The Osteotome Versus Conventional Drilling Technique for Implant Site Preparation: A Comparative Study in the Rabbit

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The aim of this research was to study the influence of the osteotome technique on insertion torque and stability values when compared with conventional surgical drilling of the implant site. A total of 20 implants (4-mm diameter, 8.5-mm long) were placed in the distal femural condyle of 10 New Zealand White rabbits. The implant sites were prepared by using either the conventional drilling technique as a control group (group A) or the osteotome technique (group B). Cutting torque and resonance frequency analyses (RFAs) were conducted at and after implant placement. The resulting values were subjected to correlation and comparative analyses between groups. Insertion torque measurements were conducted at three different levels of implant insertion: crestal, middle, and apical. Group B showed higher mean insertion torque and RFA values (P < .05). No statistically significant correlation could be observed when comparing the mean torque values with RFA values (P > .05). Bone condensation before implant insertion in low-density bone led to higher mean insertion torque and RFA values. Within the limits of this experimental study, a benefit in using the osteotome technique was observed when dealing with low-density bone. Bone condensation can improve primary stabilization of implants. (Int J Periodontics Restorative Dent 2012;32:e109–e115.)

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Achieving good primary stability is crucial for the success of implant treatment because the lack of bone support can influence osseointegration in the early stages of healing. Lack of intimate bone contact when placing implants in low-density bone leads to reduced primary stability, which can cause poor osseointegration.[1] Primary stability depends on many different factors, such as implant anatomy and surface,[2,3] bone quality and quantity,[4] and the surgical technique used.[5]

The surgical protocol proposed by Brånemark in 1969 for rehabilitation of edentulous patients is well documented and has good results.[6–9] However, failures may occur. Low bone density and limited bone volume are the most frequently mentioned parameters associated with a high failure rate.[10–14]

The alveolar process is subjected to continuous remodeling. Tooth loss leads to an enhanced resorption of the alveolar ridge,[15–17] and according to Woolfs' law, the loss of function leads to a decrease in bone density.[18]

Low-density bone is often encountered in the posterior maxilla. The success rate of dental implants in type 4 bone is significantly lower when compared to denser bone qualities.[6,19–21] Sufficient bone volume and density are key factors for implant stability and, consequently, successful implant treatment.[11,12] Implants placed in low-density bone may have reduced initial stability, which may lead to poor osseointegration during early healing phases.[22,23] To improve such a situation by achieving more bone around the implant, Johansson and Albrektsson[20] proposed a prolonged unloaded postsurgical healing period.

A useful way of measuring implant stability was developed by Meredith et al.[24–26] In this method, resonance frequency analysis (RFA) is applied, and implant stability quotient (ISQ) values are obtained to measure implant stiffness in bone. A decreased ISQ value is related to a reduced stability, which can indicate a potential failure.

Bone quality is one of the key factors influencing proper implant primary stability. Johansson and Strid[27] developed a way to evaluate bone density as a function of the torque values generated during implant placement. Friberg et al[19,28] developed this method and introduced an electric device that measures bone cutting resistance prior to and during implant placement.

The osteotome technique was introduced in the late 1970s by Hilt Tatum[29,30] as a method of improving implant stability. In 1994, Robert Summers altered Tatum's instruments and adapted them for sinus floor elevation.[31–33] Bone expansion/condensation are well-documented and established procedures in clinical practice. However, experimental studies measuring an implant's cutting resistance and stability, during and after insertion in low-density bone after using osteotomes, could not be found in the literature. Therefore, the aims of this animal experimental study were to determine the effect of the osteotome technique on implant cutting resistance and primary stability and to verify if there is a correlation between them. Conventional implant site preparation served as a control group.

Method and materials

A total of 10 New Zealand White rabbits were included (5 males, 5 females; mean age, 8.7 months; age range, 6 to 12 months) with a mean weight of 3.8 kg (range, 2.6 to 4.5 kg). All animals were sacrificed before surgery. These animals were scheduled to be sacrificed as a result of other ongoing studies. Distal femural condyles were chosen as the experimental site.

Surgical procedure

The condyles were exposed by medial arthrotomy with skin incisions and facial-periosteal flaps. In all surgical sites, cartilage and cortical bone were removed over a circular area 5 mm in diameter (Fig 1).

Implant site preparation was divided into two groups according to the surgical technique. Group A included all implants inserted with conventional drilling of the surgical bed, using a BTI System handpiece sequence (Biotechnology Institute), to 3 mm in diameter and 8.5 mm in depth with 1,500 rpm under abundant saline irrigation (Fig 2). Group B included all implants inserted after using a sequence of osteotomes (BTI System) with increasing diameters according to the manufacturer's protocol (Fig 3). After introduction of the initial handpiece for surgical bed orientation, osteotomes 1, 2, and 3 were used to the total working depth (8.5 mm). The diameters of osteotomes 1, 2, and 3 at 8.5 mm were 1.6, 1.9, and 2.7 mm, respectively. Each instrument remained in the implant site for 1 minute before the next largest diameter osteotome was used.

