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# Mjerenje stabilnosti implantata šest tjedana nakon implantacije

## *Implant Stability Measurement Six Weeks After Implantation*

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### Sažetak

Oseointegracija je strukturalna i funkcionalna veza između površine kosti i dentalnog implantata. Njegova se stabilnost postiže izravnim kontaktom koštanog tkiva i titan-oksida na površini implantata. Nedavno je razvijen instrument za analizu rezonantne frekvencije, a koristi se novom jedinicom nazvanom kvocijent stabilnosti implantata („*implant stability quotient*“ - ISQ). **Svrha:** Studijom se željelo ustanoviti koliko vrijednosti ISQ-a ovise o dobi i spolu, zatim o promjeru i dužini implantata te mjestu ugradnje, odnosno može li se uspješna oseointegracija predvidjeti u odnosu prema navedenim parametrima. **Ispitanici i postupci:** U istraživanje je bilo uključeno 30 pacijenata - 17 žena i 13 muškaraca u dobi između 23 i 71 godine. Ukupan broj implantata bio je 53, a primijenili su se oni iz sustava Straumann, tipa Standard Plus s površinom SLA. **Rezultati:** Šest tjedana nakon operativnog zahvata pacijenti su došli na kontrolni pregled te im je Osstellom izmjeren ISQ. Jednosmjernom analizom varijance potvrđena je statistički znatna razlika u vrijednosti ISQ-a u odnosu prema spolu te promjeru implantata. U odnosu ISQ-a i različitih dobnih skupina te dužine usatka i mjesta implantacije, nije potvrđena statistički znatna razlika. To su preliminarni rezultati i oni se moraju potvrditi u nekoj budućoj studiji s većim brojem pacijenata.

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### Ključne riječi

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### Uvod

Oseointegracija je strukturalna i funkcionalna veza između površine kosti i dentalnog implantata (1).

Proces cijeljenja oko njega sličan je onomu u normalnoj kosti. Istraživanja na titanskim implantatima pokazala su da se cijeljenje događa u trima fazama – osteofilnoj steokonduktivnoj i osteoadaptivnoj (2).

### Introduction

Osseointegration is a structural and functional connection between the bone surface and the dental implant surface (1).

The process of healing around the implant is similar to that in the normal bone tissue. The studies of titanium implants have shown that the process of healing is conducted in three phases: osteophilic, osteoconductive and osteoadaptive (2).

Stabilnost dentalnih implantata postiže se izravnim kontaktom između koštanog tkiva i titan-oksida na površini implantata (3). Nekoliko je čimbenika koji utječu na oseointegraciju: svojstva materijala od kojih su implantati izrađeni (4), sterilnost implantata tijekom implantacije te njihov oblik i mikrostrukturu. Rezultati dosadašnjih studija upućuju na to da svojstva površine implantata utječu kako na rani kontakt između kosti i implantata tako i na dulji doticaj nakon usađivanja (5-8).

Za dugoročnu oseointegraciju implantat mora biti postavljen u gustu trabekularnu kost s dostatnom visinom i širinom alveolarnog grebena, a pacijent ne bi trebao imati nikakvu sistemsku bolest koja bi mogla kompromitirati cijeljenje (2).

Buser i suradnici (9) pokazali su da titanski implantati s hrapavijom površinom imaju statistički veću vezivnu snagu od onih s glatkijom površinom.

Cochran i njegovi kolege (5) proveli su multicentrično istraživanje s implantatima ITI s pjeskarenom površinom i kiselinom obrađenom površinom („sandblasted and acid-etched“ - SLA). Rezultati toga prospektivnog istraživanja pokazali su da se s visokim postotkom uspješnosti suprastruktura na implantatima može izraditi šest tjedana nakon implantacije, ali rezistencija sidrišnog batrljka mora biti 35 Ncm bez kontratoraka. Uspješnost implantata veća je od 99 posto dvije godine nakon izrade suprastrukture (5).

