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Can Implant Positioning Errors be Detected by Primary Stability Measurements?

İmplantların Yerleşim Hataları Primer Stabilite Ölçümü ile Saptanabilir mi?

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ABSTRACT Objective: The aim of this study is to investigate the in vitro effects of improper implant insertion on the primary stability. **Material and Methods:** 75 dental implants were inserted 1.5 mm above the crestal level on 5 bovine bone ribs. At this stage, resonance frequency analysis (RFA) and periotest values were measured. Subsequently, the implants were fully placed. RFA and periotest measurements were repeated. The differences between 2 measurements for RFA and periotest was statistically analyzed with paired sample t-test. The correlation between the ISQ and periotest values were analyzed using Pearson correlation test at a significance level of $p<0.05$. **Results:** The primary stability of fully installed implants were found to be significantly higher than that of the improperly inserted implants both in terms of ISQ and periotest values ($p<0.01$). **Conclusion:** The findings of this in vitro study indicate that it is impossible to achieve perfect primary stability with implants in cases where they are improperly inserted in their recipient sites. As such, a drawback is most likely to occur when flapless surgery is preferred, it may therefore be advised to adopt more accurate and precise techniques.

Keywords: Dental implant; dental implantation; surgical flap

ÖZET Amaç: Bu çalışmanın amacı; tam olarak yerleştirilmeyen implantların primer stabiliteye olan in vitro etkilerinin incelenmesidir. **Gereç ve Yöntemler:** Beş adet dana kaburgası üzerine 75 dental implant kret seviyesinden 1,5 mm yukarıda olacak şekilde yerleştirilmiştir. Bu aşamada implantların rezonans frekans analizi (RFA) ve periotest değerleri ölçülmüştür. Daha sonra implantlar tamamen yerleştirilmiştir. RFA ve periotest değerleri ölçümleri tekrarlanmıştır. RFA ve periotest ölçümlerinin 2 değeri arasındaki farklar bağımlı örneklem t testi ile istatistiksel olarak incelenmiştir. ISQ ve periotest değerleri arasındaki korelasyon $p<0.05$ önemlilik düzeyinde Pearson korelasyon testi ile incelenmiştir. **Bulgular:** Tam yerleştirilmiş implantların primer stabilitesinin hem ISQ hem de periotest değerleri bakımından uygun yerleştirilmeyen implantlara göre anlamlı olarak daha yüksek olduğu bulunmuştur ($p<0,01$). **Sonuç:** Bu in vitro çalışmadan elde edilen bulgulara dayanarak, implantların yuvalarına tam olarak yerleştirilmediği durumlarda primer stabilitenin tam olarak elde edilemeyeceği görülmektedir. Flepsiz cerrahi tercih edildiğinde, bu durumla kolaylıkla karşılaşılabileceği için daha hassas ve net yöntemler kullanılması tavsiye edilebilir.

Anahtar Kelimeler: Diş implantı; diş implantasyonu; cerrahi flep

The treatment of partial and complete edentulous patients with dental implants has become a popular prosthetic treatment alternative, with proven long-term clinical success. Implant stability following surgical operation is called "primary stability" and reported as a prerequisite for osseointegration.[1,2]

As known, two implantation techniques are available. The first of these is the conventional method through which the surgical region is seen by removing the flap. The other technique is flapless surgery, which is the process of implantation on alveolus crests with adequate bone thickness and height, within the limits of the anatomical structures and without cutting the soft tissue or removing the muco-periosteal flap. When this technique is applied during an operation, osteotomy is only

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implemented on the regions where the implants are to be placed, which is followed by placing the implants and mounting the healing caps. Some authors, on the other hand, suggest osteotomy after using a punch to remove a piece of soft tissue with a size equal to implant diameter.[3-6] The main objective of this technique is to place the implants with minimum invasion and without cutting or suture.[7]

Today, stents are regarded as the golden standard for flapless surgery technique.[8,9] However, both in clinical practice and in relevant studies carried out in recent years, it has been shown that not only angular but also three-dimensional deviations occur on the post-operational positions of implants placed by relying on stents.[10-15] In cases of implantation without removing the flaps and therefore without fully seeing the operational region, implants can easily be placed on an excessively buccal, lingual, mesial or distal position, or might not be placed in the housing appropriately.

