

SHORT-TERM RADIO FREQUENCY ANALYSIS MEASUREMENTS OF ADIN IMPLANTS

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ABSTRACT

Background and Aim: The purpose of this study was to understand and monitor the transition from primary to secondary stability of implants having sand blast large grit acid etched surface, for the timing of the prosthodontic treatment via using the Radio Frequency Analysis.

Subjects and Methods: Forty-two dental implants were placed in 19 patients and Implant Stability Quotient measurements were performed at baseline, 1st, 2nd, 3rd, 4th, 6th and 8th weeks. The lengths and diameters of the implants were also correlated with Implant Stability Quotient values.

Results: The present data showed no correlation between lengths, diameters and Radio Frequency Analysis at any of the measurement times. In each group, implant stability at the baseline and 8th weeks showed significant higher Radio Frequency Analysis (RFA) values than the 2nd, 3rd and 4th weeks ($p < 0.05$). Statistically no difference was found between the baseline and 8th week measurements ($p > 0.05$).

Conclusion: Measuring Implant Stability Quotient values can help the clinician understand the condition of the implant without disrupting the healing implant-bone interface, allowing to decide the loading time.

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Keywords: Dental Implants, Osstell, Resonance Frequency Analysis, Stability

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ADIN İMPLANTLARININ KISA DÖNEM RADYO FREKANS ANALİZ ÖLÇÜMLERİ

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ÖZ

Amaç: Bu çalışmanın amacı, kumlanmış-asitlenmiş yüzeye sahip implantların primer stabiliteden sekonder stabiliteye geçişini, Radyo Frekans Analiz yöntemi kullanarak anlamak ve gözlemlemektir.

Bireyler ve Yöntem: Ondokuz hastada 42 implant yerleştirilmiş ve başlangıç, 1, 2, 3, 4, 6 ve 8. haftalarda İmplant Stabilite ölçümleri (Implant Stability Quotient-ISQ) yapılmıştır.

Bulgular: Elde edilen bilgiler, implantların boyu ve çapı ile Radyo Frekans Analiz ölçümleri arasında hiçbir zaman diliminde ilişki göstermemektedir. Tüm gruplarda implant stabilitesi, başlangıç ve 8. haftada 2, 3 ve 4. haftalara göre anlamlı derecede yüksek İmplant Stabilite ölçüm değeri göstermiştir ($p < 0.05$). Başlangıç ve 8. hafta arasında istatistiksel fark bulunamamıştır ($p > 0.05$).

Sonuçlar: İmplant Stabilite değerlerini ölçmek, iyileşen implant-kemik bağlantısına zarar vermeden, implantın iyileşme durumu hakkında fikir vererek yükleme zamanının kararında hekime yardımcı olabilir.

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Anahtar Kelimeler: Dental implant, Osstell, Radyo Frekans Analizi, Stabilite

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INTRODUCTION

Osseointegration is a direct and lasting connection between vital bone and titanium implants.¹ To achieve a successful osseointegration, primary and secondary stability criterias must be met. While the former of these implies a mechanical contact between alveolar bone and implant, the latter is the consequence of direct bone apposition on the implant surface. The shift from primary to secondary stabilization is the result of successful wound healing, starting immediately after implant placement in the surgical site.²⁻⁴

Monitoring the osseointegration process with a non-invasive and non-destructive method is important for the clinician to decide when to load the implants. Two methods used for this purpose are use of a Periotest and Radio Frequency Analysis (RFA). A Periotest is a device basically designed to diagnose and assess the periodontopathies and occlusal load, as well as to control the treatment's progress for natural teeth. It is also used for assessing the osseointegration of dental implants.^{5,6} The results of the Periotest are expressed as Periotest values (PTV), which range from -8 (lowest mobility) to +50 (highest mobility).

The RFA technique is a bending test of implant-bone complex. With the help of a transducer, a small force is applied and the amount of displacement is measured.⁷ The results are expressed as Implant Stability Quotient (ISQ), which ranges from 1 to 100. Higher ISQ values represent less displacement and therefore more stiffness of the bone-implant interface.

Meredith et al.⁸ published the resonance frequency measurements of implants in maxilla and stated that this technique could help in following the changes in stability at the implant-tissue interface. The RFA technique was then commercialized as Osstell (Integration Diagnostics, Göteborg, Sweden) and studies were reported as ISQ measurements by using the Osstell machine for different implant systems.⁹⁻¹¹ The second generation of the device, the Osstell Mentor (Integration Diagnostics AB), is wireless and Valderrama et al.¹² demonstrated that both generations correlate well but cannot be compared directly in terms of ISQ measurements. Different implant systems are also not comparable although the same measuring device is used, so multiple measurements are necessary for each implant system. Therefore, the aim of this article is to present the short-term RFA measurement results of 42 implants with SLA(Sand-blasted, Large grit, Acid etched) surface.

