A comparative study on the accuracy of the devices for measuring the implant stability

In-Ho Cho[1]*, DDS, MSD, PhD, Young-Il Lee[2], DDS, MSD, Young-Mi Kim[3], BS, RDH

[1]Professor, [2]Graduate Student, Department of Prosthodontics, College of Dentistry, [3]Graduate Student, Department of Oral Health Post graduate School of Health & Welfare, Dankook University, Cheonan, South Korea

STATEMENT OF PROBLEM. How the ISQ values measured by Osstell™ and Osstell™ Mentor are related, and whether the ISQ values acquired from the two machines changes in accordance with changes in implant stability are not yet fully understood. **PURPOSE.** The aim of this study was to find out correlation between the ISQ values acquired from Osstell™ and Osstell™ Mentor, and to evaluate the clinical effectiveness and accuracy of two devices. **MATERIAL AND METHODS.** Sixty two implants were inserted into 47 patients, and their ISQ values were measured using Osstell™ and Osstell™ Mentor. In the first stage surgery, the ISQ values of forty four implants inserted into thirty five patients were measured. In the second stage surgery, the values of fifty implants inserted into thirty seven patients were measured. The values were analyzed to determine the difference between the mean ISQ values of Osstell™ and Osstell™ Mentor. In addition, the correlation between implants used in the first and second stage of surgery with regard to their types and areas of insertion were analyzed. The difference between the ISQ values of 32 implants in each patient during the first and second stage was analyzed. The statistical assessment was carried out using SPSS V. 12.0 for Win. (SPSS Inc., Chicago, USA). The Pearson correlation coefficient was used to examine the correlation between Osstell™ and Osstell™ Mentor in the first and second stages of surgery, whereas the difference between their ISQ values was evaluated using a paired t-test. **RESULTS.** In the first stage, the mean ISQ value for Osstell™ and Osstell™ Mentor was 70.84 and 75.09, respectively, showing a significant difference ($P < .01$). In the second stage, the mean ISQ value of Osstell™ and Osstell™ Mentor was 71.76 and 75.94, respectively, also showing a significant difference ($P < .01$). The difference between the ISQ values in patients in the first and the second stages was significant with both instruments. **CONCLUSION.** The significant difference in the values obtained using the Osstell™ and Osstell™ Mentor between the first and second stages of implant surgery indicates that these values can be a convenient and precise way for evaluating the implant stability in clinical practice. **KEY WORDS.** Osstell, Osstell Mentor, ISQ, RFA, Stability [J Adv Prosthodont 2009;1:124-8]

INTRODUCTION

Osseointegration, which was defined by Brånemark[1] in 1985, is essential for the clinical success of the implant-driven restoration.[2] Therefore, measuring the implant stability is an important method for evaluating the success of an implant.[3] The implant stability can be classified into two categories: primary stability, which can be acquired while inserting the implant, and secondary stability, which is obtained during healing and remodeling of the surrounding bone. The primary stability is affected by the quantity and quality of bone that the implant is inserted into, surgical procedure, length, diameter, and form of the implant.[4,5] The secondary stability is the one developed from regeneration and remodeling of the bone and tissue around the implant after insertion but is affected by the primary stability, bone formation and remodeling, etc.[6] Many clinical and experimental methods of measuring osseointegration and implant stability has been developed. Histomorphologic research and removal torque test are classified as destructive methods. Nondestructive methods include percussion test, radi-

ography, cutting torque test while placing implants, Periotest® (Siemens AG, Benshein, Germany), and resonance frequency analysis (RFA).

