치의과학석사 학위논문

Correlation of Two Different Devices for the Evaluation of Primary Implant Stability Depending on Dental Implant Length and Bone Density: An in vitro Study

치과 임플란트 길이와 골밀도에 따른 임플란트 초기 안정성 평가를 위한 서로 다른 장치의 측정값 상관관계: 실험실적 연구

2023년 8월

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이정원의 석사학위논문을 인준함
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Abstract

1. Introduction

Non-invasive objective implant stability measurements are needed to determine the appropriate timing of prosthetic fitting after implant placement. We compared the primary implant stability results obtained using resonance frequency analysis (RFA) and damping capacity analysis (DCA) depending on the implant length and bone density, and analyzed inter- and intra-observer reliability of the two methods.

2. Materials and methods

Total 60, 4.0 mm diameter implants of various lengths (7.3 mm, 10 mm, and 13 mm) were used. Groups 1 and 2 had implants placed in an artificial bone model with a uniform density of 15 PCF (0.24 g/cm3) and 30 PCF (0.48 g/cm3), respectively. RFA was performed using an Osstell® Beacon+; DCA was performed using Anycheck®. Measurements were repeated five times for each implant. Statistical significance was set at P <0.05.

3. Results

In Group 1, bone density and primary implant stability were positively correlated, while implant length and primary implant stability were positively correlated. In Group 2, the ISQ and IST values in did not change significantly above a certain length.

4. Conclusion

Primary implant stability was positively correlated with bone density and improved with increasing implant length at low bone

densities. Compared with the Osstell® Beacon+, the simplicity of Anycheck® was easy to use and accessible.

Keywords: primary implant stability; resonance frequency analysis; damping capacity analysis; low-density bone; implant length

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Chapter 1. Introduction

The healing period required after implant placement depends on the patient's condition (e.g., pre-existing systemic disease, bone quality, and periodontal status). After implant placement, the stability should be monitored periodically to reduce unnecessarily long visits and prevent premature loading of under-healed implants. Therefore, non-invasive and objective implant stability measurements after placement are necessary to determine the appropriate time of prosthetic loading for an individual.

Implant stability, an indirect indicator of osseointegration, is a measure of the clinical im-mobility of an implant [1]. Adequate implant stability promotes bone formation after implant placement [2] and influences load distribution during occlusion after prosthetic treatment [3]. Primary implant stability refers to mechanical bone engagement and can be influenced by factors such as bone quantity and quality, implant characteristics at the implant site, and the operator's implant placement technique. Secondary implant stability refers to the biological attachment to the bone and can be affected by certain factors such as bone formation and bone remodeling at the implant-tissue interface and surrounding bone [4].

Non-invasive implant stability evaluation methods include radiographic evaluation, percussion tests, and insertion torque. Radiographic evaluation is a non-invasive method that can be performed at any stage of healing. However, several issues remain unresolved. Radiographic photographs are distorted, making them less accurate for evaluating the condition of the implant [5]. Owing

to the low incidence of implant failure, changes in radiographic bone levels alone cannot accurately predict implant stability [6].

Percussion tests are subjective and require extensive experience from a dentist. The insertion torque measurement is used to evaluate a patient's bone quality and implant stability using the injection rotational force of the implant. Although this method can be used as a relatively objective indicator, regular observation at the post-implantation stage is difficult, and lateral and longitudinal mobility cannot be assessed.

An objective method to measure implant stability is resonance frequency analysis (RFA), which evaluates the stability of implants using sinusoidal signals and small transducers, as introduced by Meredith et al. [7]. Representative measuring equipment included the Osstell ISQ and Osstell® Beacon. Osstell is used to tighten a magnetic Smartpeg coated with zinc on an ingrained implant. Using of a turning fork, magnetism is sent to the Smartpeg to obtain resonant vibration and osseointegration between the implant and alveolar bone is measured indirectly. The Implant Stability Quotient (ISQ) is recorded between 1 and 100. An ISQ value of <60, between 60 and 69, and >70 indicates low stability, moderate stability, and high stability, respectively. The higher the ISQ, the greater the implant stability.

Although this method does not physically affect the implants or alveolar bones, it cannot measure direct longitudinal or lateral perturbations. A separate instrument (Smartpeg) is required, and there is risk and inconvenience in releasing the healing abutment for measurement purposes. There is a disagreement regarding the optimal torque for tightening the Smartpeg for RFA. Subjective finger pressure during hand tightening Smatpeg could affect the

reliability of the resulting value [8, 9]. Therefore, alternative methods are required to compensate for these shortcomings.

The Damping Capacity Analysis (DCA) is another objective method used to measure implant stability. In this technique, a certain amount of force is mechanically applied to the implant post and the fluctuation of the implant in both the longitudinal and lateral directions is measured. A typical measurement device is the PerioTest M. Measured values from the PerioTest are affected by the angle of impact and high strength of the blow, and the number of blows is high (16 times) causing a feeling of rejection in the patient. In addition, the PerioTest has low reliability [10]. The recently developed modified damping capacity analysis device (Anycheck®, Neobiotech Co., Ltd., Seoul, Korea) is highly reproducible and can be measured by direct contact with the object by improving the striking method [11]. This device evaluates the osseointegration between the implant and alveolar bone by measuring the time the striking rod (head) comes into contact with the implant or abut-ment. The measurement result is called the Implant Stability Test (IST) value and is expressed as a number ranging from 1 to 99. The IST numbers are in red from 1 to 59, in orange from 60 to 64, and in green from 65 to 99.

One of the challenges in implant placement is the quality of alveolar bone and critical anatomical structures. The quality of D4 bone density is generally described as poor because it is soft and it is difficult to obtain primary stability from implants [12]. Low-density bone implant sites have been reported as the greatest potential risk factor for implant loss when working with standard bone-drilling protocols [13]. Previous studies have reported a significant difference in primary implant stability in bone densities between D2

and D4 [14]. For this reason, research is ongoing to compensate for poor primary stability at low bone density. Primary implant stability increases with a larger implant diameter because the contact area between the implant and the bone increases [15]. In this study, we aimed to compare the changes in primary implant stability by varying the length rather than the diameter of the implant.

