first study to our knowledge that reports a relationship between PS and clinician's experience and also if there is an influence on the PS of implant design. It was also observed in our experiment that T-implants may provide more stability as compared with P-implants. Similar results have also been shown in an in vitro study demonstrating that the tapered shape of

TABLE 3 Distribution of the Values of ISQ and Periotest for the Three Clinicians Using T-Implants

T-Implants									
	Osstell						Periotest		
Implant #	Investigator I		Investigator II		Investigator III		I	II	III
1	74	73	67	59	74	71	−4	−4	−3
2	72	76	64	56	71	77	−4	−5	−3
3	78	78	56	55	74	75	−3	−2	−3
4	75	72	60	41	75	76	−3	−2	−3
5	62	57	62	48	78	76	−5	−4	−5
6	66	69	59	55	77	74	−3	−3	−3
7	64	66	64	72	77	75	−5	−2	−4
8	68	67	69	75	79	76	−2	−4	−2
9	65	68	77	77	78	77	−4	−2	−6
10	72	70	65	52	79	76	−5	−2	−2
11	61	53	66	56	77	75	−5	−5	−3
12	60	62	72	67	76	75	−5	−4	0
13	74	77	61	70	80	77	−6	−3	0
14	76	78	75	67	80	79	−7	−3	−1
15	79	76	74	72	72	72	−7	−4	−1
16	78	76	63	57	60	60	17	−3	−5
17	75	78	59	46	67	65	−6	−4	−2
18	72	78	53	64	56	66	−5	−4	−1
19	76	78	60	64	65	52	−6	−4	0
20	77	78	53	66	46	52	−5	−3	1
21	68	67	63	52	59	46	−6	−3	0
22	56	57	51	51	72	77	−3	−4	0
23	56	56	63	63	78	78	−3	−4	0
24	62	62	67	70	77	77	−4	−3	−1
25	71	68	68	71	74	72	−4	−3	3
26	73	73	63	50	65	53	−4	−8	3
27	75	72	59	56	52	52	−3	−8	2
28	69	74	51	51	51	66	−2	−7	−4
29	77	70	66	66	49	54	−3	−8	−3

an implant provides more PS especially in bone type IV.[15]

The result that inexperienced clinicians inserted parallel implants with (statistically significantly) higher ISQ values than experienced clinicians and that for tapered implants there seems to be no significant difference between inexperienced and 'good' clinicians (maybe there even is a significant difference between clinician III and II) is a very interesting finding of this ex vivo study in artificial soft bones.

In another study, RFA was used to assess the effects of implant geometry and osteotomy preparation on the PS. According to this study, bone density is the more influencing factor on PS as compared with the design of the implant. They also suggested the surgical protocol for the tapered screw-type implants could be enhanced by delicate surgical techniques.[16]

The significance of bone quality and PS has been addressed by different scientific groups. In one experiment, it was assessed the effect of a self-tapping blade implant design on initial stability in tapered implants. The results showed that higher stability was seen in non-self-tapping blades implants and a weak association was also shown to exist between implant design and initial stability. The authors, though, do emphasize on the higher influence of insertion depth and block density.[17]

This present study with its large sample size establishes that T-implants show better PS as compared with P-implants and despite variation in clinician's skills they were able to achieve high PS values. Certainly, correct estimation of the bone quality by the clinician was important in order to follow the manufacturer drill guidelines.

CONCLUSIONS

Tapered-designed implants achieved greater PS than the parallel design. Both experienced and inexperienced clinicians consistently achieved PS; however, experienced clinicians achieved higher ISQ values with tapered implants in poor quality bone.

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