Although the removal torque test[7,8] is useful for measuring the degree of osseointegration of an implant, its use is limited by the direct tension placed on the interface of an implant and surrounding bone, resulting in possible failure of the implant. A percussion test measures the stability of an implant by simple percussion with the handle of a dental instrument on the implant abutment. However, this method is rather subjective and lacks precision.[9] Radiography provides a useful method for evaluating the quantity and quality of bone in the area for an implant to be inserted before placing the fixture, as well as the quantity and quality of the adjacent marginal bone, suitability of an abutment for prosthodontic treatment and height of the peri-implant bone.[10,11] However, uniform resolution and standardized taking of X-rays are difficult to achieve. In addition, it is difficult to perceive changes in the bone structures and morphology of the implant-bone interface. While Chai et al.[12] reported that Periotest® could be an objective and

*Corresponding author: In-Ho Cho
Department of Prosthodontics, College of Dentistry, Dankook University
San 7-1, Shinboo-Dong, Cheonan, Choongnam, 330-716, Korea
Tel, +82 41 550 1971: e-mail, cho8511@dku.edu
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reproducible method of evaluating implant stability, Derhami *et al.*[13] concluded that its result lacks consistency since it is susceptible to the height of the abutment, measurement angle, and the distance between the implant and hand piece. Meredith *et al.*[4,14] showed resonance frequency analysis as a means of measuring implant stability. In this method, an L-shaped transducer composed of two piezo-ceramic components is connected to an implant and as the frequency increases from 5k Hz to 15k Hz, the first curved resonance frequency detected is considered as the peak. This can be a useful way of evaluating implant stability because of its objectivity and availability to continuously observe the changes in stability that follows the healing process.[6,15]

Osstell™ (Integration Diagnostics Ltd., Göteborg, Sweden) (Fig. 1) and Osstell™ Mentor (Integration Diagnostics Ltd., Göteborg, Sweden) (Fig. 2) are devices developed for the clinical application of resonance frequency analysis. Osstell™ (electronic method), which was developed first, measures the resonant frequency by connecting the implant to a transducer, whereas Osstell™ Mentor (magnetic method) measures the resonant frequency using the magnetic frequencies by connecting the implant to a Smartpeg™ (Integration Diagnostics Ltd., Göteborg, Sweden). The RFA value is converted into an ISQ (implant stability quotient) that is scaled from 1 to 100.[14,16] The ISQ increases in proportion to the stiffness of the bone-implant interface or with that of the peri-implant bone.[4,6,14]

Currently how the ISQ values measured by Osstell™ and Osstell™ Mentor are related, and whether the ISQ values acquired from the two machines changes in accordance with changes in implant stability are not yet fully understood.

This study examined the correlation between the ISQ values measured by Osstell™ and Osstell™ Mentor as well as the coincidence of the two instruments, and evaluated their utility in practice by investigating the changes in implant stability as a function of time.

MATERIAL AND METHODS

Specimen
Sixty two implants inserted into 47 patients who received implant treatment in the Department of Prosthodontics, College of Dentistry, Dankook University were examined. The patients' age ranged from 23 to 78 years with a mean age of 51. Only two-stage implants were used in this study. In the first stage of surgery, 44 implants placed in 35 patients (28 implants in the mandibles and 16 in the maxillas) were measured. In the second stage of surgery, 50 implants were inserted into 37 patients: 36 implants in the mandible and 14 in the maxilla. Twenty five patients with 32 implants underwent the measurements in both stages. Twelve implants in 10 patients were measured in the first stage only, whereas 18 implants in 12 patients were measured in the second stage only (Table I).

Implants
The implants used for insertion were Replace™ Select Tapered TiUnite (NobleBiocare™ AB, Sweden), Brånemark System® MKIII TiUnite (NobleBiocare™ AB, Sweden), Osseotite® (3i Corp, USA), US II (Osstem, Korea) (Table II).

Thirty implants from Replace™ Select Tapered TiUnite, 11 from Brånemark System® MKIII TiUnite, 2 from US II and 1 from Osseotite® were inserted in the first stage of surgery. Their lengths and diameters are shown in Tables III and IV, respectively.

