# A Comparison Between Cutting Torque and Resonance Frequency in the Assessment of Primary Stability and Final Torque Capacity of Standard and TiUnite Single-Tooth Implants Under Immediate Loading

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***Purpose:*** *In this study, standard Brånemark System implants and Brånemark TiUnite implants were evaluated regarding primary stability and placement torque. The correlation between placement torque and primary stability as well as the influence of implant design on placement torque and primary stability were examined.* ***Materials and Methods:*** *Twelve patients who presented bilateral loss of either maxillary lateral incisors or premolars were treated with 24 immediately loaded dental implants. Each patient received 1 standard 3.75 × 13-mm Brånemark System implant and one 3.75 × 13-mm TiUnite Mk III implant. One at a time, each implant was connected by a transducer to an Osstell machine that automatically translated a resonance frequency value for the implant into an implant stability quotient value. Osseocare equipment was used to measure the placement torque for both types of implants.* ***Results:*** *Statistical analysis showed higher mean values for standard implants in relation to placement torque and resonance frequency values.* ***Discussion:*** *There was no overall correlation between placement torque and resonance frequency values; this finding supported previous studies.* ***Conclusion:*** *Stability was shown to be higher for the standard implants. Mean values of torque resistance were higher for the standard implants than for the TiUnite implants. Implant design appeared to influence primary stability and placement torque.* INT J ORAL MAXILLOFAC IMPLANTS 2004;19: 578–585

**Key words:** *dental implants, immediate loading, placement torque, resonance frequency*

Tooth loss can result in many problems for the patient, ranging from functional problems such as masticatory difficulties to psychologic difficulties related to esthetic alterations. For these reasons the loss of just 1 tooth can cause the patient to seek rehabilitation. Osseointegrated implants have created a revolution in functional and esthetic rehabilitation. The surgical protocol proposed by Brånemark and colleagues in 1969 included a 2-stage surgical technique: The implant was placed in bone and completely covered by oral mucosa, so that functional loading was avoided during the initial healing period of the bone tissue.[1,2]

However, the requirement of a healing period under submerged and stress-free conditions has been questioned. Research into immediate loading protocols has shown encouraging results since the 1980s.[3] Several studies involving immediate loading of single-tooth implants placed using a 1-step surgical protocol have been published in an attempt to improve the esthetic results, reduce the treatment

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period, and simplify the process of replacing a single tooth.[4–6] In immediate loading protocols, an implant is placed in bone and loaded at once or within 48 hours of surgery. Many clinical and histologic studies have been conducted to evaluate the success and clinical applications of this procedure, because the introduction of occlusal/functional loading is a critical factor in the healing of bone tissue.

The evaluation of an immediate loading technique demands a quantitative method for the measurement of implant stability and osseointegration. Realistic clinical comparisons of the performance of different implant systems and a method of assessing the influence of variations within an implant system such as changes in geometry or surface modifications are also desirable.

A useful method of implant evaluation was described by Meredith and associates.[7] In this method, resonance frequency analysis is applied and values are obtained to measure implant stability and the marginal bone level. A decrease in the resonance frequency value is related to a decrease in stiffness, which can indicate a potential for failure.

Bone quality is one of the key parameters influencing successful implant placement. It can be evaluated in terms of 2 factors: its mechanical properties (density, hardness, and stiffness) and its physiologic properties (healing ability and regenerative capacity).[8] Johansson and Strid[9] described a technique whereby bone quality as a function of density and hardness could be derived from the torque values generated during the thread placement procedure as part of implant placement. They postulated that the energy used in cutting the thread prior to or during implant placement is a combination of the thread placement force from the tip of the instrument and the friction created as the remaining part of a tap or implant enters the site.

Taking into account these considerations, the authors proposed the placement of single implants and their restoration using an immediate loading procedure to:

- Evaluate standard Brånemark System implants and TiUnite implants (Nobel Biocare, Göteborg, Sweden) regarding primary stability and placement torque,
- Verify the correlation between placement torque and primary stability, and
- Analyze the influence of implant design on the placement torque and primary stability.

