Journal of
Periodontology
&
Implant Dentistry

Research Article

Resonance Frequency Analysis of Clinical Stability of Astra Tech and ITI Implant Systems

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Received: 26 August 2010; Accepted: 15 November 2010
J Periodontol Implant Dent 2010; 2(2): 66-69
This article is available from: http://dentistry.tbzmed.ac.ir/jpid

Abstract

Background and aims. Resonance frequency analysis (RFA) offers a noninvasive clinical measurement of stability and osseointegration of implants; it is a useful tool to establish implant loading time. The RFA values are represented by a quantitative unit called the Implant Stability Quotient (ISQ) on a scale from 1 to 100. The aim of the present study was to measure the stability of Astra Tech and ITI dental implants during the healing period and determine the factors that affect the ISQ.

Materials and methods. In this study fourteen healthy subjects who were candidates for dental implants were randomly divided into two groups. Group one received 15 Astra Tech and group two received 15 ITI dental implants. Bone type was classified according to the Lekholm and Zarb index (D1-D4). RFA was used for direct measurement of implant stability on the day of implant placement and 1, 3 and 6 months after implant placement. Data were analyzed by ANOVA, Student's *t*-test and Spearman rank correlation test using SPSS 11.5 with 95% confidence interval.

Results. The means of ISQ for Astra Tech implant after 3 and 6 months were significantly greater than those for ITI implant ($p<0.05$). Statistical analysis showed higher ISQ values for mandible with Type I and Type II bone than maxilla and Type III and Type IV bone ($p<0.05$); implant diameter was significantly correlated to implant stability ($p<0.05$).

Conclusion. Our data suggest that bone quality, implant surface texture (implant system) and diameter can affect implant stability and loading time.

Key words: **ISQ, loading, osseointegration, dental implant stability.**

Introduction

Dental implant stability is a prerequisite for osseointegration. There are different ways of measuring implant stability, such as the Periotest; however, they have been criticized for their lack of resolution, poor sensitivity and their operator sensitivity.[1,2] Resonance frequency analysis (RFA) offers a noninvasive clinical measure of stability and presumed osseointegration of implants;[4,5] it is a useful tool to establish

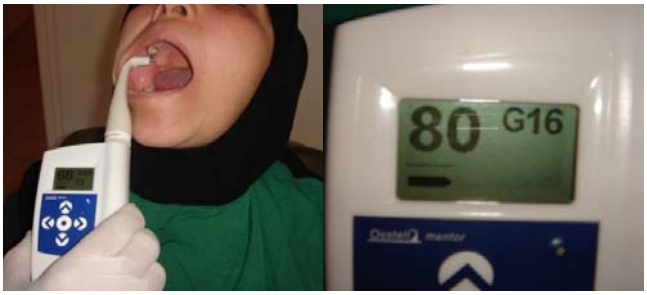

Figure 1. Implant stability measurement by Osstell device and ISQ.

implant loading time.[6] The RFA values are represented by a quantitative unit called the Implant Stability Quotient (ISQ) on a scale from 1 to 100, and are measured with the Osstell (Integration Diagnostics AB, Gothenburg, Sweden) (Figure 1); an increased ISQ value indicates increased stability.[4] Clinically, RFA values have been correlated with changes in implant stability during osseous healing, failure of implants to osseointegrate and the supracrestal dimensions of the implant.[3,7]

The aim of the present study was to measure and compare the stability of Astra Tech and ITI dental implants during the healing period up to six months after implant placement via resonance frequency analysis and determine the factors that affect ISQ, such as bone quality (D1-D4) (Lekholm and Zarb index 1985).[3]

Material and Methods

In this study fourteen healthy subjects who were candidates for dental implants were randomly divided into two groups. Group one received 15 Astra Tech and group two received 15 ITI dental implants. All the implants achieved initial stability. Bone type was classified according to the Lekholm and Zarb index (D1-D4).[3] RFA was used for direct measurement of implant stability on the day of implant placement and 1, 3 and 6 months after implant placement (Figure 1). Kolmogorov-Smirnov test was used to ascertain normality of data. Data were analyzed by two-way ANOVA, Student's *t*-test and Spearman rank correlation test using SPSS11.5 software.