MATERIALS AND METHODS

Nineteen subjects (aged 19-79, mean age: 51±11.07) who received 42 implants were examined. The study protocol was approved by Istanbul Medipol University Ethics Committee (no: 203). Patients with systemic diseases -such as uncontrolled diabetes mellitus, osteoporosis or autoimmune diseases- as well as immunosuppressed patients and pregnant women were not included. Cases involving immediate implant placement or in need of advanced surgical techniques including sinus lifting, ridge splitting or bone grafting were not included either. Prior to surgery, panoramic radiographs were taken and the amount of available bone and anatomical relationships were evaluated. All patients underwent thorough periodontal therapy and oral hygiene instructions were given before surgical approach.

Implant Placement and Prosthetic Rehabilitation

All operations were done under infiltration anesthesia with articaine HCl containing 0.006 mg epinephrine HCl (Ultracain D-S, Sanofi Aventis, İstanbul, Turkey). Full-thickness mucoperiosteal flaps were raised and implants were placed according to the manufacturer's protocol. Healing abutments were placed in order to make weekly measurements possible and flaps were then closed using 3-0 silk sutures. All patients received postoperative instructions and were prescribed antibiotics (amoxicillin/clavulanic acid, 2g per day for 5 days) and analgesics (diclofenac sodium, 150 mg for 5 days). Sutures were removed after 7 days. Prosthesis was delivered after the 8th week of measurement.

Implants

Implants used in this study were from a single manufacturer (ADIN Dental Implant Systems, Israel) with the SLA surface; diameters and lengths ranging between 3.5-5 mm and 8-13 mm, respectively. Twenty-two of the implants were Touareg-S implants and 20 of the implants were of the Touareg-X type. The difference between these two types is in their apex design.

RFA Measurements

RFA measurements were made with the Osstell Mentor device at baseline immediately after implant placement and then at the 1st, 2nd, 3rd, 4th, 6th and 8th weeks. The Smartpeg of the device was connected to the implant and measurements were performed and recorded from the buccal side (BL) and from the mesial side (MD).

Statistical Analysis

The statistical assessment was carried out using SPSS 15.0 for Windows. Distribution of parameters was tested with Kolmogorov-Smirnov test. Student's t-test was used to compare the parameters between the groups. In determining the difference between the averages of different RFA periods, repeated measures analysis of variance and Bonferroni tests were used. No power analysis was used in this study.

RESULTS

All 42 implants osseointegrated successfully and could be restored after 8 weeks. Among the 42 implants, 15 (35.7 %) were placed in maxilla and 27 (64.3 %) were placed in the mandible.

The lengths and diameters of the implants are shown in Table 1. Implant length did not have a significant effect on RFA measurements when 8-10 mm and 11.5-13 mm implants were grouped together ($p > 0.05$) (Table 2), also implant diameters did not have an effect on RFA measurements, 3.5-3.75 mm and 4.2-5 mm implants were grouped together ($p > 0.05$) (Table 3).

RFA measurements of all 42 implants on a weekly basis and comparisons between all measurements are shown in Table 4 and Figure 1. For all implants, there were no significant differences between the baseline (76.00 ± 5.29) and 8th week (75.69 ± 4.68) measurements ($p > 0.05$). Third week measurements (73.50 ± 5.97) demonstrated the lowest ISQ value ($p = 0.038$) (Figure 1). Both baseline and 8th week ISQ measurements were significantly higher from those of the

2nd, 3rd and 4th weeks, 73.86 ± 6.03 , 73.50 ± 5.97 and 74.00 ± 5.04 , respectively ($p < 0.05$).

DISCUSSION

This study evaluated the short-term RFA measurements of 42 SLA surface implants to monitor the healing pattern and to decide the loading time. Two different implant types, by means of macro-design, were used. The difference between these two groups was present according to their apex design. Since statistical analysis showed no significance at any time point (data not shown) between these groups, all implants were evaluated together.