Nedavno je razvijen instrument (*Osstell, Integration Diagnostics AB, Gothenburg, Švedska*), kojim se analizira rezonantna frekvencija, a za to se koristi nova jedinica nazvana kvocijent stabilnosti implantata („implant stability quotient“, ISQ) (10). U raščlambi rezonantne frekvencije rabi se prijenosnik pričvršćen za implantat, a uključuje se iznad razine frekvencije zvuka, istodobno očitavajući vrijednost. Vrijednost ISQ-a mijenja se od 1 do 100, s time da je 100 najviša vrijednost. Minimalna vrijednost za uspješnu integraciju implantata iznosi 47 (11).

Svrha studije bila je ustanoviti koliko vrijednost ISQ-a ovisi o dobi i spolu, zatim o promjeru i dužini implantata te mjestu implantacije, odnosno može li se uspješna oseointegracija predvidjeti u odnosu prema navedenim parametrima.

## Ispitanici i postupci

U istraživanje je bilo uključeno 30 pacijenata - 17 žena i 13 muškaraca u dobi između 23 i 71 godine. Ukupan broj implantata bio je 53, a koristili

The stability of dental implants is accomplished by direct contact between the bone tissue and the titanium-oxides on the implant surface (3). Several key factors affect osseointegration. These factors include the characteristics of materials (4), sterility of implants during implantation, design, shape and microstructure of implants. The results of previous studies suggest that the characteristics of the implant surface can not only influence the early contact between the bone and the implant, but continue to affect bone-to-implant contact long after the implant placement (5-8).

For long-time osseointegration the implant should be inserted in the area of high bone trabecularity, with sufficient height and width of the alveolar ridge and the patient should not suffer from any systemic diseases which could compromise healing (2).

Buser et al. (9) have shown that titanium implants with rough surface have statistically significant higher binding strength than titanium implants with smoother surfaces.

Cochran et al. (5) carried out a multicentric clinical trial on ITI® implants with a sandblasted and acid-etched (SLA) surface. The results of this prospective trial demonstrate that these implants can be restored after approximately six weeks of healing with high success, as determined by the resistance to abutment placement with 35 Ncm and no counter torque. The implant success rate is greater than 99% two years after restoration (5).

Recently, a clinical instrument has been developed to analyze resonance frequency by using a new unit called implant stability quotient (ISQ) (*Osstell, Integration Diagnostics AB, Gothenburg, Sweden*) (10). The resonance frequency analysis makes use of a transducer, attached to an implant, which is excited over a range of sound frequencies with subsequent response analysis. ISQ value varies from 1 to 100, where 100 represents the highest degree of stability. The minimal ISQ level for successfully integrated implants is 47 (11).

The aim of this study was to establish whether the ISQ level depends on the age and gender, implant diameter, implant length and implant position. In other words, the aim was to establish whether a successful osseointegration could be predicted by these parameters.

## Material and Methods

This study included 30 patients, 17 females and 13 males aged between 23 and 71. The total number of implants was 53. The Straumann implants sys-

su se oni iz sustava Straumann tipa Standard Plus s površinom SLA. Rabili su se oni dužine 8, 10 i 12 mm ovisno o visini alveolarnog grebena. U mandibuli je uračunana sigurnosna granica od 2 mm iznad mandibularnog kanala (18). Promjer implantata bio je 3,3, 4,1 i 4,8 mm, ovisno o širini alveolarnog grebena. Svi pacijenti - sudionici u istraživanju bili su zdravi – nisu imali sistemskih bolesti koje bi mogle kompromitirati cijeljenje. Prije operacije svi su potpisali upitnik o zdravlju koji preporučuje Međunarodna stomatološka federacija (FDI - Federation Dental International).

Implantati su usađeni u mandibulu i maksilu jednofaznom operativnom tehnikom iz sustava Straumann, dosljedno prateći kirurški protokol prema preporukama proizvođača. Tijekom operativnog zahvata nisu primijenjene metode koštane augmentacije. Svi su implantati bili primarno stabilni, što je i klinički potvrđeno. Šavovi su uklonjeni deset dana nakon zahvata. Sve su rane uredno zacijelile.