## MATERIALS AND METHODS

### Patient Data

Twelve patients, 8 women and 4 men ranging in age from 24 to 46 years (average age 35 years), were selected for the study. All presented with bilateral loss of either maxillary lateral incisors or premolars (Fig 1a). None of the patients presented with systemic disease that could hinder or complicate the surgical procedure. Preliminary periapical radiographs were made to check the bone height available for implant placement. The bone width was determined clinically with a pachymeter (Mitutoyo, São Paulo, Brazil), an instrument used for measuring the thickness of an object, especially thin objects such as a plate of bone or a membrane.

### Implants

Each patient received a standard 3.75 × 13-mm Brånemark System implant on either the left or right side of his or her mouth (side was chosen randomly) and a Brånemark TiUnite implant of the same length and diameter on the other side (Table 1). This implant size was chosen based on preliminary periapical and panoramic radiographic analyses of the edentate areas that would receive the implants. A study by Ericsson and colleagues[4] showed that smaller implants were unable to withstand immediate loading of a single-tooth prosthesis. The radiographs were analyzed for width and length of the bone available without applying any further techniques (eg, grafting to increase the amount of available bone, using shorter implants).

The standard Brånemark System implant (Fig 1b) was chosen because it represents the classic implant and has been used in many investigations of osseointegration. The TiUnite Mk III implant (Fig 1c) belongs to a new generation of implants and has a different screw design and surface treatment. Some authorities believe it has improved the initial and secondary stability, optimizing clinical results.[10–12]

According to the manufacturer, the TiUnite Mk III implant can be used for all cases in which there is an appropriate amount of bone tissue. The TiUnite Mk III design is similar to the Regular Platform Mk II. The 2 designs have the same screw profile, the same neck features, and parallel wall macrogeometry with a double-threaded cylindric implant body.[10]

### Surgical and Prosthetic Procedures

All the implants were placed using a single-stage surgical protocol. All patients had similar bone densities (bone types 2 or 3 according to Lekholm and Zarb's system of classification[13]) at all placement

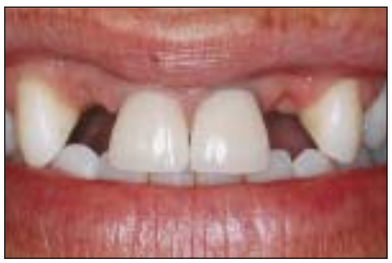

**Fig 1a** A patient with bilateral loss of the maxillary lateral incisors.

**Fig 1b** A standard Brånemark System implant.

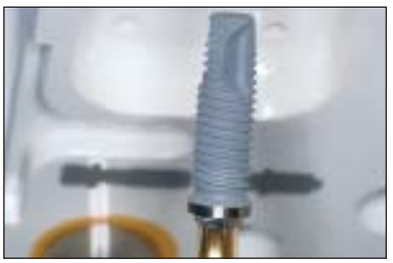

**Fig 1c** A TiUnite Mk III implant. Compare the surfaces and the apical thirds of the 2 different types of implants.

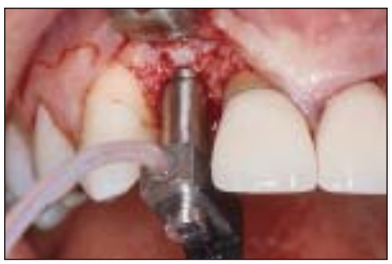

**Fig 1d** *(Left)* A TiUnite implant connected to the Osstell equipment by a transducer for resonance frequency evaluation.