Table I. Number of patients and implants used in this study

	Number of patients	Number of implants
1st surgery	35 (10)	44 (12)
2nd surgery	37 <12>	50 <18>

( ): Number of patients and implants measured only in the 1st surgery
< >: Number of patients and implants measured only in the 2nd surgery

Table II. Classification of implants used in this study

Implant system	R/S	Brå MKIII	US II	Osseotite®	Sum
N	38	21	2	1	62

Table III. Diameter of the implants used in the 1st surgery

Diameter	NP	RP	WP	Sum
N	2	22	20	44

NP: Narrow Platform, RP: Regular Platform, WP: Wide Flat Platform

Table IV. Length of the implants used in the 1st surgery

Length (mm)	8	10	11.5	13	16	Sum
N	1	19	7	16	1	44

Table V. Diameter of the implants used in the 2nd surgery

Diameter	NP	RP	WP	Sum
N	3	28	19	50

Table VI. Length of the implants used in the 2nd surgery

Length (mm)	10	11.5	13	16	Sum
N	16	10	22	2	50

Fig. 1. Osstell™ (Integration Diagnostics Ltd., Göteborg, Sweden).

Fig. 2. Osstell™ Mentor (Integration Diagnostics Ltd., Göteborg, Sweden).

In the second stage of surgery, 29 implants from R/S, 18 from Brå MKIII, 2 from US II and 1 from Osseotite® were inserted. Tables V and VI, respectively list their lengths and diameters.

Methods of measurement

Using Osstell™ and Osstell™ Mentor, each ISQ value was measured after inserting the implant in the first stage and after removing the cover screw in the second stage surgery. While using the Osstell™, implant system and the transducer which was modified for different diameters were put on to the implant without any contact with surrounding soft tissue.

With Osstell™ Mentor, a Smartpeg™ was connected to the implant in accordance with the diameter, and the measurements were taken from the buccal and mesial sides. Both instruments required three identical values and stored them in the computer.

Analysis

Forty four implants from the first stage surgery and 50 from the second stage of surgery were analyzed to determine the difference between the mean ISQ values of Osstell™ and Osstell™ Mentor. In addition, the correlation between implants used in the first and second stage of surgery with regard to their types and areas of insertion were analyzed.

The difference between the ISQ values of 32 implants in each patient during the first and second stage surgery was analyzed.

The statistical assessment was carried out using SPSS V. 12.0 for Window (SPSS Inc., Chicago, IL, USA). The Pearson correlation coefficient was used to examine the correlation between Osstell™ and Osstell™ Mentor in the first and second stages of surgery, whereas the difference between their ISQ values was evaluated using a paired *t*-test. A paired *t*-test was used to examine the difference between the ISQ values in each surgery in an identical patient.

RESULTS

Table VII shows the ISQ values of the 44 implants obtained using Osstell™ and Osstell™ Mentor.

The measurements from the two instruments were significantly different ($P < .01$) and showed a significant correlation ($r = 0.61$; $P < .01$) (Table VIII). The scatter diagram is shown in Fig. 3.

There was a significant correlation in ISQ values from Osstell™ and Osstell™ Mentor ($P < .01$) for the implants placed in mandible, whereas there was no correlation for those inserted in the maxilla.

As for the correlation with regard to the implant types, there was a significant correlation with Replace™ Select Tapered TiUnite ($P < .01$), whereas there was no correlation with the Brånemark System® MKIII TiUnite.

Table IX lists the ISQ values of the 50 implants obtained with

Osstell™ and Osstell™ Mentor.

The ISQ values obtained from Osstell™ and Osstell™ Mentor showed a significant difference ($P < .01$) as well as a significant correlation ($r = 0.65$; $P < .01$), (Table X). Fig. 4 shows the scatter diagram.

Table VII. Mean and SD of the ISQ values measured using Osstell™ and Osstell™ Mentor in the 1st surgery

	Osstell™	Osstell™ Mentor
Range	60 - 83	64 - 88
Mean/SD	70.84 ± 6.13	75.09 ± 6.08

Table VIII. Pearson's correlation coefficient between Osstell™ ISQ and Osstell™ Mentor ISQ in the 1st surgery

	OT	OTM
OT		
OTM	*	

OT : Osstell™ , OTM : Osstell™ Mentor
*denotes a pair of groups significantly different at the 0.01 level

Table IX. Mean and SD of the ISQ measured with Osstell™ and Osstell™ Mentor in 2nd surgery