Results

Fourteen patients were included in this study with a mean age of 38 years (28-58 years old) with no contraindications for implant placement. Table 1 shows the mean ± SD of ISQ values for the two groups.

The mean ISQ values for Astra Tech implant system after 3 and 6 months were significantly greater than those for ITI implant system ($P < 0.05$) (Table 1 and Figure 2)

Statistical analysis after adjustment for covariates

Table 1. Means (±SD) of ISQ values for Astra Tech and ITI implant systems

Evaluation interval	Astra Tech		ITI		P value
	Mean	SD	Mean	SD	
Baseline	63.93	2.81	65.36	3.89	p=0.29
Month 1	63.73	3.15	65.20	4.70	p=0.32
Month 3	77.93	2.54	70.86	4.13	p<0.001*
Month 6	81.66	1.95	78.86	3.85	p=0.018*

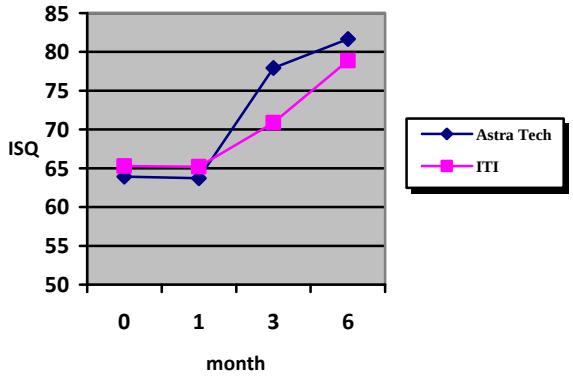

Figure 2. Mean of ISQ values for Astra Tech and ITI implant systems.

(implant system and diameter and length) showed higher ISQ values for mandible than maxilla (Table 2 and Figure 3)

Two-way ANOVA showed that there was no interaction between implant system and bone quality (den-

Table 2. Mean (±SD) of ISQ values in maxilla and mandible

Evaluation interval	MAXILLA		MANDIBLE		
	Mean	SD	Mean	SD	t-test
Baseline	62.36	2.31	66.93	2.65	p =0.00*
Month 1	61.93	3.05	67.00	3.18	p =0.00*
Month 3	73.36	4.60	75.53	5.13	p =0.21
Month 6	78.30	3.31	82.13	1.92	p =0.001*

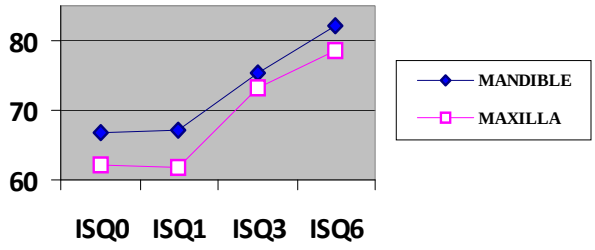

Figure 3. Mean of ISQ values in the maxilla and mandible.

Table 3. Two-way ANOVA showed Type II bone has significantly higher ISQ value than Type III and Type IV bone

	0		1		3		6	
Variable	**Sig**	**F**	**Sig**	**F**	**Sig**	**F**	**Sig**	**F**
Diameter	0.04*	4.63	0.005*	9.70	0.017*	6.64	0.60	0.27
Length	0.57	0.31	0.52	0.40	0.04*	4.67	0.84	0.03
System	0.26	1.55	0.14	2.61	0.00*	47.38	0.01*	8.80
Density	0.05*	15.44	0.02*	31.87	0.01*	6.50	0.02*	23.89
System*Density Interaction	0.47	0.76	0.70	0.35	0.76	0.26	0.82	0.19

Table 4. Mean ± SD of ISQ values at baseline and 1-, 3-, and 6-month intervals in different systems and different bone qualities