**Fig 2** *(Right)* The Osseocare equipment.

**Table 1 Distribution of Maxillary Edentate Areas and Implant Type Received**

| Patient | Site | Implant type |
|---|---|---|
| 1 | Right first premolar | TiUnite Mk III |
| | Left first premolar | Standard |
| 2 | Right lateral incisor | TiUnite Mk III |
| | Left lateral incisor | Standard |
| 3 | Right first premolar | TiUnite Mk III |
| | Left first premolar | Standard |
| 4 | Right lateral incisor | Standard |
| | Left lateral incisor | TiUnite Mk III |
| 5 | Right lateral incisor | Standard |
| | Left lateral incisor | TiUnite Mk III |
| 6 | Right lateral incisor | TiUnite Mk III |
| | Left lateral incisor | Standard |
| 7 | Right first premolar | Standard |
| | Left first premolar | TiUnite Mk III |
| 8 | Right second premolar | Standard |
| | Left second premolar | TiUnite Mk III |
| 9 | Right second premolar | Standard |
| | Left second premolar | TiUnite Mk III |
| 10 | Right first premolar | TiUnite Mk III |
| | Left first premolar | Standard |
| 11 | Right lateral incisor | Standard |
| | Left lateral incisor | TiUnite Mk III |
| 12 | Right second premolar | Standard |
| | Left second premolar | TiUnite Mk III |

sites. This density permitted implant placement after the surgical alveolus had been created without the preliminary screw-tapping.

The surgical procedure consisted of local anesthesia and an incision, followed by mucoperiosteal flap elevation. Spherical drill speeds of 1,500 rpm were used to penetrate the cortical bone and make the initial mark for the implant location. Cylindric drills 2 mm wide and 13 mm long, pilot drills from 2 to 3 mm wide, cylindric drills 3 mm wide and 13 mm long, and finally countersink drills were used.

The implants were placed with an Osseocare motor (Nobel Biocare) with a calibrated torque of 50 Ncm and 20 rpm. Immediately following implant placement, the stability measurement was made with the Osstell equipment (Integration Diagnostic, Göteborg, Sweden) (Fig 1d). Impression copings were connected to the implants, and impressions were made for the fabrication of provisional crowns, which were cemented at the end of the day or on the following day. They were adjusted with occlusal and proximal contacts and without contact in protrusion and lateral excursion.

### Placement Torque Measurements

An electronic instrument was used to measure local placement torque of the implants (ie, in the crestal third, the middle third, and the apical third of each implant). Osseocare is a machine developed for perforation of the bone, implant placement, and abutment connection. It also enables measurement of torque during the prosthetic procedures (Fig 2). It has 3 modes: high-velocity surgery, low-velocity surgery, and prosthetic. To avoid mechanical overload of the equipment or bone tissue, Osseocare can only apply a limited amount of torque—20, 30, 40, or 50 Ncm in the surgical mode and 10, 20, 32, or 45 Ncm in prosthetic mode. The Osseocare unit is equipped with function measures that can be used