This study primarily aimed to compare the values obtained using two different devices for primary stability depending on the dental implant length and artificial bone density and to investigate the correlation of results from the two devices. The secondary aim was to analyze the inter- and intra-observer reliabilities of the two devices.

Chapter 2. Materials and Methods

2.1 Preparation of artificial bone blocks and dental implants

In this study, 4.0 mm diameter internal connection type implants (IS-III Active, Neobiotech, Seoul, Korea) of various lengths (7.3 mm, 10 mm, and 13 mm) were used (Figure 1). Polyurethane bone models (Sawbones; Pacific Research Laboratories Inc., Washington, DC, USA) were used to simulate cancellous bone, and the size of the artificial bone block was 130 mm × 90 mm × 40 mm (Figure 2). Two different types of polyurethane bone models were compared: one with a uniform density of 15 PCF (0.24 g/cm3, Group 1) and the other with a uniform density of 30 PCF (0.48 g/cm3, Group 2).

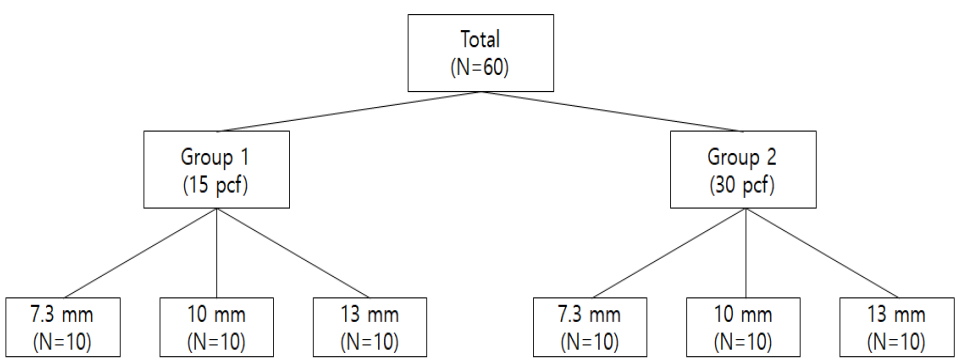

Figure 1. The schematic diagram.

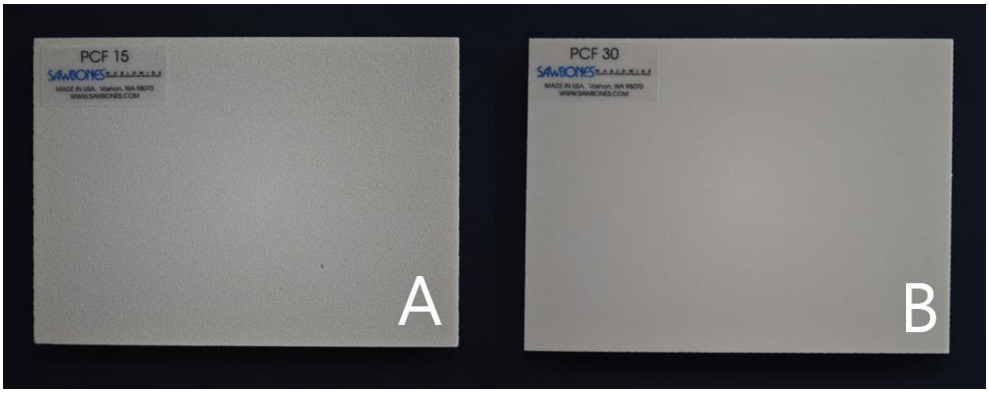

Figure 2. Artificial bone blocks. (A) 15 PCF, (B) 30 PCF.

2.2 Surgical procedure and implant placement

Sixty implants were used, 30 in each group and they consisted of three different lengths (10 implants each): 7.3 mm, 10 mm, and 13 mm. The implant placement site was prepared using two drilling protocols according to the manufacturer's instructions. In Group 1, a 2.2 mm initial drill was used [16], and in Group 2, a 2.2 mm initial drill, final drills of 3.0 mm and 3.5 mm, and a 3.5 mm tap drill were used (Figure 3). Both groups used the Neo Master Kit (Neobiotech, Seoul, Korea) and were drilled at 1,200 rpm.

Each implant was placed 30 mm apart. All implants used in the study were inserted at a constant depth and angle using a specially designed implant placement and drilling machine (Hangil Technics, Gyeonggi, Korea) (Figure 4 and Figure 5). The insertion torque was kept constant at approximately 18 Ncm for Group 1 and 37 Ncm for Group 2.

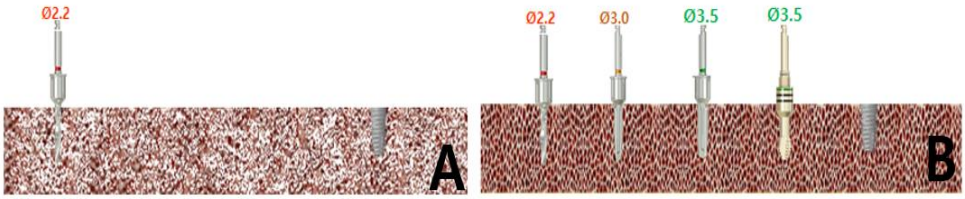

Figure 3. Drilling protocol. (A) Group 1: 15 PCF, (B) Group 2: 30 PCF.

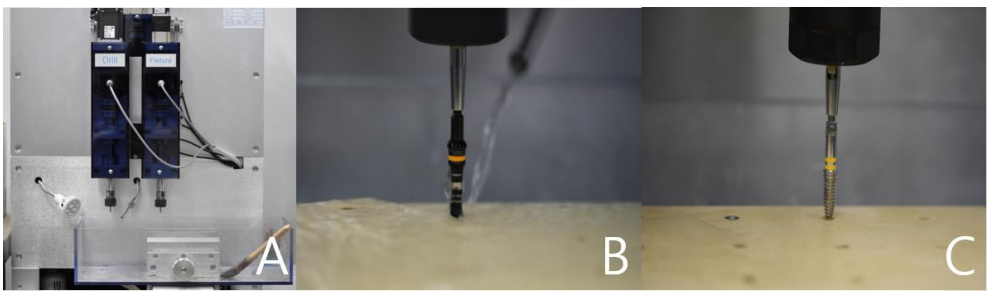

Figure 4. Specially designed implant placement and drilling machine. (A) Implant placement and drilling machine (B) Drilling before implant placement, (C) Implant placement.

