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Determination of the Effect of Periimplantitis-Induced Bone Defects on Implant Stability by Resonance Frequency Analysis Method: An Ex-Vivo Study

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Research Article

History

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ABSTRACT

Objectives: Periimplantitis is an infectious disease that causes the resorption of the alveolar bone around the implant. This resorption compromises osseointegration by affecting bone-implant contact. This study aimed to determine the effects of experimentally created 3-walled periimplantal defect models at different depths on osseointegration.

Materials and Methods: This study was designed as an ex-vivo study. Fresh bovine ribs were used in this study. A total of 14 dental implants of 3.5x10 mm size were placed on the fresh beef rib, and then periimplantal bone defects of different depths were experimentally created. There are a total of 4 groups in the study, they are respectively; healthy group, 1.5 mm deep defect, 2.5 mm deep defect, and 5 mm deep defect group. For all of these groups, osseointegration was evaluated with the Osstell penguin device using the resonance frequency analysis method from four regions of each implant, mesial-distal buccal palatinal, to determine the osseointegration level according to the amount of bone-implant contact.

Results: While the highest ISQ values were observed in the healthy group, the difference between the other groups and the healthy group was not statistically significant, except for the 5 mm defect group. The results of the 5 mm defect group were significantly lower than those of the other three groups.

Conclusions: It has been observed that there will be a significant decrease in osseointegration according to osstell scores in periimplantal defects with a defect depth of 5 mm.

Key words: Osseointegration, Peri-Implantitis, Resonance Frequency Analysis.

Peri-İmplantitise Bağlı Kemik Defektlerinin İmplant Stabilitesi Üzerine Etkisinin Rezonans Analiz Yöntemiyle Belirlenmesi: Ex-Vivo Çalışma

Süreç

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ÖZ

Amaç: Peri-implantitis, implant çevresindeki alveolar kemiğin rezorbsiyonuna neden olan enfeksiyöz bir hastalıktır. Bu rezorpsiyon, kemik-implant temasını etkileyerek osseointegrasyonu azaltır. Bu çalışma, deneysel olarak oluşturulan 3 duvarlı periimplantal defekt modellerinin farklı derinliklerde osseointegrasyon üzerindeki etkilerini belirlemeyi amaçlamaktadır.

Gereç ve Yöntemler: Çalışma ex-vivo olarak tasarlanmıştır. Çalışmada taze sığır kaburgası kullanıldı. Sığır kaburgası üzerine 3.5x10 mm boyutlarında toplam 14 adet dental implant yerleştirildi ve ardından deneysel olarak farklı derinliklerde periimplantal kemik defektleri oluşturuldu. Çalışmada toplam 4 grup vardır, bunlar sırasıyla; sağlıklı grup, 1,5 mm derinlikte defekt, 2,5 mm derinlikte defekt ve 5 mm derinlikte defekt grubu. Tüm bu gruplar için, kemik-implant temas miktarına göre osseointegrasyon düzeyini belirlemek için ostell cihazı ile her bir implantın mezial-distal bukkal palatinal olmak üzere 4 bölgesinden rezonans frekans analizi yöntemi kullanılarak osseointegrasyon değerlendirildi.

Bulgular: En yüksek ISQ değerleri sağlıklı grupta iken, 1,5 mm derinlikte defekt, 2,5 mm derinlikte defekt grupları ile sağlıklı grup arasındaki fark istatistiksel olarak anlamlı değildi. 5 mm defekt grubunun sonuçları diğer 3 grubun sonuçlarına göre anlamlı derecede düşük bulundu.

Sonuçlar: Defekt derinliği 5 mm olan periimplantal defektlerde osstell skorlarına göre osseointegrasyonda anlamlı bir azalma olduğu saptandı.

Anahtar Kelimeler: Osseointegrasyon, Peri-Implantitis, Rezonans Frekans Analizi.