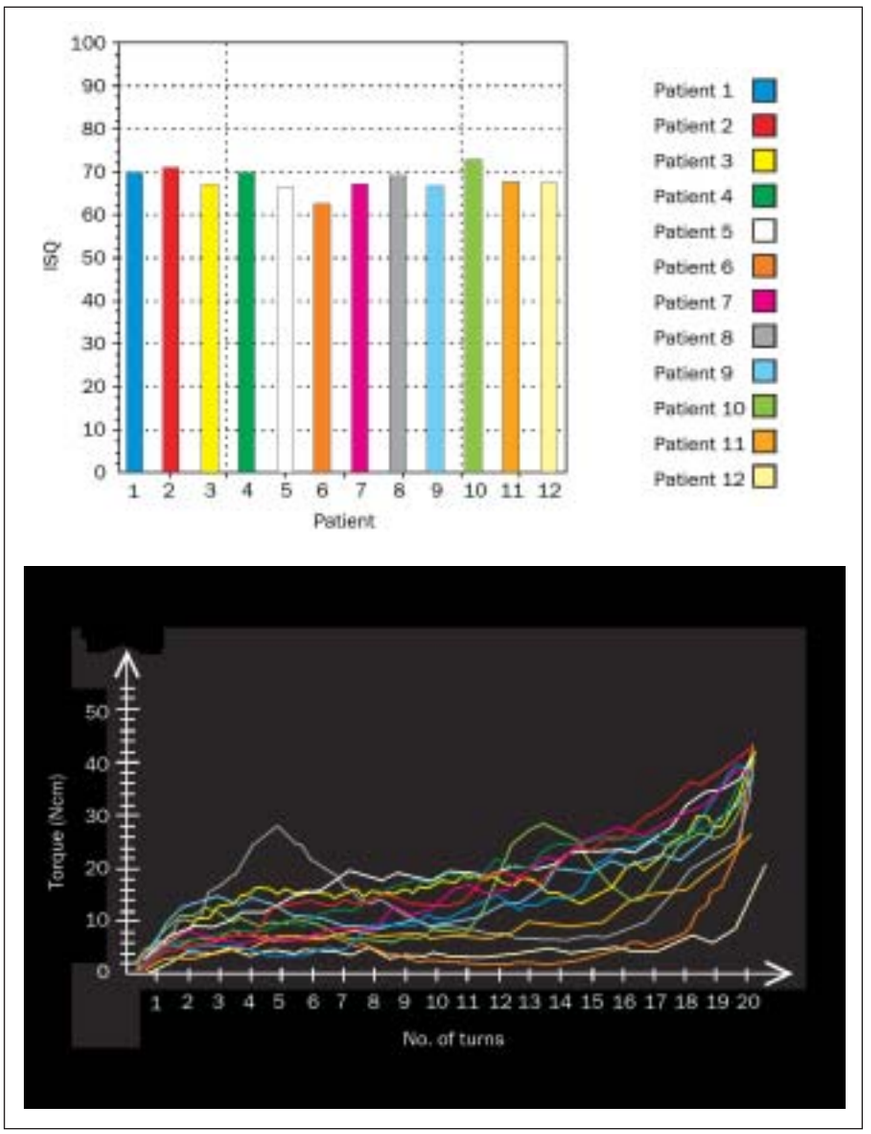


**Fig 3** ISQ and placement torque values for the standard implant group.

in the low-velocity surgery and prosthetic modes.

### Resonance Frequency Measurements

Resonance frequency analysis was completed immediately following implant placement. An L-shaped transducer was directly connected to each implant, 1 implant at a time. The transducer was attached to the top of the implant, perpendicular to the alveolar crest, using a screw with 10 Ncm torque. Its upright beam part was placed on the palatal side. Osstell is an instrument developed to analyze resonance frequency; it is capable of measuring clinical stability and assessing implant osseointegration. The transducer was stimulated by a sinusoidal signal at frequencies of 4 to 10 kHz, and the resonance frequency value was calculated through the signal received by this frequency analyzer. The results are demonstrated by an implant stability quotient (ISQ) value that ranges from 0 to 100 and is directly proportional to stability.[14] Figures 3 and 4 illustrate the ISQs and placement torque values for each patient and type of implant.

### Statistical Analyses

The linear correlation between each implant third, number of turns with torque, and ISQ was analyzed. Furthermore, the linear correlation between torque and ISQ for each implant group was analyzed. To compare the 2 types of implants, paired *t* tests were used for statistical analyses. A value of $P \leq .05$ was considered significant.