2.3. Implant stability measurements

2.3.1. Resonance frequency analysis measurements

The RFA measurements were performed using an Osstell® Beacon+ (Integration Diagnostics, Göteborg, Sweden) (Figure 6). Before the implant stability measurements were made, the bone block was firmly fixed to the vise. A type 5 Smartpeg was fastened to the implant using a plastic mount at 4–6 Ncm by hand tightening, according to the manufacturer's instructions. Measurements were performed in four directions (three times in each direction) at a distance of 3–5 mm and at an angle of 45°, and the ISQ measurements were averaged in the four directions for each implant (Figure 7). This procedure was repeated five times [17].

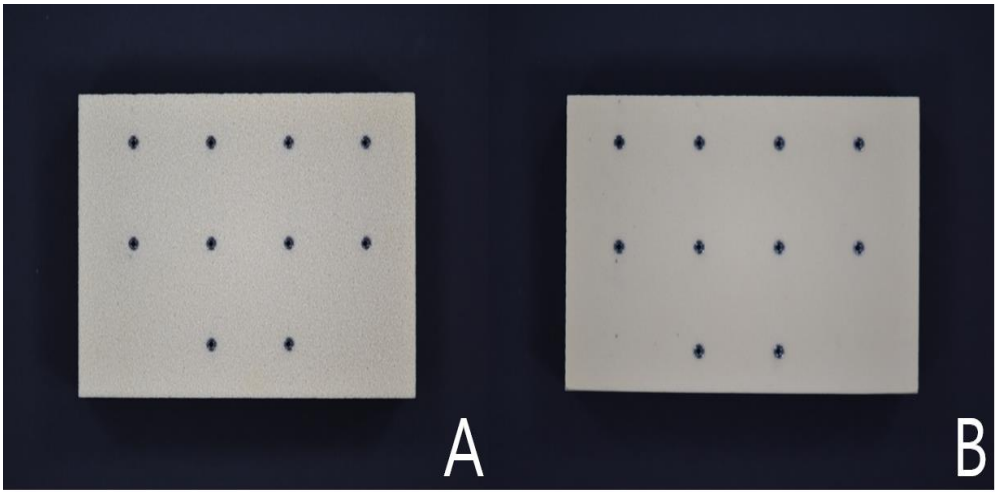

Figure 5. Artificial bone blocks with fixture installed. (A) Group 1, (B) Group 2.

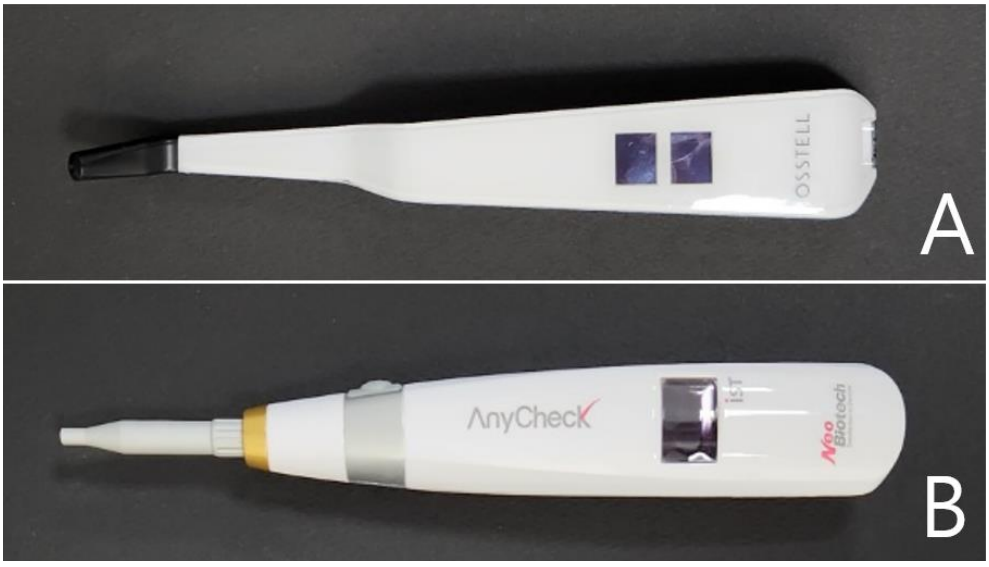

Figure 6. Implant Stability Measurement Devices. (A) Osstell® Beacon+ , (B) Anycheck®.

2.3.2. Damping capacity analysis measurements

The DCA was performed using Anycheck® (Neobiotech, Seoul, Korea) (Figure 6). For the measurements, a Ø4.8 × 4 mm healing abutment was tightened with a constant force of 10 Ncm using a torque ratchet and torque wrench. A 10° jig was made using a

polyvinyl siloxane impression material (putty) to maintain a constant upward angle of 0° to 30° with respect to the ground following the manufacturer's manual. Five replicates were recorded as the average IST values measured in two implant directions (Figure 7).