Šest tjedana nakon usađivanja pacijenti su došli na kontrolni pregled. Za procjenu uspješnosti implantacije primijenili su se kriteriji Busera i suradnika (13) te Cochran i njegovih kolega (5). Oni uključuju odsutnost klinički determiniranog pomaka implantata, zatim odsutnost bola i drugih subjektivnih simptoma te prosvjetljenja oko implantata. Za sva 53 implantata smatralo se da su bili uspješno usađeni te se pristupilo mjerenju ISQ-a Osstellom sa sidrišnim batrljkom SmartPeg.

Varijable su podijeljene u sljedeće kategorije:

1. dobna kategorija - 22 do 35 godina; 36 do 45; 46 do 55; 56 do 65 i 66 do 71 godine;
2. spolna kategorija - muški i ženski;
3. duljina implantata - 8 mm, 10 mm i 12 mm;
4. promjer implantata - 3,3 mm, 4,1 mm i 4,8 mm;
5. mjesto implantacije - maksila i mandibula;
6. vrijednost ISQ-a: 38 do 87.

Statistička analiza uključivala je deskriptivnu statistiku i jednosmjernu analizu varijance praćenu testom Post-Hoc. Rezultati s p-vrijednošću manjom od 0,05 smatrali su se statistički znatnima.

## Rezultati

### Deskriptivna statistika

Pacijenticama je bilo ugrađeno 52,8 posto implantata (28 implantata), a 47,2 posto (25 implantata) dobili su muškarci. Srednja dob sudionika bila je 48 (+/-13) godina - srednja dob pacijentica bila je 47 (+/-14) godina, a pacijenata 50 (+/-12) godina. U maksilu je bilo usađeno 62 posto implantata (33),

tem, type Standard Plus with a sandblasted and acid-etched (SLA) surface was used. The length was either 8 mm, 10 mm or 12 mm which was determined according to the available bone height only. In the mandible, a security margin of 2 mm above the mandibular canal was taken into account (12). The implant diameter included 3.3 mm, 4.1 mm and 4.8 mm according to the available ridge width.

All patients included in this study were healthy, without systemic diseases which could compromise the healing. Before surgical procedure all patients had signed a questionnaire recommended by the World Dental Federation (FDI).

The implants were placed into the mandible and maxilla using a non submerged technique, according to a strict surgical protocol following the manufacturer's instructions. During the surgeries no bone augmentation was used. All implants had primary stability which was clinically determined. The sutures were removed 10 days after the surgery. All wounds healed properly.

Six weeks after the surgery, the patients had a follow-up exam. The success criteria proposed by Buser et al. (13) and Cochran et al. (5) were followed. They included absence of clinically detectable implant mobility, absence of pain or any subjective sensation and absence of radiolucency around the implant. All 53 implants were considered successful and ISQ levels were measured by Osstell mentor device with SmartPeg abutment.

The variables were divided into the following categories:

1. age: 22-35 years, 36-45 years, 46-55 years, 56-65 years and 66-71 years;
2. gender: male and female;
3. implant length: 8mm, 10 mm and 12 mm;
4. implant diameter: 3.3 mm, 4.1 mm and 4.8 mm;
5. implant placement: maxilla and mandible;
6. ISQ value: 38 to 87

Statistical analysis included descriptive and Univariate Analysis of Variance followed by Post Hoc Test. Results with p-value less than 0.05 were considered significant .

## Results

### Descriptives

In female patients 52.8 % of implants (28 implants) were inserted and 47.2 % (25 implants) were inserted in male patients. The mean age of patients was 48 (+/-13), the mean age of female patients was 47 (+/-14) and of male patients 50 (+/-12). Sixty-two percent (62%) of implants (33 implants) were

a u mandibulu 38 posto (20). Usadaka promjera 3,3 mm bilo je 50,9 posto (27), onih od 4,1 mm 39,6 posto (21), a onih promjera 4,8 mm bilo 9,5 posto (5). Implantata dužine 8 mm bilo je 11,3 posto (6), 10 mm 37,7 posto (20), 12 mm 45,3 posto (24), a onih od 14 mm 5,7 posto (3).

Srednja vrijednost ISQ-a bila je 75 (+/-11).