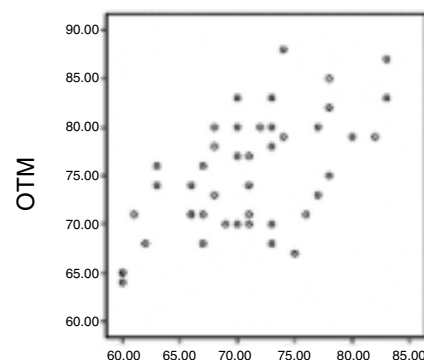|	Osstell™	Osstell™ Mentor
Range	55 - 84	55 - 88
Mean/SD	74.14 ± 6.64	78.90 ± 7.21

Fig. 3. Scatter diagram of Osstell™ ISQ and Osstell™ Mentor ISQ in the 1st surgery.
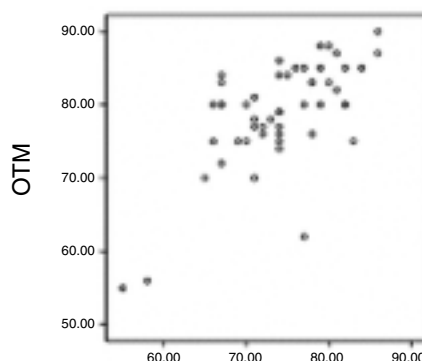

Fig. 4. Scatter diagram between Osstell™ ISQ Osstell™ Mentor ISQ in 2nd surgery.

Table X. Pearson's correlation coefficient between Osstell™ ISQ and Osstell™ Mentor ISQ in the 2nd surgery

	OT	OTM
OT		
OTM	*	

*denotes pair of groups significantly different at the 0.01 level

Table XI. ISQ values of the patients measured in 1st and 2nd surgery

	OT	OTM
1st surgery	71.28 ± 6.22	75.44 ± 6.42
2nd surgery	75.00 ± 5.61	80.06 ± 5.42

Table XII. Results of the paired *T*-test between the 1st surgery ISQ and 2nd surgery ISQ in Osstell™ and Osstell™ Mentor

	OT1	OTM1	OT2	OTM2
OT1				
OTM1				
OT2	*			
OTM2		*		

OT1 : ISQ measured with Osstell™ in the 1st surgery
OTM1 : ISQ measured with Osstell™ Mentor in the 1st surgery
OT2 : ISQ measured with Osstell™ in the 2nd surgery
OTM2 : ISQ measured with Osstell™ Mentor in the 2nd surgery
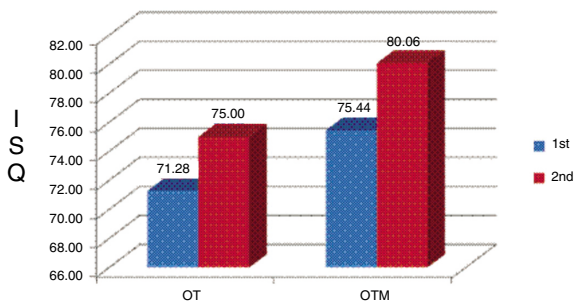*denotes pair of groups significantly different at the 0.01 level

Fig. 5. ISQ value measured with Osstell™ and Osstell™ Mentor in the 1st and 2nd surgery.

The ISQ values of Osstell™ and Osstell™ Mentor exhibited a significant correlation ($P < .01$) regardless of the location of insertion and types of implants inserted.

Table XI lists the ISQ values of the 32 implants inserted into 25 patients obtained with Osstell™ and Osstell Mentor™ during the first and second stage surgery.

The changes in the ISQ values of both Osstell™ and Osstell Mentor™ showed a significant difference ($P < .01$) (Table XII) (Fig. 5).