The aim of this study is to investigate the effect of the installation depth during flapless implant surgery on primary stability.

MATERIAL AND METHODS

In the study, a total of 75 dental implants (Nobel Replace Conical Connection PMC 4.3/11.5, Nobel Biocare, Gothenburg, Sweden) were placed on 5 bovine bone ribs freshly taken from a butcher store. Dental implants were installed into bone at equal distances from each other, first by hand and then with the help of a ratchet with a torque of 25 N/cm^2, after the holes were opened in accordance with the surgical protocol recommended by the manufacturer (Figure 1). During the installation process, first each implant was embedded 1.5 mm above the bone level. At this stage, resonance frequency analysis (RFA) (Osstell, Gothenburg, Sweden) and Periotest (Periotest Classic, Medizintechnik Gulden, Germany) were measured separately by four different examiners. Prior to RFA measurements, pegs (Smartpeg, Osstell, Gothenburg, Sweden) were placed by each examiner (Figure 2). The measurements were performed once in parallel and once perpendicular to the length of the ribs, and the average of these two results were recorded as a single implant stability quotient (ISQ) value.

After demounting the peg from the relevant implant, a gingiva former (Nobel Biocare, Gothenborg, Sweden) was screwed into the implant and periotest measurement was performed by each examiner (Figure 3). Periotest measurements were also performed once in parallel and once perpendicular to the length of the ribs, and the average of these two results were recorded as a single periotest value.

After completing the measurements, the implants were embedded into bone with the help of the ratchet with a torque of 25 N/cm^2 into their final position. At this stage, RFA and Periotest measurements were performed again and the corresponding values obtained from each examiner were recorded.

FIGURE 1: Performing osteotomy by implant drill.

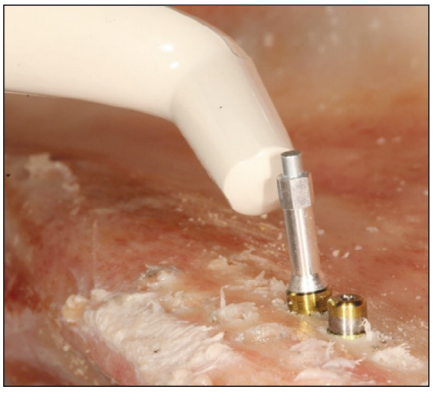

FIGURE 2: The resonance frequency analysis measurements with osstell.

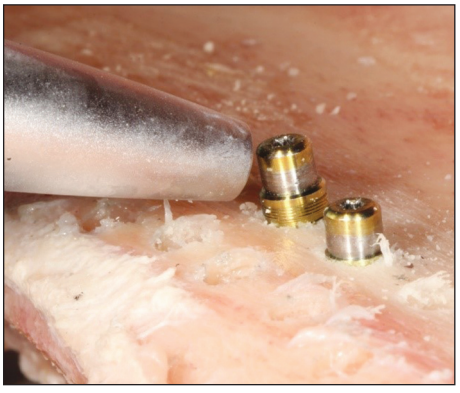

FIGURE 3: Periotest measurement.

STATISTICAL ANALYSIS

The assessment of the data found in the study was carried out with SPSS (Statistical Package for Social Sciences) for Windows 15.0 (Microsoft Corporation, USA). The differences in the ISQ and Periotest values between the fully and not fully installed implants were compared using paired sample t-test. The correlation between the ISQ and Periotest values were analyzed using Pearson correlation test at a significance level of $p<0.05$.

RESULTS

The average ISQ values of fully-installed implants were found to be significantly higher than those of not fully-installed implants ($p<0.01$) (Table 1). The average Periotest values of fully-placed implants measured with Periotest were found to be significantly lower than those of not fully-installed implants ($p<0.01$) (Table 1). The correlation between the ISQ and Periotest values were negative both for fully ($r=-0.475$, $p=0.001$) and not fully-installed ($r=-0.326$, $p=0.004$) dental implants (Table 2).

TABLE 1: PTV and ISQ assessment of fully and not sufficiently inserted implants.