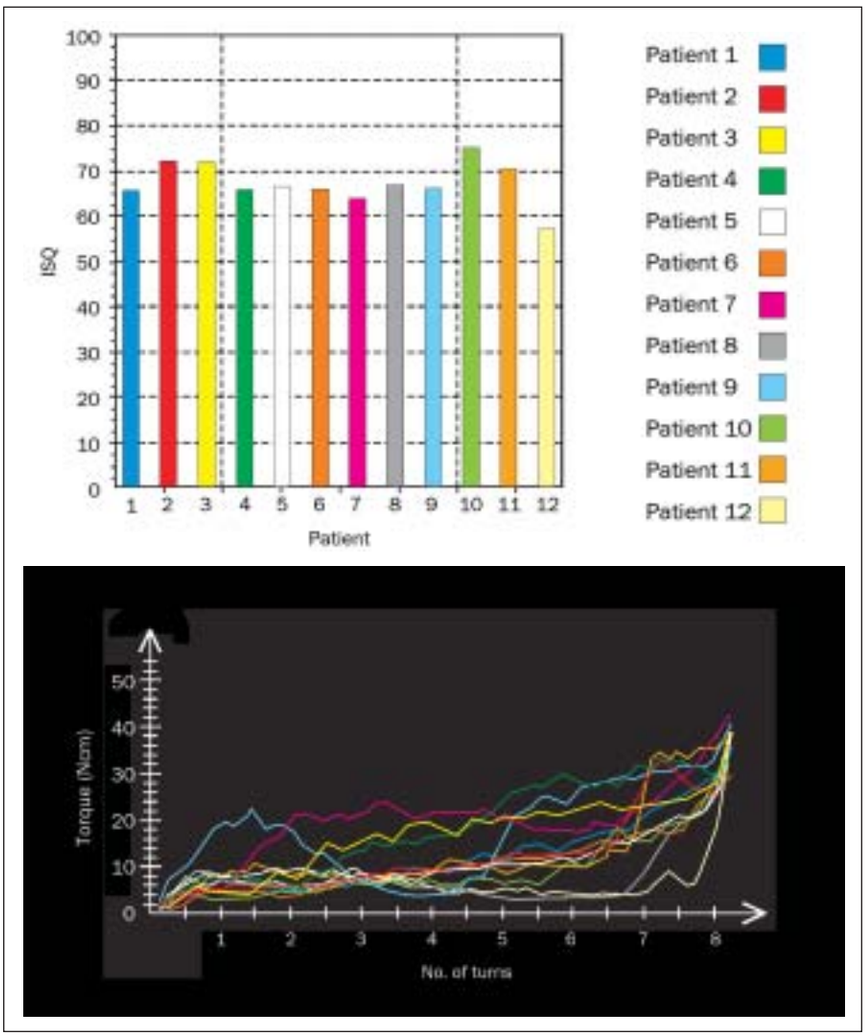


**Fig 4** ISQ and placement torque values for the TiUnite Mk III implant group.

## RESULTS

The original data from the 12 patients are reported in Table 2.

Table 3 shows the linear correlation coefficients ($r$) between the apical third (T1), middle third (T2), crestal third (T3); number of turns with torque; and ISQ at the different types of implants, and the significance level of each significant correlation.

Significant linear correlations were found between the placement torques for T1, T2, and T3 for TiUnite implants ($P < .01$). The linear correlations between the placement torques for the same variables were not significant for the standard implants. This difference might be considered an indication that the 2 types of implants showed different ISQ and placement torque values.

Table 4 shows mean values, standard deviations, and $P$ values for comparison of the 2 types of implants used and statistical analyses for each variable evaluated.

The mean torque values and mean number of turns for the 2 types of implants differed significantly ($P \leq .01$). The mean ISQs and mean T1 torque values for the 2 implant groups also differed significantly ($P \leq .05$). The mean T2 and T3 torque values for the 2 implant groups did not differ significantly.

## DISCUSSION

The purpose of the present study was to evaluate the primary stability of standard Brånemark System implants and TiUnite Mk III implants using Osstell; to evaluate placement torque using Osseocare; to determine whether there was a correlation between primary stability and placement torque; and to determine whether implant design has an influence on either placement torque or resonance frequency.