### *Jednosmjerna analiza varijance*

Jednosmjernom analizom varijance potvrđena je statistički velika razlika u vrijednosti ISQ-a u odnosu prema spolu (Tablica 1.) promjeru implantata (Tablice 2. i 3.). Implantati od 4,1 mm imali su najviše vrijednosti ISQ-a. Slijede implantati promjera 3,3 mm i 4,8 mm.

Između ISQ-a i različitih dobnih skupina te dužine implantata i mjesta implantacije, nije bilo statistički znatne razlike.

inserted in the maxilla, and 38 % (20 implants) in the mandible.

There were 50.9 % of implants (27 implants) with 3.3 mm in diameter, 39.6 % with 4.1 in diameter (21 implants) and 9.5 % with 4.8 in diameter (5 implants). There were 11.3 % of implants 8 mm long (6 implants), 37.7 % were 10 mm long (20 implants), 45.3 % were 12 mm long (24 implants) and 5.7 % were 14 mm long (3 implants).

The mean ISQ value was 75 (+/-11).

### *Univariate analysis of variance*

Univariate analysis of variance has shown significant difference of ISQ between the genders (Table 1) as well as between ISQ and implant diameter (Tables 2 and 3). The implants of 4.1 mm in diameter have shown the highest ISQ values followed by 3.3 mm and 4.8 mm.

Between ISQ and different age groups, the implant length and the implant placement did not show any significant correlation.

**Tablica 1.** Odnos između ISQ-a i spola  
**Table 1** Relation between ISQ and gender

Spol • Gender	ISQ				
	N	Mean	Std. D.	F	p*
Ženski • Female	28	72	13	6,973	0,011
Muški • Male	25	79	5		
Ukupno • Total	53	75	11		

\* Univariate Analysis of Variance

**Tablica 2.** Odnos između ISQ-a i promjera implantata  
**Table 2** Relation between ISQ and implant diameter

Promjer implantata • Implant Diameter	ISQ				
	N	Mean	Std. D.	F	p*
3,3 mm	27	73	11	4,520	0,016
4,1 mm	21	80	5		
4,8 mm	5	67	21		
Total	53	75	11		

\* Univariate Analysis of Variance

**Tablica 3.** Post Hoc Test  
**Table 3** Post Hoc Test

implant diameter(I) implant diameter (J) promjer implantata	Mean Difference (I-J)	Std.Error	p	
3,3 mm	4,1 mm	-6,79	2,960	<b>0,026</b>
	4,8 mm	6,33	4,953	0,207
4,1 mm	3,3 mm	6,79	2,960	<b>0,026</b>
	4,8 mm	13,11	5,063	<b>0,013</b>
4,8 mm	3,3 mm	-6,33	4,953	0,207
	4,1 mm	-13,11	5,063	<b>0,013</b>

## **Rasprava**

Analiza vibracije implantata unutar kosti korisna je u procjeni povezanosti implantata s kosti (14), a označava stupanj oseointegracije. Pokazala se boljom od procjene stupnja oseointegracije Periotestom (15). Prosječna vrijednost ISQ-a u istraživanjima razlikuje se od autora do autora. Tako su Zix i suradnici (16) objavili vrijednosti u rasponu od 48 do 68 i pokazali više vrijednosti ISQ-a kod mušaka-

## **Discussion**

The analysis of the vibration behaviour of implants in the bone may be a useful indication of the bone-implant coupling (14) as a function of the degree of osseointegration. The resonance frequency analysis appeared to be a more precise technique than the damping capacity assessment (Periotest) (15).

The average ISQ values vary between authors. Zix et al. (16) have reported values between 48 and

raca, a niže kod žena u menopauzi. Naši su rezultati pokazali statistički veliku razliku u vrijednosti ISQ-a u odnosu prema spolu pacijenata. Srednja vrijednost ISQ-a kod pacijentica za 7 je niža nego kod pacijenata.