	Stability		
	Not sufficiently inserted	Full inserted	p
	Avg±SD	Avg±SD	
ISQ	49.94±2.75	53.87±2.70	0.001**
PTV	-2.63±1.65	-4.97±1.40	0.001**

Paired sample t-test;**p<0.01.
ISQ: Implant Stability Quotient; PTV: Periotest value.

TABLE 2: PTV-ISQ correlation for not sufficiently inserted and fully placed implants.

	ISQ-PTV	
	r	p
Not sufficiently inserted	-0.326	0.004**
Full inserted	-0.475	0.001**

r: Pearson correlation coefficient; **p<0.01.
ISQ: Implant Stability Quotient; PTV: Periotest value.

DISCUSSION

One of the most important factors affecting the long-term success of dental implants is osseo-integration. Primary stability, which is the stability exhibited by the implants immediately after placement, plays a key role in osseointegration.[2] The most common method to measure implant stability today is RFA.[1,16] It has been noted that RFA offers objective results for the measurement of primary stability, in addition to serving as a very useful method observing the changes in implant stability not only during the placement process but also during the recovery period and so on.[17]

Although RFA values were obtained in Hertz in the early times when RFA technique was newly developed, they were later converted to ISQ with the further development of the technique. ISQ values vary between 1 and 100, and lower values stand for weaker stability, whereas higher values show that better stability has been achieved.[18] Periotest is a measuring device used for assessing the osseo-integration of dental implants and the diagnosis of natural teeth due to periodontal deterioration. The value obtained from Periotest varies between -8 and +50 and a lower result stands for higher stability.

Today, there is a tendency towards performing intra-oral surgery as simply as possible and without damaging the adjacent tissues. Therefore, it has been suggested that dental implants should be placed by employing the flapless technique.[19] However, it has been noted that the flapless surgery technique, which is regarded as a blind surgical method, may result in perforation on the cortical bone due to the difficulty of predicting the shape and the curving of the alveolar bone.[20] It has also been reported that the flapless surgery technique should not be employed in suspicious cases where the width of alveolus may not be

sufficient.[8] Besides, it is recommended that a stent should be prepared in order to place the implants in their proper positions and to avoid the possibility of damaging anatomic structures such as the maxillary sinus and the mental foramen, as well as employing computer-aided navigation techniques, which have recently become a golden standard for dental implant treatment.[11] However, although navigation systems are considered as reliable, there are also studies showing that there may be minimal differences between the planned position of an implant and its final position after placement.[12,21] Such a minimal difference may seem as an angular difference and/or may result in the implant being on an excessively buccal, lingual, mesial or distal position, or even make the implant seem left in an excessively deep or outer position. Such cases may result in various problems aesthetically or mechanically, either in the short term or in the long run. Besides, it is possible in such cases that anatomic structures may get damaged. Placing the implants in an excessively deep or outer position may also bring along peri-implantary problems on the long run. On the other hand, whether the implants have been fully placed in the holes or not may easily go unnoticed during surgical interventions when the operational area cannot be fully seen, which may result in the implant being left out of the target housing.

According to the findings of this study, the primary stability value of an implant not fully placed in its hole is significantly lower than the value that can be achieved under normal conditions. On the other hand, screwing the implants until their final tightness degree without seeing the implants fully cannot guarantee their placement in the right position, especially while working on bones such as type-4. This *in vitro* study shows that the desired level of primary stability cannot be achieved completely in cases where the implants have not been fully placed in their holes.

CONCLUSION

It should be taken into consideration that complications mentioned hereby may be encountered when the flapless surgery technique is employed for placing the implants. It is in the wake of this study that the flapless surgery technique should be abandoned especially in presence of an excessively thick mucosa and auxiliary techniques to minimize the margin of error.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Hakan Bilhan, Onur Geçkili;* ***Design:*** *Canan Bural, Altuğ Çilingir;* ***Control/Supervision:*** *Hakan Bilhan;* ***Data Collection and/or Processing:*** *Gökçen Ateş, Aliye Ceren Ürgün;* ***Analysis and/or Interpretation:*** *Çağlar Bilmenoğlu, Gökçen Ateş;* ***Literature Review:*** *Çağlar Bilmenoğlu;* ***Writing the Article:*** *Çağlar Bilmenoğlu, Gökçen Ateş;* ***Critical Review:*** *Canan Bural.*

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