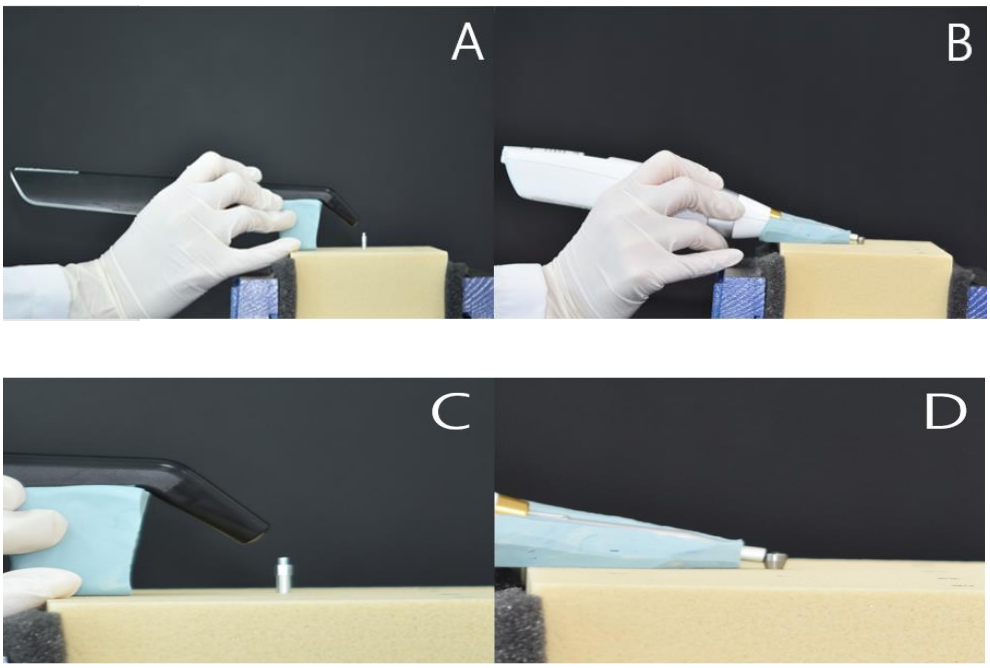

Figure 7. Primary Implant Stability Measurement. (A) Osstell® Beacon+ , (B) Anycheck® (C) Contactless Measurement with Osstell® Beacon+ (D) Contact measurement with Anycheck®.

2.3.3. Intra- and inter-observer reliability

The intra-observer reliability is related to the concordance of the ISQ and IST values of repeated measurements performed by one observer for the same implant. The inter-observer reliability is related to the concordance of the ISQ and IST values obtained by three observers for the same implant. The observer consisted of two experts and one non-expert.

2.4. Statistical analysis

A paired t-test was performed to verify whether the ISQ and IST values of the two bone densities (Groups 1 and 2) demonstrated a significant difference. Simple linear regression analysis was also applied to assess the effect of bone density (15 PCF and 30 PCF) on ISQ and IST values. One-way ANOVA was performed to verify that the ISQ and IST values of the three implant length (7.3 mm, 10 mm, and 13 mm) reported a significant difference. Simple linear regression analysis was also applied to assess the effect of the implant length (7.3 mm, 10 mm, and 13 mm) on the ISQ and IST values. In addition, reliability analysis was conducted to determine the internal consistency and inter-observer consistency of observers 1, 2, and 3 of Osstell® Beacon+ in RFA and Anycheck® in DCA.

The reliability was determined by calculating Cronbach's alpha. A Cronbach alpha coefficient of 0.6 to <0.7, 0.7 to <0.8, and >0.8 are considered to attain an acceptable, good, and excellent confidence level. Simple linear regression analysis was used to confirm the correlation between the ISQ and the IST value. All calculations were conducted using SPSS software (version 25, SPSS), and significance was defined as P <0.05.

Chapter 3. Results

3.1. Effect of bone density

The difference in primary stability depending on bone density is illustrated in Figure 8.

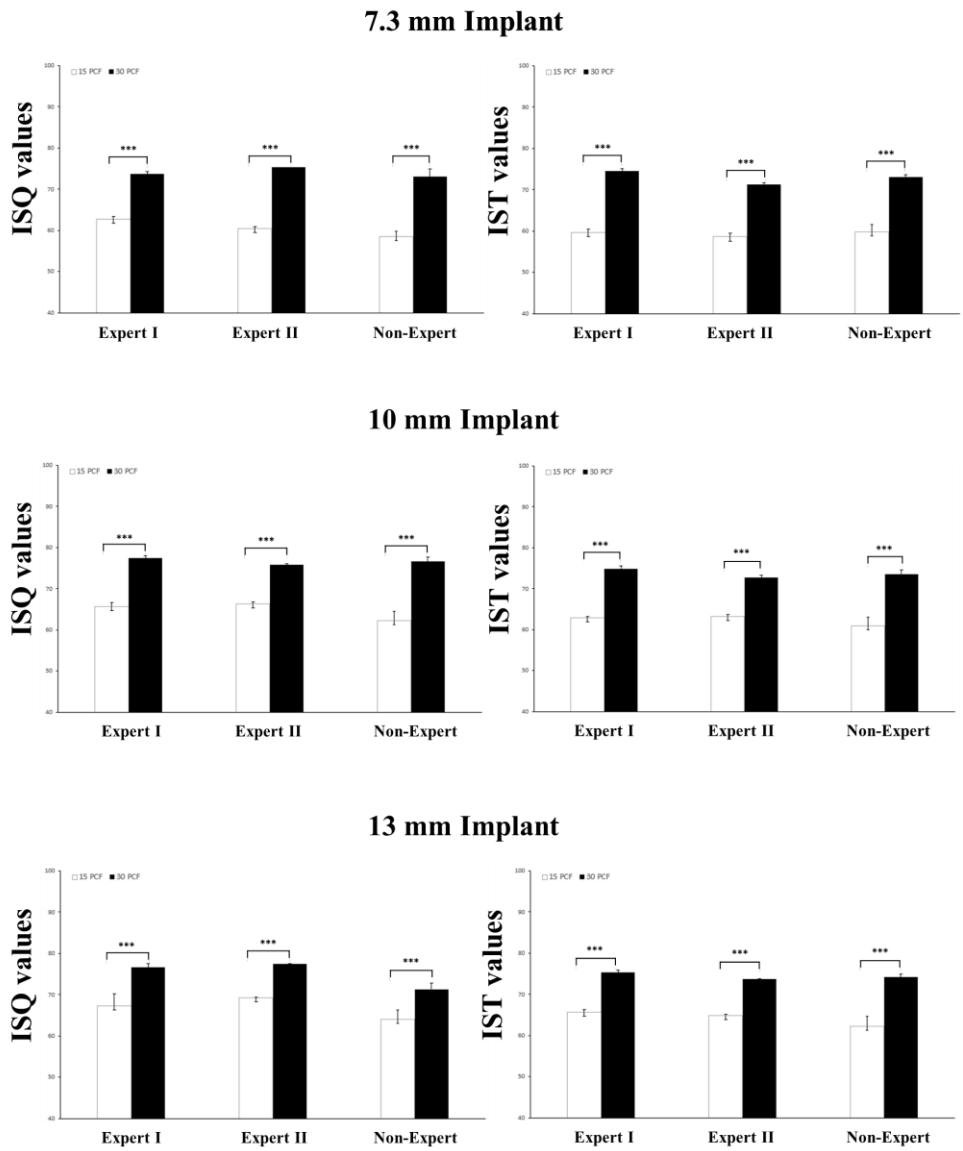

Figure 8. The Implant Stability Quotient and the Implant Stability Test value depending on density. *** P <0.001.