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Introduction

Periimplantitis, defined as an inflammatory disease of the tissues around an implant, is one of the most important inflammatory diseases that affect the long-term success of dental implant treatment. Periimplantitis is characterized by bleeding on probing and marginal bone loss with a pocket depth of more than 4 mm around the implant.[1]

The diagnosis of periimplant bone loss is made using periapical radiographs, but these radiographs do not always provide clear results, especially in imaging initial bone loss.[2] The early detection of periimplantitis in clinical examinations is key to bone loss prevention and periimplant health. any studies that the radiological determination of periimplant bone loss is difficult, especially in the early period; to overcome this difficulty, a search was made for diagnostic devices that can make more precise measurements, which are easy to measure and repeatable.[3,4]

Approximately 20 years ago, Meredith *et al.* developed a resonance frequency analysis (RFA) method to determine osseointegration. The OsstellTM is a manufactured tool for measuring implant stability using RFA. (SmartpegTM; Osstell, Gothenburg, Sweden). Recently, a mobile device called PenguinTM (MultipegTM; Penguin Integration Diagnostics, Gothenburg, Sweden) was developed for this purpose. Using this method, both instruments can measure the implant stability quotient (ISQ) of implants.[5]

In studies on the RFA method, it has been stated that the amount of bone-implant contact is the main determinant method.[6-9] However, studies on how much the ISQ value will change in bone loss, especially in the periimplantal region, are limited.

The purpose of this study was to investigate whether ISQ values can predict periimplantal defects with different morphologies.

Material and Methods

Ethical approval of this study was approved by Nuh Naci Yazgan University Scientific Research and Ethics Committee (2022/001-006). All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and the Helsinki Declaration of 1975, as revised in 2008.

The current study was a planned ex-vivo study. Fresh, young beef ribs were used in this study. The Bovine Tissues were not frozen and were used fresh directly for the study. The ribs were stabilized during drilling. The soft tissues and periosteum were carefully dissected using with blunt dissection and the bone surface was exposed. The implant sockets were then prepared by a single operator using the drilling protocols of the manufacturer's instructions. The bovine rib was morphologically similar to the type III–IV bones. While the coronal (2–3 mm) portion was cortical bone, the bone in the apical region of the implant consisted mostly of spongiosa.[10]

When ex vivo studies using bovine ribs related to periimplantitis were examined in the literature. Miotk *et al.* In a study of periimplantitis diagnostic accuracy in CBCT, Minsua *et al.* in which they measured buccal bone thickness, and experimental periimplantitis studies by Yao *et al.* showed that the model we used in the current study concept is a frequently preferred study model.[11-13]

Periimplant defects were created at different depths with trephine burs after osteotomy *(Figure 1(a-c))*. 4 groups in total are used in the study; they are as follows: Group 1: Control group, group 2:3-walled defect with a 1.5 mm defect depth, group 3:3-walled defect 2.5 mm defect depth and group 4:3-walled defect 5.0-mm defect depth. In 2,3 and 4. group defects were created in the vestibule walls. In determining the morphology of periimplant defects reference studies based on Monje *et al.* were taken into account in *Table 1.*[14]

At the each of groups, after placement of the implants (n=14) (SLA surface, conical geometry, V-shaped, 3.5 x10 mm; Nucleoss T6, İzmir/ Türkiye) from the mesial, distal, palatal vestibule surfaces of each implant, Penguin TM device (MultipegTM; Penguin Integration Diagnostics, Gothenburg, Sweden) made 4 consecutive ISQ measurements.

The mean of the four values was calculated as the final ISQ of each implant. All data were analyzed using descriptive methods. A two-sample t-test was used to compare the mean differences between the two groups. The Wilcoxon rank sum test and Kruskal–Wallis test were used to analyze non-parametric data. To compensate for multiple testing situations, the Mann–Whitney U-test was applied, and p-values were corrected using the Bonferroni adjustment procedure and compared with an alpha level of 0.05. All statistical analyses were conducted by using SPSS version 21 software (SPSS, Chicago, IL, USA)

Table 1. Distribution of study groups

Defect Depth Type of defect	Group 1: Control	Group 2: Depth :1.5 mm (≤%25 of implant length)	Group 3: Depth:2.5 mm (≤%25-50 of implant length)	Group 4: Depth :5 mm (≥50 of implant length)
No Defect	n= 14	-	-	-
There walls	-	n=14	n=14	n=14

Figure 1: a: Preparation of implant bed, b: Implant placement, c: ISQ measurement with Ostell Penguin TM (MultipegTM; Penguin Integration Diagnostics, Gothenburg, Sweden), d: Experimentally created periimplantal defect with 3 wall depth 2. 5 mm, e: Experimentally created periimplantal defect with 3 wall depth 3. 5 mm, f: Experimentally created periimplantal defect with 3 wall depth 5 mm.