Nedir i njegovi kolege objavili su vrijednost 47 kao najnižu vrijednost ISQ-a za uspješnu oseointegraciju (11). U našoj studiji srednja vrijednost ISQ-a bila je 75. Tako visoka razina oseointegracije može se objasniti činjenicom da su svi pacijenti uključeni u studiju bili bez sistemskih bolesti koje bi mogle kompromitirati cijeljenje.

U svojoj su studiji Nedir i suradnici (11) evaluirali Osstell kao dijagnostički instrument odmah nakon implantacije, budući da je primarna stabilnost implantata vrlo važna za postignuće oseointegracije. Zaključili su da su sigurno stabilni oni implantati koji imaju vrijednost ISQ-a  $\geq 47$ . Nekoliko autora pretpostavilo je da primarna stabilnost implantata može biti koristan pokazatelj oseointegracije (17,18) te da se tako može predvidjeti ishod imedijatnog opterećenja implantata (19-21).

U našoj studiji postignuta je statistički velika povezanost između vrijednosti ISQ-a i promjera implantata. Implantati promjera 4,8 mm imali su najniže srednje vrijednosti ISQ-a (67).

Pretpostavlja se da implantati s većom površinom postižu više vrijednosti ISQ-a. U našoj studiji bilo je samo pet implantata s promjerom 4,8 mm, što je neznatan broj za kompetentnu raspravu. Implantati promjera 4,1 mm imali su višu srednju vrijednost ISQ-a (80) nego oni od 3,3 mm (73). Takvi su se rezultati mogli očekivati s obzirom na to da implantati promjera 4,1 mm imaju veću površinu u doticaju s kosti.

Također je postignuta razlika u vrijednosti ISQ-a između implantata u maksili (73) i onih u mandibuli (78). Iako su vrijednosti ISQ-a bile niže u maksili, razlika nije statistički znatna.

Bischof i suradnici (22) pokazali su više vrijednosti ISQ-a (primarna stabilnost) u mandibuli (59,8 $\pm$ 6,7) nego u maksili (55,0 $\pm$ 6,8). Razlika je statistički velika iako vrijednost ISQ-a u odnosu prema lokalizaciji implantata u čeljusti nije znatna. Nakon tri mjeseca postignuta stabilnost bila je ponovno veća u mandibuli nego u maksili.

Drugi su autori uporabom Brånemarkovih implantata također dokazali da je stabilnost implantata veća u mandibuli nego u maksili (17,23,24), te da na to utječe dužina implantata (22-26). Ti rezultati odgovaraju rezultatima dobivenima u našoj studiji.

68 and have shown higher ISQ values in males and lower values in females in menopause. Our results have shown significantly different ISQ values regarding the patient gender. The mean ISQ value of implant placed in female patients was lower by 7 than those placed in male patients.

Nedir et al. reported 47 as the lowest ISQ value required for successful osseointegration (11). The mean ISQ value in this study was 75. This high level of osseointegration could be explained by the fact that the patients included in the study had no systemic diseases which could have compromised the healing.

In their study, Nedir et al. (11) evaluated the Osstell as a diagnostic tool at implant placement whereas primary stability plays a key role in achieving osseointegration. They concluded that implant stability could be reliably determined for implants with an ISQ  $\geq 47$ . Several authors suggested that primary stability may be a useful predictor for osseointegration (17,18) and that high primary stability makes immediate loading more predictable (19-21).

Our study has shown statistically significant correlation between ISQ values and the implant diameter. The implants of 4.8 mm in diameter have shown the lowest ISQ (67). It could be expected that implants with greater surface achieve higher ISQ levels. In our study only five implants had 4.8 mm in diameter so that the number is not relevant for the discussion. The implants with 4.1 mm in diameter have shown higher ISQ values (78) than implants with 3.3 mm in diameter (73). This result is expected regarding the fact that implants with 4.1 mm in diameter have greater bone to implant surface.

Our study has also shown the difference of ISQ values between implants placed in the maxilla (73) and those placed in the mandible (78). Although the ISQ was lower in the maxilla, the difference was not significant.