DISCUSSION

Since the first report by Brånemark in 1969, many clinical and experimental studies have shown that the insertion of an osseointegrated implant is a good treatment for either fully or partially edentulous patients.[17] Clinically, an implant shows an excellent long-term success rate of approximately 90%.[18,19] However, failure can occur due to the unsuitable quantity and quality of bone, infection during the healing process, and an excess load while functioning, etc.[14]

Although clinically severe mobility and obvious bone absorption observed in radiography can guarantee failure of an implant, it is difficult to confirm this without such evidence.[20] RFA is a non-destructive and objective way of assessing the bone-implant interface.[20] It can also measure the change in implant stability as a function of time, and it is useful for determining the critical time for making prosthetics.[15]

According to Nkenke *et al.*[21], RFA is not affected by the PTV (Perio test value) or bone quality, but by bone-to-implant contact. Huang *et al.*[22] also suggested in their histomorphologic study that the bone-to-implant contact and RFA were related. While Friberg *et al.*[23] mentioned that RFA was related to the cutting force when inserting an implant, Huang *et al.*[24] used RFA to demonstrate that the implant stability increases during the healing period and reported it to be a precise and reliable device. Valderrama *et al.*[20] stated that in cases of a low ISQ value, an adequate healing period would be necessary before loading, whereas Friberg *et al.*[25] reported that a low ISQ value indicated failure of an implant weeks before radiographic evidence could be obtained. Glauser *et al.*[16] suggested that RFA could be used to diagnose the possibility of implant failure before the presence of clinical evidence.

The stability of 44 implants were tested, and the results showed that Osstell™ displayed ISQ values ranging from 60 to 83 with an average of 70.84, while those for Osstell™ Mentor ranged from 64 to 88 with a mean value of 75.09. The difference between the two devices was 4.25, which was statistically significant. Regarding the 50 implants tested during their second stage surgery, the ISQ values for Osstell™ and Osstell™ Mentor showed a mean value of 74.14 and 78.90, respectively. The difference was 4.76, which was also significant.

During the second stage surgery, the locations in jaws or types of implants did not have a significant impact on the results of the two devices as observed for the first stage surgery, whereby the implants were inserted in the maxillas with the exception of the Brånemark System® MKIII TiUnite. In first and second stages of surgery, Osstell™ Mentor was likely to give 4 - 5 higher ISQ values than Osstell™. With the relatively consistent difference between these two devices, Osstell™ and Osstell™ Mentor are objective and can measure the implant stability confidently. These results are somewhat different from Valderrama's report, ISQ values for Osstell™ Mentor were 8 to 12 points higher than those for Osstell™. This appears to be because Valderrama *et al.* used one-stage implants, whereas two-stage implants were used in this study. While a one-stage implant is measured at 2.8 mm above the bone level with Osstell™, Osstell™ Mentor involves connecting the implant to a

SmartPeg™, which causes a larger difference between the two devices. Recognizing this difference in one-stage implants would help in their clinical application.

The changes in ISQ values according to the healing process were recorded in the same patient, while he or she underwent each stage of surgery with the two different devices. The ISQ values measured in first and second stage surgery using the Osstell™ ranged from 60 to 83 with the mean value of 71.28. In the second stage surgery, they ranged from 65 to 85 with the mean value of 75.00, this change was statistically significant. With the Osstell™ mentor, the values ranged from 64 to 85 in the first surgery with an average of 75.44, whereas they ranged from 62 to 88 with an average of 80.06 in the second stage surgery. This difference was statistically significant. This shows that the ISQ value measured in the second stage surgery showed a significant increase compared to that of the first surgery, which is in agreement with Meredith *et al.*[26] and Rasmusson *et al.*[27] This also suggests that observing the ISQ values constantly after placing an implant in the case of a one-stage implant or after the second procedure in the case of a second-stage implant, would be very useful for determining the critical time for a final prosthetic setting.

CONCLUSION

The ISQ values obtained using Osstell™ and Osstell™ mentor were examined. Both instruments showed a significant difference in the ISQ values (4 to 5 points) with a significant correlation ($P < .05$). The healing process increased the ISQ values significantly for both instruments ($P < .05$). Overall, measuring the implant stability with Osstell™ and Osstell™ mentor is objective and reliable, and can be considered a useful method in practice.

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