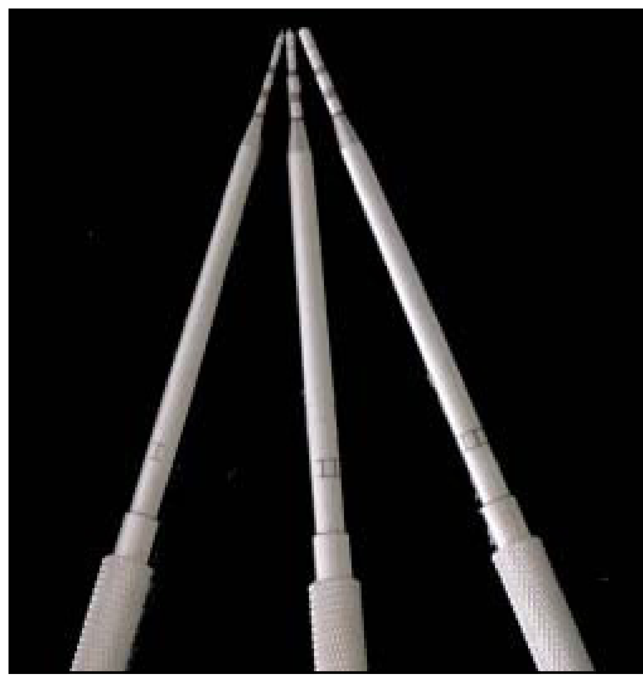
Bone density was evaluated and registered during implant site preparation. In all cases, bone was considered to be D4 according to the Misch classification of bone density.[5]

Finally, implants were inserted in both groups. Because implants were placed in low-density bone, all implants could be inserted at the same vertical level with no need for use of a countersinking drill. A total of 20 BTI screwed implants, all 4 mm in diameter and 8.5 mm in length, were chosen to ensure the entire implant body was in contact with only trabecular bone.

Fig 1 (above) *Distal articular condyle after cortical bone removal.*

Fig 2 (above right) *Drill sequence used for surgical preparation of implant sites in group A (control group).*

Fig 3 (right) *Osteotome sequence used for surgical preparation of implant sites in group B (test group).*



Insertion torque measurement

An electronic instrument (Osseocare, Nobel Biocare) was used for the total mean cutting torque evaluation during low-velocity implant insertion. Measurements were conducted at three different levels (Fig 4): *(1)* R1 (crestal), implant inserted in the first third of the surgical bed; *(2)* R2 (middle), implant inserted in the middle third of the surgical bed; and *(3)* R3 (apical), implant inserted in the last third of the surgical bed.

The Osseocare device allows torque values to be transferred through a magnetic card to a personal computer for subsequent data evaluation.

RFA

RFA was completed immediately after each implant was placed using Osstell (Integration Diagnostics) equipment. A 5-mm-long "L" shaped transducer (F1 type) was applied to the implant hexagon and screwed into place (Fig 5). The values were represented as an ISQ

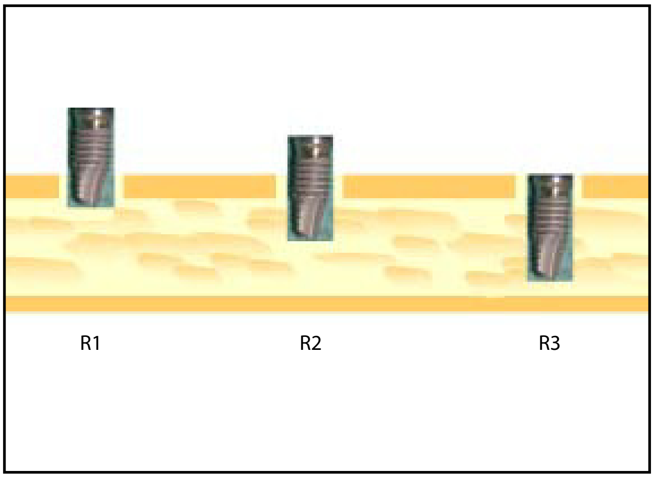


Fig 4 *Cutting torque evaluation at three different levels of implant insertion (R1, crestal; R2, middle; R3, apical).*

Fig 5 *Transducer in place for RFA.*

value and stored on a personal computer for further analysis.

Statistical analysis

Mean values and standard deviations of each group evaluated were calculated for the insertion torque and ISQ values. The Spearman correlation test was conducted to correlate the mean insertion torque values in each level of implant introduction (R1, R2, and R3) to the corresponding RFA values. To evaluate the association between groups (drills/osteotome), and insertion torque and ISQ values, the Student *t* test was conducted. A *P* value ≤ .05 was considered significant. The assumptions needed for application of the Student *t* test were tested and found to be satisfied through use of the Levene test. All calculations were performed using SPSS for Windows (SPSS).