**Table 2 Data Used in the Statistical Analysis of 24 Implants Placed in the Maxilla**

| | TiUnite Mk III | | | | | | Standard | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Patient | Site | No. of turns | T1 | T2 | T3 | Torque (Ncm) | ISQ | Site | No. of turns | T1 | T2 | T3 | Torque (Ncm) | ISQ |
| 1 | Right first premolar | 8.25 | 5 | 11 | 22 | 35.5 | 70 | Left first premolar | 20.25 | 4 | 11 | 26 | 36.75 | 67 |
| 2 | Right lateral incisor | 8.75 | 5 | 10 | 23 | 29.75 | 71 | Left lateral incisor | 17.25 | 8 | 16 | 31 | 43.5 | 72 |
| 3 | Right first premolar | 9.00 | 7 | 19 | 25 | 36.5 | 67 | Left first premolar | 19.75 | 12 | 17 | 23 | 42.75 | 72 |
| 4 | Left lateral incisor | 9.75 | 8 | 18 | 28 | 38.75 | 66 | Right lateral incisor | 19.00 | 7 | 19 | 30 | 41.00 | 70 |
| 5 | Left lateral incisor | 9.25 | 12 | 19 | 29 | 42.00 | 67 | Right lateral incisor | 19.25 | 8 | 9 | 18 | 39.50 | 67 |
| 6 | Right lateral incisor | 9.00 | 4 | 9 | 18 | 29.50 | 63 | Left lateral incisor | 19.25 | 6 | 3 | 11 | 43.75 | 66 |
| 7 | Left first premolar | 8.25 | 7 | 15 | 30 | 38.50 | 64 | Right first premolar | 17.00 | 12 | 21 | 25 | 42.75 | 67 |
| 8 | Right second premolar | 9.50 | 6 | 5 | 13 | 38.75 | 69 | Left second premolar | 21.50 | 17 | 10 | 15 | 41.25 | 67 |
| 9 | Left second premolar | 8.75 | 11 | 12 | 25 | 37.50 | 66 | Right second premolar | 17.50 | 14 | 9 | 29 | 41.00 | 67 |
| 10 | Right first premolar | 9.00 | 4 | 6 | 17 | 26.75 | 73 | Left first premolar | 19.50 | 9 | 13 | 24 | 42.00 | 75 |
| 11 | Left lateral incisor | 9.75 | 5 | 8 | 16 | 27.00 | 70 | Right lateral incisor | 23.75 | 7 | 9 | 23 | 35.75 | 67 |
| 12 | Left second premolar | 7.75 | 4 | 4 | 7 | 20.25 | 57 | Right second premolar | 16.25 | 6 | 6 | 8 | 39.75 | 68 |

T1 = apical third of the implant; T2 = middle third of the implant; T3 = crestal third of the implant.

**Table 3 Correlation Coefficient (*r*) Between the Apical, Middle, and Crestal Thirds of the Implants; the Number of Turns Required; and ISQ**

| Variable | Placement torque (Ncm) | ISQ |
|---|---|---|
| TiUnite Mk III | | |
| T1 | 0.75588* | 0.00815 |
| T2 | 0.72069* | 0.01764 |
| T3 | 0.76444* | 0.20967 |
| Turns | 0.33635 | 0.57357 |
| ISQ | 0.19722 | |
| Standard | | |
| T1 | 0.37004 | –0.12801 |
| T2 | 0.37004 | 0.45748 |
| T3 | 0.00273 | 0.44209 |
| Turns | –0.54497 | –0.07411 |
| ISQ | 0.21908 | |

*$P \leq .01$ (*t* test).

**Table 4 Means, Standard Deviations, *P* values of Comparison for Mk III and Standard Implants**

| Variable | Mean | SD | *P* |
|---|---|---|---|
| ISQ | | | –2.24* |
| Mk III | 66.92 | 4.16 | |
| Standard | 69.00 | 2.80 | |
| Placement torque | | | –3.77** |
| Mk III | 33.40 | 6.57 | |
| Standard | 40.81 | 2.52 | |
| Turns | | | –20.80** |
| Mk III | 8.92 | 0.62 | |
| Standard | 19.19 | 2.08 | |
| T1 | | | –2.43* |
| Mk III | 6.50 | 2.68 | |
| Standard | 9.17 | 3.81 | |
| T2 | | | –0.39 |
| Mk III | 11.33 | 5.37 | |
| Standard | 11.92 | 5.40 | |
| T3 | | | –0.48 |
| Mk III | 21.08 | 7.01 | |
| Standard | 21.92 | 7.43 | |

*$P \leq .05$ (*t* test).
**$P \leq .01$ (*t* test).

Many authors agree that primary stability is important for the success and longevity of osseointegrated implants.[1,14–17] There are 3 determinant parameters for achieving primary stability: implant geometry, surgical procedure, and bone quality of the recipient site (in regard to density and stiffness).[14] Implant surfaces and designs have been modified to make placement easier, which reduces trauma and surgical time and enhances the potential to improve primary and secondary stability.[14–16]

There have been many attempts to discover a noninvasive and efficient method to evaluate implant stability and osseointegration. Many tests have been suggested: percussion, radiographic methods, resonance frequency analysis, placement resistance, the Periotest, reverse torque, and vibration methods in sonic and ultrasonic ranges.[8] Of these, resonance frequency analyses and placement resistance methods appear to be the most efficient and least contraindicated, which is why they were selected for this investigation. There has been a trend toward the use of TiUnite Mk III and Mk IV implants instead of standard Brånemark System implants because of the improvements that have been made in terms of surface and design. The present study was undertaken to evaluate the primary

stability and placement torque with these 2 implant types to determine if the evolution of the implant design has really improved implant performance. In this study, it was determined that there was no direct relationship between ISQ (ie, primary stability) and placement torque. Some implants showed higher placement torque but not greater primary stability.