The difference in ISQ value according to bone density was as follows: In the artificial bone block with 7.3 mm implants, in Group 1, the mean for each expert was 62.75 and 60.52, and 58.51 for the non-expert. In Group 2, with medium density, the mean for each expert was 73.69 and 75.28, and 73.02 for the non-expert, with a significant difference between the two groups (P <0.001). At 7.3 mm, the correlation coefficient (R) between bone mineral density (BMD) and the ISQ value was 0.995, 0.999, and 0.978 for experts I and II, and the non-expert, respectively. In the artificial bone block with 10 mm implants, in Group 1, the mean for each expert was 65.64 and 66.40, and 62.27 for the non-expert. In Group 2, the mean for each expert was 77.45 and 75.82, and 76.57 for the non-expert, with a significant difference between the two groups (P <0.001). The correlation coefficient(R) between BMD and the ISQ value at 10 mm was 0.992, 0.998, and 0.972 for expert I and II, and the non-expert, respectively. In the artificial bone block with 13 mm implants, in Group 1, the mean for each expert was 67.35 and 69.30, and 64.08 for the non-expert. In Group 2, the mean for each expert was 76.63 and 77.40, and 71.36 for the non-expert, with a significant difference between the two groups (P <0.001). The correlation coefficient(R) between BMD and the ISQ value at 13 mm was 0.918, 1.000, and 0.891 for expert I and II, and the non-expert, respectively.

The differences in IST value according to bone density were follows: In the artificial bone block with 7.3 mm implants, in Group 1, the mean for each expert was 59.60 and 58.61, and 59.80 for the non-expert. In Group 2, with medium density, the mean for each expert was 74.47 and 71.33, and 73.00 for the non-expert, with a significant difference between the two groups (P <0.001). The

correlation coefficient (R) between BMD and the IST value at 7.3 mm was 0.995, 0.994, and 0.980 for expert I and II, and the non-expert, respectively. In the artificial bone block with 10 mm implants, in Group 1, the mean for each expert was 62.88 and 63.24, and 61.03 for the non-expert. In Group 2, with medium density, the mean for each expert was 74.91 and 72.83, and 73.64 for the non-expert, with a significant difference between the two groups (P <0.001). The correlation coefficient (R) between BMD and the IST value at 10 mm was 0.996, 0.995, and 0.971 for expert I and II, and the non-expert, respectively. In the artificial bone block with 13 mm implants, in Group 1, the mean for each expert was 65.73 and 64.91, and 62.25 for the non-expert. In Group 2, with medium density, the mean for each expert was 75.33 and 73.68, and 74.14 for the non-expert, with a significant difference between the two groups (P <0.001). The correlation coefficient (R) between BMD and the IST value at 13 mm was 0.994, 0.999, and 0.962 for experts I and II, and the non-expert, respectively.

As presented in Figure 9 and Table 1, bone density is highly correlated with primary implant stability at all lengths. The regression coefficient significance test revealed a significant positive correlation between bone density and primary implant stability. Therefore, the higher the bone density, the higher the primary implant stability.