Results

The influence of the surgical technique on implant stability was evaluated using a comparative analysis with mean insertion torque and ISQ values. Mean insertion torque values were higher at all implant insertion levels (R1, R2, and R3) for implants placed after using the osteotome technique (group B) when compared with those inserted using the conventional technique with handpieces of increasing diameters (group A). The higher mean cutting torque values in both groups were obtained for the placement with insertion of the last third (crestal) of the implant body in the surgical site, which corresponds to the entrance of the implant crestal module (Table 1).

RFA showed a better primary stability for implants placed after the osteotome technique (group B) compared to those in group A, which was noted by higher ISQ values (Table 1).

To correlate RFA values after implant placement with mean torque values for R1, R2, and R3, the Spearman correlation test was used. A statistically significant correlation could not be obtained for any parameter analyzed. However, a higher level of correlation between RFA and cutting torque values was observed at R1 (r = 0.4, P = .08; Table 2).

The Student *t* test was used for the comparative analysis between implant insertion according to the conventional technique (group A) and that after using the osteotome technique (group B). Statistically significant values were obtained for each parameter analyzed ($P \leq .05$): insertion torque values at R1, R2, and R3 levels and ISQ values (Table 3).

Discussion

Trabecular bone compression to improve bone density has been used successfully in reconstructive surgery for a long time.[34,35]

Clinical use of the osteotome technique has been described. However, those studies generally emphasize the survival rate of implants placed after using bone compression techniques.[30–33,36–44] There is a lack of experimental studies that evaluate implant stability and stiffness in bone when the osteotome technique is used for surgical site preparation. This study aimed to fill this void in experimental studies to support the clinical tendency to use bone expansion techniques when dealing with low-density bone (either by using osteotomes or reducing the last handpiece's diameter).

The absence of a mechanical rest can jeopardize osseointegration.[1] If primary stability was improved after bone compression, it could then be understood why dental implants placed in low-density bone have higher success rates after using osteotomes. Therefore, it was the aim of this animal study to evaluate the influence of the osteotome technique on insertion torque and stability values when compared to conventional surgical preparation of the implant site.

The results of this animal study revealed that the benefits of the osteotome technique in implants placed in low-density bone are the increased torque needed for implant insertion and higher ISQ values.

Table 1 Analysis of insertion torque (R1, R2, R3; Ncm) and RFA (ISQ) values

	No. of implants	Mean	Minimum	Maximum	SD
R1					
Group A	10	0.6	0	1	0.52
Group B	10	2.0	1	3	0.67
R2					
Group A	10	0.9	0	2	0.57
Group B	10	2.7	1	6	1.57
R3					
Group A	10	1.2	0	3	0.79
Group B	10	2.9	1	7	1.73
RFA					
Group A	10	56.2	38	81	13.47
Group B	10	70.9	61	82	7.46

SD = standard deviation.

Table 2 Insertion torque and RFA correlation analysis

	No. of implants	*r*	*P*
R1	20	0.40	.080
R2	20	0.18	.450
R3	20	0.18	.457

Table 3 Student *t* test (group A vs group B) for insertion torque and RFA values

	No. of implants	*t*	*P*
R1	20	27.56	< .001
R2	20	11.66	.003
R3	20	8.00	.011
RFA	20	9.11	.007

Mechanical stimuli are said to improve implant success rates,[39,44] accelerate formation of trabecular bone,[45–47] and increase bone quality.[48,49] The increased new bone formation of compressed cancellous bone grafts has been demonstrated in previous animal studies.[34]

The heat generated during implant surgical site preparation with a high-velocity handpiece is well described in the literature, even when proper saline irrigation is used.[50–53] The osteotomes are gently inserted into place or tapped to the desired depth using a surgical mallet. During this procedure, heat generation is not likely. Therefore, use of the osteotome technique instead of handpieces for implant surgical site preparation reduces this potentially harmful effect.

When the alveolar crest does not provide sufficient bone volume and density for proper implant placement, augmentation procedures have to be performed.[13] These interventions often require an additional surgical site and have a reduced implant success rate associated with the use of bone substitutes.[38] Moreover, the osteotome technique may also allow the surgeon to perform a sinus floor elevation[31–33] and alveolar expansion,[29,30,37] decreasing the need for augmentation procedures and reducing morbidity, operating time, and associated costs.

Within the limits of the present study, it can be concluded that there may be a clinical benefit in using the osteotome technique when dealing with low-density bone. Bone condensation can improve the mechanical rest of implants placed in bone of reduced density. More trials must be carried out in animals with bone mechanical properties more comparable to those of humans to confirm this finding.

The fact that a statistically significant correlation could not be found between RFA and mean insertion torque values can be explained by the reduced sample size used. This analysis should be repeated in further experiments with a larger number of implants. In a similar study, Friberg et al[54] compared placement torque and RFA measurements of maxillary implants. They concluded that there was no overall correlation between cutting torque and ISQ values; a significant relationship could only be found with insertion torque at level R1.

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