RFA, as an evaluation method, has been used in in vitro and in vivo studies for a long time.¹³ The technique has shown an evolution from a wired system to a wireless one and it is still evolving to be more sensitive and repeatable.^{8,12,14,15} Although RFA is a widely used, non-invasive technique, it is still criticized by some researchers for measuring only the general stiffness of the bone-implant interface and not the exact relationship between the bone and implant surface.¹⁶ A new method is being developed by Kim et al.¹⁷ to evaluate the stability of implants by using inductive sensors. The authors speculate that their method showed better consistency and differentiability with implant stability compared to RFA in various implantation conditions,¹⁸ but it has not yet been commercialized.

Concerning the effect of implant length on RFA measurements, there is no consensus in the literature. In the present study, the implants were grouped as short (8-10 mm) and long (11.5-13 mm). The decrease in the third week in the shorter group

Table 1. Distribution of implants by length and diameter

		n	%
Implant length	8 mm	10	23.8
	10 mm	5	11.9
	11.5 mm	18	42.9
	13 mm	9	21.4
Implant diameter	3.5 mm	2	4.8
	3.75 mm	24	57.1
	4.2 mm	12	28.6
	5.0 mm	4	9.5

Table 2. Comparison of implant length and RFA measurements

RFA	Implant length		p
	8-10 mm	11.5-13 mm	
	Mean±SD	Mean±SD	
Baseline	76.86 ± 4.40	75.52 ± 5.74	0.436
1 th week	75.80± 5.78	74.96 ± 4.52	0.606
2 th week	73.33 ± 6.33	74.15 ± 5.96	0.680
3 th week	71.33 ± 6.83	74.70 ± 5.19	0.080
4 th week	72.46 ± 5.59	74.85 ± 4.60	0.144
6 th week	73.93 ± 4.77	75.74 ± 4.51	0.230
8 th week	75.13 ± 4.94	76.00 ± 4.59	0.571

Table 3. Comparison of implant diameter and RFA measurements

RFA	Implant diameter		p
	3.5-3.75 mm	4.2-5.0 mm	
	Mean±SD	Mean±SD	
Baseline	75.07 ± 5.17	77.50 ± 5.29	0.152
1 st week	74.57 ± 5.21	76.37 ± 4.42	0.258
2 nd week	75.19 ± 5.13	71.68 ± 6.88	0.067
3 rd week	73.61 ± 5.71	73.31 ± 6.57	0.876
4 th week	73.84 ± 4.85	74.25 ± 5.48	0.804
6 th week	74.57 ± 4.49	75.94 ± 4.88	0.362
8 th week	75.07 ± 4.66	76.68 ± 4.67	0.284

was more dramatic than the longer one but did not reach a significant level at any time point ($p>0.05$). Meredith et al.¹⁸ measured the resonance frequencies of implants using the first generation implant/transducer system and stated that the measurements were related to the length of the implant above the bone, which they called effective implant length. Sim and Lang¹⁹ used tissue level implants having the same diameter but different lengths. In their study, resonance frequencies were assessed by the Osstell Mentor. Although their results also showed no statistical significance, they speculated that implant length was an effective factor for

ISQ values at the baseline, but after 2 weeks short implants showed almost identical results to the long ones. Güler et al.²⁰ and Quesada-Garcia et al.²¹ also published reports stating that there is no relationship between the length of the implants and ISQ measurements. In contrast to these studies, Barikani et al.²² tested the effect of implant length on primary stability in different bone types and concluded that the implant stability was affected by length especially in D3 bone. In the present study bone type was neglected. Two finite element analysis studies also showed positive correlation between the length of the implant and RFA measurements. In one of these studies,²³

Table 4. RFA measurements of all implants on a weekly basis

RFA	
Baseline	76.00 ± 5.29
1 th week	75.26 ± 4.95
2 th week	73.86 ± 6.03
3 th week	73.50 ± 5.97
4 th week	74.00 ± 5.04
6 th week	75.09 ± 4.63
8 th week	75.69 ± 4.68

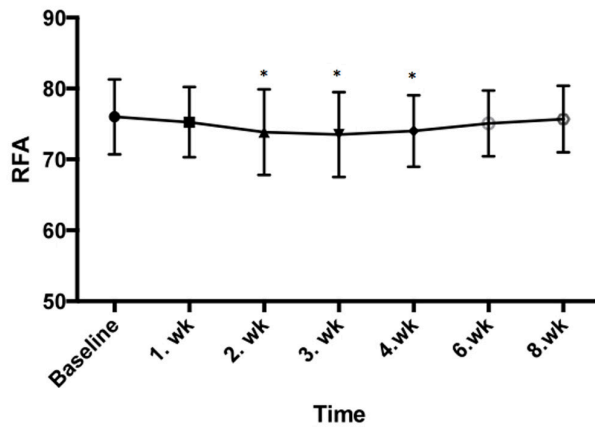


Figure 1. RFA measurements of all implants on a weekly basis
* $p < 0.05$, compared to baseline and 8th week measurements