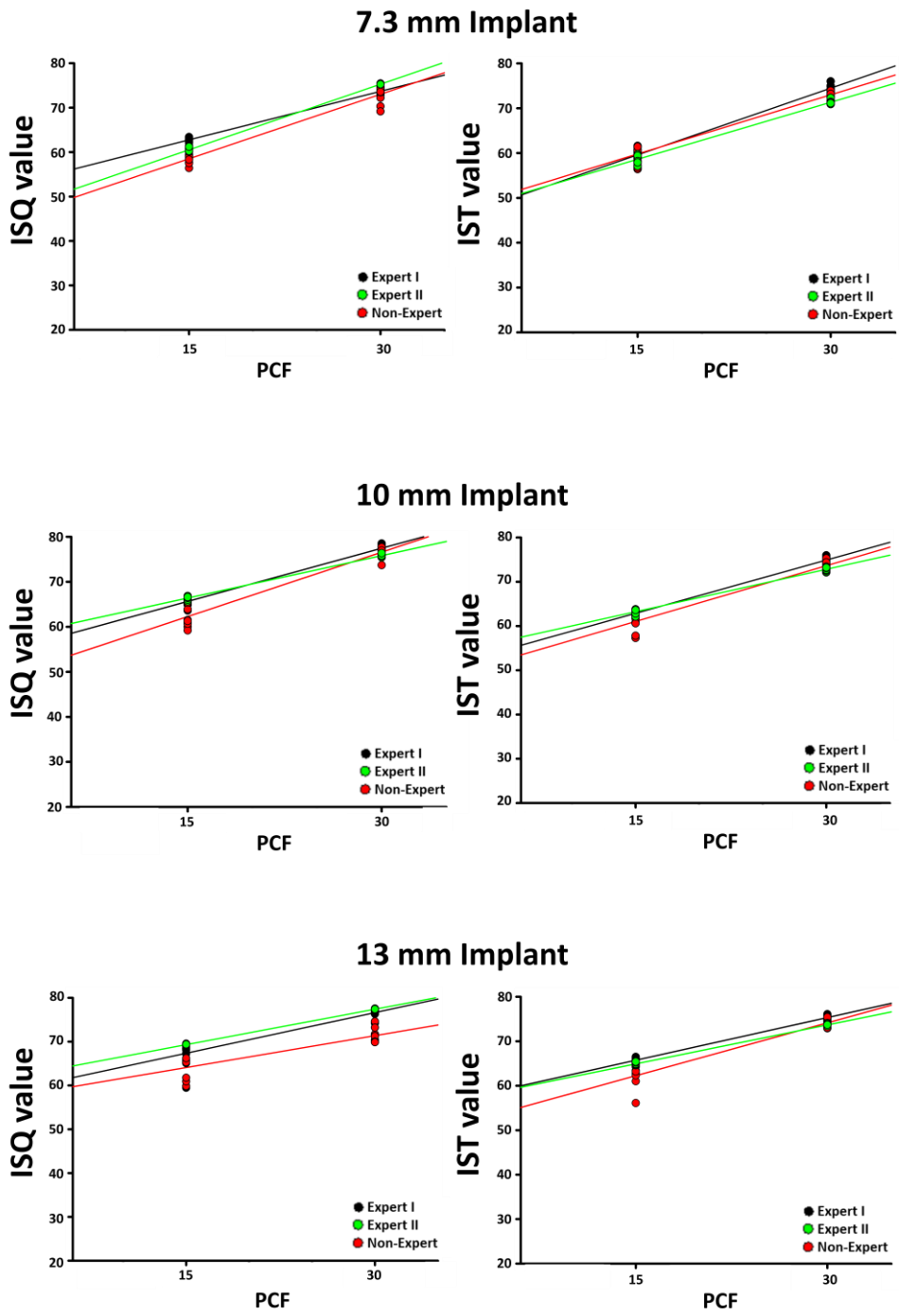

Figure 9. Correlation: The Implant Stability Quotient and the Implant Stability Test value versus bone density.

Table 1. Primary stability depending on density

			7.3mm	10mm	13mm
R^2	ISQ value	Expert I	0.989	0.984	0.842
		Expert II	0.998	0.996	0.999
		Non-Expert	0.956	0.944	0.793
	IST value	Expert I	0.990	0.992	0.988
		Expert II	0.988	0.990	0.998
		Non-Expert	0.961	0.944	0.925

R: Correlation Coefficient; ISQ: Implant Stability Quotient; IST: Implant Stability Test

3.2. Effect of implant length

The difference in ISQ value according to the implant length is presented in Figure 10. In Group 1, Low-density, there was a significant difference between 7.3 mm and 10 mm, and between 7.3 mm and 13 mm for expert I (P = 0.0032, P <0.0001). There was no statistically significant difference between 10 mm and 13 mm; however, the ISQ value increased with length. For expert II, there was a significant difference among all lengths (P <0.0001). For the non-expert, there was a significant difference between 7.3 mm and 10 mm, and between 7.3 mm and 13 mm (P = 0.008, P <0.0001). There was no statistically significant difference between 10 mm and 13 mm; however, the ISQ value increased with length. In Group 2, which had medium density, there was a significant difference among

all lengths for expert I and II (P <0.05). For the non-expert, there was a significant difference between 7.3 mm and 10 mm, and between 10 mm and 13 mm (P <0.0001).

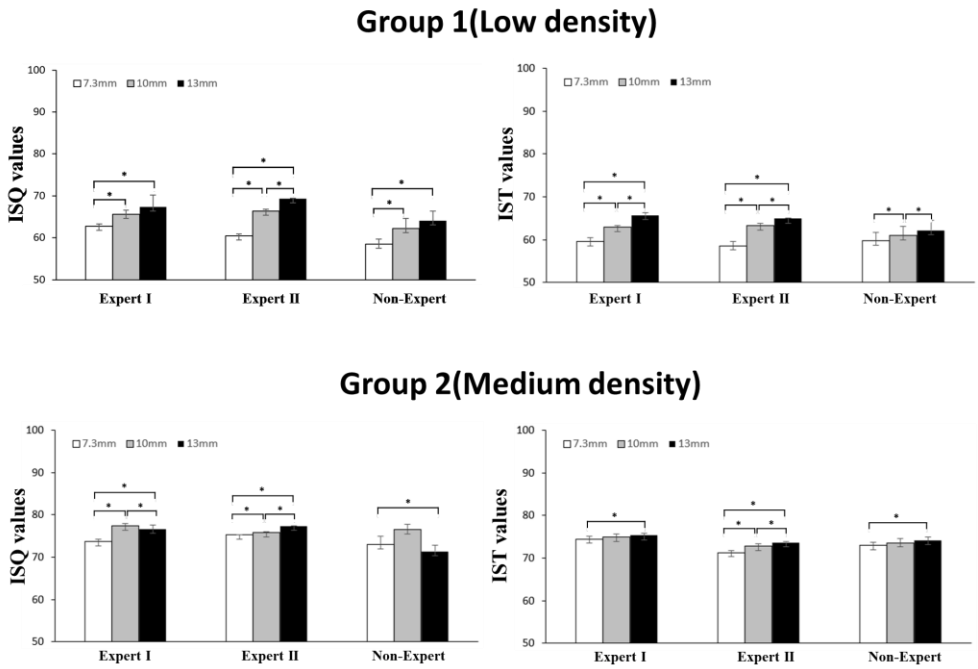

Figure 10. The Implant Stability Quotient and the Implant Stability Test value depending on fixture length. * P <0.05.

The differences in IST value according to implant length are presented in Figure 10. In Group 1, for expert I, the IST value increased with increasing length, with a significant difference between 7.3 mm and 10 mm and between 7.3 mm and 13 mm (P <0.0001). However, between 10 mm and 13 mm, the IST value significantly decreased with increasing length (P <0.0001). For expert II, there was a significant difference among all lengths (P <0.0001). For the non-expert, there was a significant difference between 7.3 mm and 13 mm (P <0.05), however unlike the other observers, the IST value decreased with increasing length. There was no statistically significant difference between 7.3 mm and 10

mm. however, the IST value increased with increasing length. There was no statistically significant difference between 10 mm and 13 mm, however the IST value decreased with increasing length. In Group 2, for expert I, there was a significant difference between 7.3 mm and 13 mm (P = 0.015). There was no statistically significant difference in the other lengths; however, the IST value increased as the length increased. For expert II, there was a significant difference among all lengths (P <0.0001). For the non-expert, there was a significant difference between 7.3 mm and 13 mm (P = 0.011). There were no statistically significant differences between the other lengths; however, the IST value increased with increasing length.