Bischof et al. (22) showed higher ISQ (primary stability) in the mandible (59.8 $\pm$ 6.7) than in the maxilla (55.0 $\pm$ 6.8). The difference between jaws was significant, although the implant localization did not affect the ISQ significantly. After 3 months, the gain in stability was higher in the mandible than in the maxilla.

Other authors have also shown with Brånemark implants that implant stability was higher in the mandible than in the maxilla (17,23,24) while implant length did not affect implant stability (22-26). This data corresponds with our results.

Balleri et al (23) have shown that high implant stability can be achieved with short implants and

Balleri i njegovi kolege (23) istaknuli su da se visoka stabilnost implantata može postići kraćim implantatima u posteriornim regijama. Friberg i suradnici (25) pokazali su da se stabilnost implantata pozicioniranih u spongioznoj maksilarnoj kosti povećava s vremenom.

Farzad i njegovi kolege dokazali su da se visoka stabilnost implantata može postići u stražnjim regijama mandibule (27). U njihovoj studiji nije istaknuta razlika u vrijednosti ISQ-a između molara/premolara, vrste implantata, zatim njihove dužine i promjera te između unilateralnih i bilateralnih mostova, iako su implantati bili stabilniji u mostovima s trima nego s dvama implantatima. Oko implantata vidljivo je zdravo meko tkivo i minimalna resorpcija kosti. Pacijenti su općenito bili jako zadovoljni rezultatima liječenja (27).

Na kraju možemo pretpostaviti da rezultati ove studije pokazuju da vrijednost ISQ-a ovisi o spolu kao što je pokazano već prije (16). Promjer implantata također je utjecao na njegovu stabilnost. Dužina nije utjecala na vrijednost ISQ-a, kao što je bilo objavljeno u prijašnjim studijama (22-26).

Ova studija također pokazuje da dob pacijenta te mjesto implantacije ne utječu na vrijednosti ISQ-a.

Kako su se u studiji rabila samo 53 implantata, potrebna su daljnja istraživanja s više usadaka. To su preliminarni rezultati koji se moraju potvrditi u nekoj budućoj studiji s većim brojem pacijenata.

placement in posterior regions. Friberg et al. (25) have shown that the stability of implants placed in soft maxillary bone increases with time.

Farzad et al. found that high implant stability can be reached in the posterior mandible (27). In their study there were no differences in ISQ values between molars/premolars, implant types, implant widths, implant length or uni- or bilateral mandibular bridges although the implants were more stable in three-implant bridges than in two-implant bridges. Good mucosal health in the periimplant soft tissue and minor bone resorption around the implants were observed. The patients were generally very satisfied with the treatment outcome (27).

In conclusion, this study suggests that ISQ value depends on the gender as was reported earlier (16). The implant diameter also affected the implant stability. The implant length did not affect the ISQ level as shown in previous studies (22-26).

This study also suggests that the age and the implant placement have no influence on the ISQ level.

Regarding the fact that only 53 implants were included in this study, further studies with a greater number of implants should be performed. These are preliminary results and need to be confirmed in a future study which will encompass a larger number of patients.

## Abstract

Osseointegration is a structural and functional connection between the bone surface and the dental implant surface. The stability of dental implants is accomplished by direct contact between the bone tissue and the titanium-oxides on implant surface. Recently, a clinical instrument has been developed to analyze the resonance frequency by using a new unit called the implant stability quotient (ISQ). **Purpose:** The aim of this study was to establish whether the ISQ level depends on the age and gender, implant diameter and length and implant position, that is, could successful osseointegration be predicted by these parameters. **Material and Methods:** This study included 30 patients, 17 females and 13 males aged between 23 and 71. The total number of implants was 53. The Straumann implants system, type Standard Plus with a sandblasted and acid-etched (SLA) surface was used. **Results:** Six weeks after the surgery, the patients had a follow-up exam and the ISQ levels were measured by Osstell. Univariate analysis of variance has shown significant difference of ISQ value regarding gender as well as between ISQ and implant width. No statistically significant correlation was shown in relation of ISQ and different age groups, implant length and implant placement. These are preliminary results that need to be confirmed in some future studies that will include more patients.

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## Key words

Dental Implantation, Endosseous; Dental Implants

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