implants were fixed in the bone by joining corresponding nodes of implant and bone. The other study, Pattijn et al.²⁴ also rigidly fixed the implant and bone surfaces assuming a full osseointegration. These modeling conditions may not be reflecting the exact clinical situations, which prevents a direct comparison with the present results. Another study by Östman et al.²⁵ also reported a relationship between implant length and RFA measurements but their results are in the opposite direction of the aforementioned studies, stating lower stability for longer implants. The authors explained that lower stability may be due to reduced implant diameter in the marginal bone level to prevent friction during placement and prolonged drilling time which may cause over preparation of the implant bed. Differences between implant morphologies, experience level of the practitioners, as well as diameters of drills used in the present study also prevent a direct comparison of the results.

The diameter of the implants did not have a significant effect on ISQ measurements in the present study when 3.5-3.75 and 4.2-5mm implants were grouped together. Bischof et al.²⁶ and Han et al.²⁷ also reported that implant diameter was not a factor for ISQ measurements. On the contrary, there are also studies suggesting that there is a relationship between the diameter of the implant and ISQ values.^{21,22,28} The increase in diameter can let the implant engage more of the buccal/lingual cortical bones,²⁵ therefore resulting in increased baseline ISQ values. Also more diameter means more surface available for osseointegration resulting in increased ISQ values in the following weeks.²⁰

Bone healing around dental implants is a complex phenomenon. There are two different definitions depending on where osteoblasts begin to form bone: Distance osteogenesis and contact osteogenesis. In the former, new bone begins to form from native bone towards the implant, whereas in the latter osteoblasts migrate and attach at the implant surface and then start to synthesize bone matrix towards native bone.²⁹ Other cell types, including osteoclasts, also play their parts and appear in a chronological sequence.³⁰ In a fracture healing model, Schell et al.³¹ reported that osteoclasts are active from the very early phases of bone healing. Histological studies by Berglundh et al.³ and Abrahamsson et al.^{4,32} also reported necrosis and resorption of bone in contact with the implant, which is responsible for mechanical primary stability. This bone apposition and resorption events affect RFA measurements clinically. In our study, ISQ results started to decrease from the 1st week and reached their minimum at the 3rd week. Han et al.²⁷ investigated the factors influencing RFA during implant tissue integration

CLINICAL DENTISTRY AND RESEARCH

and concluded that the lowest ISQ was reached at 3 weeks. They also recommend monitoring implant stability at the 8th week, since the results were restored at that time post-surgically. Makary et al.¹⁴ also recorded a significant fall at the 3rd week, which increased at the 6th week. Another study by Shokri and Daraeighadikolaei³³ monitored 15 SLA implants for 11 weeks after surgery. Their lowest recordings were reached at the 4th week within a range between 62 and 79 which was even accepted as stable.³⁴

Although primary stability initially decreases due to osteoclastic activity and then increases as a result of osteoblastic activity, the relationship between Bone Implant Contact (BIC) and RFA measurements is still being debated. Animal^{32,35,36} and human^{37,38} histological and histomorphometrical studies fail to show a correlation between these two parameter. Degidi et al.³⁷ explains this situation as a result of two dimensional histologic sections which represents the three dimensional BIC and the mineralized bone to implant contact may not accurately depict the strength of the connection between the implant and the bone.

Another parameter which affects osseointegration process is the biomaterial's itself. Properties such as surface topography, surface chemistry and surface energy/wettability have influences on wound healing via cells which will eventually give rise to osseointegration.³⁹ Since we used only SLA surface in the present study, the biomaterial influences are neglected. Ignoring the bone type evaluation is a limitation for this study. The authors suggest the placement of standardized implants into similar bone types in the forthcoming studies.

CONCLUSION

In conclusion, routine RFA measurements can be easily performed without disrupting the healing implant-bone interface and allow the practitioner to decide when to load implants. Weekly measurements may help us to understand the shift from mechanical stability to biological integration, but it is not feasible to evaluate the patients every week. Studies reporting RFA measurements for different implant systems may allow clinicians to understand the loading time for each implant system only by measuring the ISQ value.

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CLINICAL DENTISTRY AND RESEARCH

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