Table 2. Statistical Comparison of the control and bone defects score of ISQ Among the Four Groups

	Total (n=56)	Group 1 (n=14)	Group 2 (n=14)	Group 3 (n=14)	Group 4 (n=14)	p value
Ostell	72.28±4.53	74.68±1.9^{a}	74.29±1.87^{ac}	74.75±1.64^{ace}	65.39±2.97^{bde}	0.0001

Results are expressed as mean – standard deviation.
There are no significant differences between the averages shown with the same letter in the same row (Tukey's HSD).

Results

The ISQ value measurement methodology was developed using the average of four ISQ measurements taken from various surfaces of each sample (mesial-distal, palatinal, and lingual). The results of the ISQ measurements are displayed in Table 2, according to statistical assessments.

There were no statistically significant differences between Groups 1, 2, and 3. There was a statistically significant difference between group 4 and all other groups ($p<0.001$).

Discussion

Implant stability is primarily determined by bone-implant contact, which has been noted in numerous studies. Although a connection exists between the degree of bone-implant contact (BIC) and ISQ scores, this connection is not well understood.[8,15] Some researchers suggest that there is no direct relationship between BIC and ISQ scores because the viscoelastic structure of the alveolar bone makes it difficult to predict how the bone will react to mechanical stimulation. Additionally, it should be remembered that the BIC may also be impacted by the bone's mineral density and histological structure. Studies have revealed, for instance, that cortical bone makes a greater contribution to ISQ values than spongiosum bone.[16,17]

Ito *et al.* evaluated RFA scores in defects at different depths, which represent different amounts of bone loss. The findings of this study indicated that the most substantial reduction in RFA occurred when the screws in the implants' most coronal regions were loosened, whereas there was no discernible difference when the screws in the implants' more apical regions were loosened.[8]

Shin *et al.* examined the impact of the defect type and depth on implant stability. The cortical bone thickness in the current investigation ranged from 2.7 to 3.18 mm, and circumferential defects between 2.5 and 5 mm were produced around the implant. The ISQ values in the 5 mm defects were found to be substantially lower than those in the control and 2.5 mm defects. These results led the author to the conclusion that implant stability and ISQ values are decreased by cortical bone loss.[18]

In a cadaveric study, Turkyilmaz *et al.* found a linear association between the development of vertical defects and the loss of bone around implants.[19]

In the current study, 3 walled bone defects of four different sizes were created to represent different amounts of bone loss (bone destruction was experimentally created from the vestibule). The study's findings showed that for every 1 mm change in the ISQ score, there was an average decline of 2.7 mm. Loss in the first 2 mm of the coronal bone led to a significant decrease.

The morphological features of periimplantal defects have been extensively investigated in previous studies.[20-22] One of the first studies on this subject was by Schwarz *et al.* They described the periimplantitis defect configuration[23] Then Monje et al modified it. In this study, we used the classification proposed by Monje *et al.* The classification is as follows:

Class I: Infraosseous defect Class Ia: Buccal dehiscence,

Class Ib: 2-3 walls defect, Class Ic: Circumferential defect,

Class II: Supracrestal/horizontal defect,

Class III: Combined defect; 2-walled, 3-walled, peripheral bone defects have been observed. In addition, Monje *et al.* determined that the defects originating from periimplantitis were mostly in the 3-walled Clas1b type.[14]

The minimum ISQ score was used for osseointegration. According to studies by Sennerby and Meredith, loading implants requires a minimum ISQ value of 65, and ISQ values lower than 45 are highly likely to result in loss of osseointegration.[24]

Three limitations of the current study were previously planned ex vivo. These results included one type of bone: a cow-bone-like type 3 bone. If we study different types of bones, the results of the study could be different from those of the current study. Second, we only investigated the defects of the three walls. Within the scope of this study, other periimplantal defects weren't included in the study. Implant stability was determined using only one parameter. If we had one more parameter for implant stability measurement, the results of this study would be more powerful.

Conclusions

If the depth of the periimplant defect is equal to or higher than ½ of the total implant length, the RFA scores significantly decreased, and the risk of losing the implant increase.

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Conflicts of Interest Statement

The authors declare that they have no conflicts of interest.

Author Contributions

Protocol development: TEK.
Data collection and analysis: TEK and OK.
Manuscript preparation: TEK and OK.
Manuscript editing: TEK.

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