	0		1		3		6	
Bone quailty	**Astra**	**ITI**	**Astra**	**ITI**	**Astra**	**ITI**	**Astra**	**ITI**
Moderate(D2)	67.00±0.00	65.50±3.53	69.00±0.00	67.00±4.24	80.00.±0.00	69.00±4.24	85.00±0.00	81.50±0.70
Low(D3)	64.90±2.23	67.57±3.45	64.60±2.41	67.14±4.45	78.20±2.85	72.42±4.31	82.10±1.52	80.14±3.38
Very Low(D4)	60.75±1.50	62.50±3.01	60.25±0.95	62.33±4.27	76.75±1.50	69.66±3.93	79.75±1.25	76.50±3.98

Table 5. Spearman rank correlation test and significant correlation (*) between implant diameter and ISQ values

Evaluation interval	Implant Diameter	Implant Length
ISQ 0	rs=0.13 p=0.48	rs=0.050 p=0.79
ISQ 1	rs =0.22 p=0.24	rs=0.17 p=034
ISQ 3	rs=041 *p=0.02	rs=0.19 p=0.31
ISQ6	rs=0.035 p=0.85	rs=0.061 p=0.75

sity), and bone density had a significant effect on implant stability after adjustments for covariates of implant diameter and length. It showed that the main factors were implant system (Astra Tech and ITI) and bone quality (D2, D3, and D4). It also showed that ISQ is significantly higher in Type II bone compared to Type III and Type IV ($P < 0.05$). Implant diameter also had a significant effect on ISQ but implant length did not. Finally, implant system significantly influenced ISQ values and implant stability at 3-month and 6-month intervals (Tables 3 and 4).

Spearman rank correlation test showed that implant diameter is significantly correlated to implant stability ($P < 0.05$) (Table 5) but implant length does not correlate to implant stability.

Discussion

Dental implants are a successful treatment modality for missing teeth.[14-16] There are several ways to evaluate the bone-implant interface. Invasive methods, like the amount of torque required to remove an implant, have been used in animal studies.[17-18] Clearly, this is a destructive method in which the application of shear stress at the implant interface leads to failure; therefore, it is not applicable for clinical assessment.[4-19] Cutting torque measurement is a clinical method that uses cutting resistance measurements during threading of implants and has been used by several investigators to identify bone densities during implant placement.[20-22] Although this technique provides an assessment of bone quality at the time of placement, it does not allow for any direct measurement of the changes that influence the supporting bone over time. RFA is a non-invasive objective testing modality of implant stability, which is a useful tool to establish implant loading time. The quantity and location of cortical and trabecular bone surrounding the implant are important factors in stability as they contribute to bone-implant contact (5); Nedir et al[8] observed that the majority of implants in the maxilla and mandible had ISQ values of <60 and >60, respectively. Consistent with the results of our study, Barewal et al[5] and Bischof et al[23] found higher values in the mandible, with statistically significant differences in the latter.[24] Likewise, Peñarrocha et al[9] reported more failures in the maxilla when they placed 642 Defcon® implants with early loading; 12 fixtures failed, 10 of which were placed in the maxilla. The bone quality and implant stability are lower in posterior areas; for this reason the posterior implant success rate is less than the anterior.[10] In the anterior area, the thick cortical and the dense trabecular bone will increase primary stability; in this study, ISQ was higher in this area than the posterior region. Some authors suggest that using longer and wider implants increases primary stability due to the increased bone-implant contact surface area.[11-13] In the present study implant diameter was significantly correlated to increased implant stability and ISQ value.

Conclusion

Our data suggest that RFA values are correlated with changes in implant stability during osseous healing, and if ISQ values decrease we can avoid implant failure by a decrease in load. Furthermore, bone quality can affect implant stability and time of loading. For Type I and Type II bone implant success is higher than Type III and Type IV and they can be loaded faster. For poor quality bone we must use thicker implants or highly textured ones. Finally, both Astra Tech and ITI implant systems are clinically successful systems but we suggest further studies on other systems and resonance frequency method.

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