3.3. Correlation between the Implant Stability Quotient and the Implant Stability Test values versus density and fixture length

The changes in the ISQ and IST value with density are presented in Figure 9. For both the Osstell® Beacon+ and Anycheck®, primary implant stability increased with increasing bone density, regardless of implant length.

In Figure 11, in Group 2, the primary implant stability did not display any specific change with increasing implant length; however, in Group 1, the primary implant stability increased with increasing implant length.

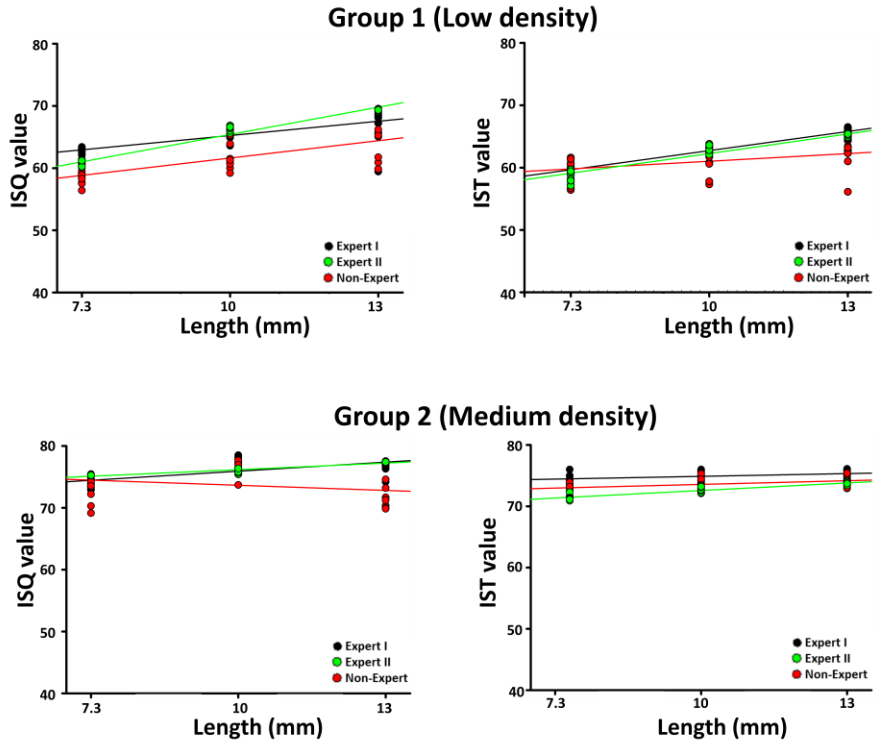

Figure 11. Correlation between the Implant Stability Quotient and the Implant Stability Test value versus fixture length.

Table 2. The Implant Stability Quotient and the Implant Stability Test value depending on fixture length

Group		ISQ			IST		
		Expert I	Expert II	Non-Expert	Expert I	Expert II	Non-Expert
1 (Low density)	R^2	0.547	0.956	0.573	0.941	0.885	0.197
2 (Medium density)	R^2	0.471	0.900	0.066	0.251	0.858	0.264

3.4. Intra- and Inter-observer reliability of devices

The results of the intra- and inter-observer reliability analysis of the Osstell® Beacon+ and Anycheck® using different measurement methods are listed in Table 3.

The intra-observer reliability of the Osstell® Beacon+ and Anycheck® was excellent across all observers.

The Osstell® Beacon+ and Anycheck® had inter-observer reliability of 0.971 and 0.984, respectively, regardless of observer expertise.

Table 3. Intra-observer and inter-observer reliability of devices

	Intraobserver Reliability			Interobserver Reliability
	Expert I	Expert II	Non-Expert	
Osstell® Beacon+	0.996	0.998	0.996	0.971
Anycheck®	0.998	0.998	0.998	0.984

Chapter 4. Discussion

In line with the trend towards continuous monitoring using objective and qualitative methods to determine the status of implant stability, this study analyzed the reliability of measurement devices using RFA and DCA, which are commonly used to measure implant stability in clinical practice. Moreover, an experiment was designed to investigate the trends in the ISQ and the IST value with changes in bone density and implant length.

Previous studies comparing different implant stability measurement devices were performed using pig bones [18, 19]. The use of this particular biological sample can result in variability in bone quality owing to factors such as different bone density, depending on the distribution of heterogeneous bone cells in the cross-section or the site of the specimen [20]. Artificial bones were used to eliminate the confounding variables. Although an artificial bone cannot fully mimic the viscoelastic properties of actual bone tissue, it has the advantage of having the density, size, and shape of bone to be consistent and can be modeled in the most necessary forms. These advantages allowed us to represent the structure of the human cancellous bone as closely as possible [21].

Lekholm and Zarb reported high implant success rate in types 1-3 bone quality, whereas in a type 4 bone with little cortical bone layer, the success rate was low owing to the poor primary stability of the implant, resulting in no osseointegration [22]. Moreover, in a study conducted by Jaffin et al., the fixture failure rate was significantly higher in type 4 bones than in other types of bones [23]. These findings suggest that the bone quality is a major determinant of

fixture loss. Hao et al. reported that the average bone density is the lowest in the maxilla, and the posterior maxilla is composed of D4 with a small cortical bone layer [24]. In this study, a bone block without a cortical bone layer was used to exclude the effect of the cortical bone layer on the primary stability of the implant, and the effect of the cancellous bone block on the primary stability of the implant was compared at a density of 15 PCF (0.24 g/cm3) and 30 PCF (0.48 g/cm3). In the artificial bone blocks without a cortical bone layer, the ISQ and the IST value of Group 2 were significantly higher than those of Group 1. By contrast, an attempt was made to implant the fixture in a bone block of 10 PCF (0.16 g/cm3). Unfortunately, proper implantation torque could not be achieved owing to poor bone quality, resulting in the elimination of the fixture and an inability to perform the experiment.