All patients presented with bilateral loss of either maxillary lateral incisors or premolars. In all implant sites the bone tissue was classified as type 2 or 3 using the Lekholm and Zarb classification system.[13] During the surgical preparation there was a relatively low penetration resistance to the sequential drills, so it was not necessary to use tapping drills. The implant length and diameter (3.75 × 13 mm) as well as the implant placement procedure were standardized.

Through statistical analyses it has been observed that among all the compared variables a significant, positive statistical correlation was found only with the use of TiUnite Mk III for placement torque at T1 ($r$ = 0.75588), T2 ($r$ = 0.72069), and T3 ($r$ = 0.76444) ($P \leq .01$). When using the standard Brånemark System implant there was no significant statistical correlation for any variable studied in this investigation. Thus, given that the same procedure was used for the placement of all implants, it can be asserted that the different designs of the standard Brånemark System and the TiUnite Mk III implants had an influence on the results.

Friberg and coworkers[16] compared placement torque and resonance frequency measurements of maxillary implants. They reported on TiUnite Mk II implants, an intermediary implant generation between the standard Brånemark System implants and the TiUnite Mk III. A significant relationship was found between placement torque and resonance frequency at implant placement only in the upper/crestal third of the implants. However, Friberg and coworkers' final results also showed that there was no overall correlation between placement torque and ISQ.

The standard implant had greater placement torque than the Mk III at the apical third ($P \leq .05$). This performance can be related to implant design, placement capacity, and bone tissue type where the implant was placed. However, a significant statistical difference was not found for T2 or T3 for the same implant, probably because of implant diameter similarity. The only disadvantage of the standard implant compared to TiUnite Mk III was that a larger number of turns were required for its placement and its final torque. These results are in agreement with Glauser and associates,[10] who found that with Mk III implants, which feature a double thread design, placement time could be reduced by 50% without an increase in heat production. Thus, it would seem from their study as well that the TiUnite Mk III implant design influenced primary stability and placement torque.

Nobel Biocare claims that TiUnite Mk III and TiUnite Mk IV implants have greater primary stability and a better final torque when compared with the standard and Mk II implants. However, Glauser and associates[10] published a study in which placement torque and resonance frequency for 3 implant types (Mk II, Mk III, and Mk IV) were compared. The results showed that there was no statistical difference between the Mk II and Mk III implants in regard to placement torque or resonance frequency, but that there was a significant difference ($P \leq .05$) between the Mk IV implants and the other 2 groups.

In the present study the TiUnite Mk III implant did not show greater mean values for primary stability or placement torque. Thus, the manufacturer's claim that the greater apical screw area of TiUnite Mk III would improve apical cortical coupling, guaranteeing greater stability and final torque than the standard type may be contested.

The mean ISQ values obtained with Osstell were significantly greater with the standard implants than with the TiUnite Mk III (69.00 vs 66.92; $P \leq .05$); the mean values of placement torque resistance measured by Osseocare were also significantly greater with the standard implants than the TiUnite Mk III (40.81 vs 33.40; $P \leq .01$). There was no relationship between the ISQs and the placement torque values; however, the implant design had an influence on the primary stability and placement torque.

The performance of the standard implant appeared to be better than that of the TiUnite Mk III in regard to placement torque and resonance frequency. The scientific data obtained in this study may be an important factor when considering an immediate loading procedure. However, as the sample size was small, lack of significance cannot be interpreted as the absence of an association where the test results were nonsignificant. These results suggest that new studies need to be developed for a better understanding of the studied variables.

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