Baek et al. found that the ISQ value of patients with short implants were not significantly different from those of patients with regular implants, suggesting that the length of the implant did not affect its stability and prognosis [25]. Bischof et al. reported that primary implant stability demonstrated significant differences depending on the bone quality; however, implant diameter and length did not affect the primary implant stability [26].

However, unlike the above studies, there was a significant difference in primary implant stability according to implant length (Figure 10). In the low-density artificial bone block, there appeared to be a positive correlation between implant length and primary implant stability (Figure 11). However, in medium-density artificial bone blocks, there was either no difference or a decrease in the primary implant stability when implants >10 mm were placed. Thus, at low densities, placing longer implants was effective in

compensating for primary implant stability, whereas at medium densities, longer implants were not necessarily beneficial to primary stability. Therefore, at a medium density, it is believed that placing a 10 mm implant is sufficient to achieve primary implant stability. This is because at high bone density, solid bone will hold the implant well regardless of the length of the implant [27]. In contrast, at low bone density, the longer the length of the implant, the greater the contact area of the bone has with the implant, which increases the stability of the implant. In addition, from a biomechanical perspective, many studies have reported that longer implants can lower the crown to implant (C/I) ratio and prevent alveolar bone loss and implant failure [28–30]. Therefore, when performing implant procedures on patients with poor bone quality, it can be expected that the primary stability of the implant will be complemented by the use of longer implants whenever possible.

Implant stability depends on the measurement device, angle, and observer [10]. The sensitivity and reliability of implant stability measurement devices are a topic of increasing interest. Buyukguclu et al. reported that experts with >4 years of experience measured primary implant stability with Osstell ISQ and Penguin RFA using RFA and found Osstell ISQ to be more reliable than Penguin RFA [31]. Lee et al. demonstrated the relative reliability of the Anycheck® device based on the reliability of the Periotest M using the percussive agitation method [11]. In our study, we compared the intra- and inter-observer reliability of Osstell® Beacon+ for the RFA method and Anycheck® for the Modified DCA method using one non-expert and two experts. Both devices demonstrated a good level of reliability; however, the difference in ISQ value was relatively large between the non-expert and experts. This is

because when the Smartpegs were tightened to measure the ISQ value, the non-expert had difficulty applying a constant force and maintaining a constant distance using the contactless measurement method (Figure 7C). In contrast, Anycheck® is a contact measurement method (Figure 7D) and the measurement process is simple, so the difference between the IST value of the non-expert and experts is small. In this study, ISQ value for Osstell® Beacon+ using RFA and the IST value for Anyceck® using DCA displayed similar trends with changes in bone density and implant length, although the value was not consistent among observers (Figures 9 and 11). Therefore, it is crucial that implant stability measurements be performed by the same observer during follow-up appointments rather than relying on a specific measurement device.

This study has several limitations. Although we used artificial bone with the density specified by the International Organization for Standardization (ISO) 1183, we could not perfectly simulate the mechanical properties and clinical conditions of the actual in vivo bone. Furthermore, according to the manual, the most accurate IST value was obtained when the healing abutment and the rod were perpendicular (90°). Therefore, in this study, the jig was made at an angle as close to the vertical as possible to eliminate errors owing to the angular deviation during the measurement. However, in actual clinical applications, vertical measurements are difficult because of the length of the healing abutment and treatment position of patient. Further research is needed on how the ISQ and IST value change with implant length at different densities.

Chapter 5. Conclusions

Within the limitation of this in vitro study,

1. In the artificial bone block, the primary stability of both devices was significantly higher in models with medium bone density, regardless of the implant length and observer.

2. At low bone density, primary stability improved with increasing implant length, whereas at medium density there was no significant difference in primary stability beyond 10 mm. This finding suggests that long implants can be an effective alternative to compensate for the primary stability of implants in patients with poor bone quality.

3. The results from both devices displayed similar trends regardless of bone density and implant length variations, with no differences between the devices.

4. Compared to Osstell® Beacon+, the simplicity of the measurement process makes Anycheck® easy and simple to use, regardless of the observer’s expertise.

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국문초록

치과 임플란트 길이와 골밀도에 따른 임플란트 초기 안정성 평가를 위한 서로 다른 장치의 측정값 상관관계: 실험실적 연구

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1. Introduction

임플란트 식립 후 적절한 보철물 장착 시기를 결정하기 위해서 비침습적이고 객관적인 임플란트 안정성 측정이 필요하다. 임플란트 길이와 골밀도에 따라 공진 주파수 분석법(RFA)과 타격식 동요도 측정법(DCA)을 이용하여 얻은 초기 임플란트 안정성 결과를 비교하고 두 방법의 관찰자 간 및 관찰자 내 신뢰도를 분석하였다.

2. Materials and Methods

다양한 길이(7.3mm, 10mm, 13mm)의 직경 4.0mm 임플란트 총 60개를 사용하였다. 그룹 1과 그룹 2는 각각 15 PCF(0.24g/cm3) 및 30 PCF(0.48g/cm3)의 균일한 밀도를 가진 인공 뼈 모델에 임플란트를 식립하였다. RFA는 Osstell® Beacon+를 사용하여 수행되었고, DCA는 Anycheck®를 사용하여 수행되었다. 측정은 각 임플란트에 대해 5회 반복하였다. 통계적 유의성은 $P<0.05$로 설정하였다.

3. Results

그룹 1에서 골밀도와 초기 임플란트 안정성이 양의 상관관계를 보였고, 임플란트 길이와 초기 임플란트 안정성도 양의 상관관계를 보였다. 그룹 2에서는 임플란트 길이가 일정 길이 이상에서 ISQ 및 IST 값이 크게 변하지 않았다.

4. Conclusions

1차 임플란트 안정성은 골밀도와 양의 상관관계가 있었으며, 낮은

골밀도에서는 임플란트 길이가 길어질수록 개선되었다. Osstell® Beacon+와 비교했을 때, Anycheck®는 사용이 간편하고 접근성이 높았다.

주요어: 초기 임플란트 안정도; 공진 주파수 분석법; 타격식 동요도 측정법; 낮은 밀도 뼈; 임플란트 길이

감사의 글

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