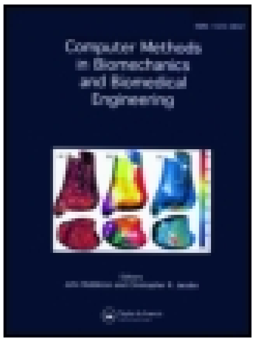

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Implant primary stability with an osteocondensation drilling protocol in different density polyurethane blocks

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ABSTRACT
The implant primary stability is a fundamental condition for avoiding implant micro-motions that might result in fibrous encapsulation; its achievement is facilitated by macro- and micro-geometry of the implant, and by the bone density and architecture at the intended implant site. The aim was to evaluate an osteocondensing drilling protocol for dental implant positioning compared to standard protocol on polyurethane block. A total of 40 implants, 20 for each osteocondensing group (Test) and 20 for standard drilling group (Control), were positioned. Insertion torque (IT), removal torque (RT), and Periotest were measured. A IT, RT, and Periotest significant difference was present in favor of the implant osteocondensing protocol. The results suggested that osteocondensing protocol represents a useful technique for implant placement in poor density bone.

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Bone condensation; implant osteotomy; polyurethane block; primary stability

Introduction

Anatomical and morphological alterations in the posterior maxilla follow the teeth loss and induce a significant bone quality and bone volume reduction (Van der Weijden et al. 2009). These alterations could influence achievement of the primary stability of the dental implant for oral rehabilitation during the surgery (Javed and Romanos 2010; Tumedei et al. 2020).

The primary stability represents a key factor for obtaining osseointegration of dental implants inserted in the maxillary bone and for the long-term success rates of implant-supported rehabilitation with dental implants (Albrektsson and Lekholm 1989).

The achievement of this clinical outcome results from the mechanical interaction between the implant and the bony walls during the insertion (Piattelli et al. 2011).

Moreover, the primary stability represents a necessary condition for the healing of the peri-implant bone, for the new bone formation and functional maturation also defined as secondary stability (Albrektsson et al. 2003; Scarano et al. 2018).

The obtaining of primary stability can be conditioned by several factors such as implant geometry, morphology of the threads, implant surface, different drilling techniques for dental implant, implant drills characteristics, bone quantity and quality, the geometric design of the implant, surgical technique, and insertion torque(IT), protocol of preparation sequence, and the native bone density (Degidi et al. 2012; Falco et al. 2018; Scarano et al. 2018; Gehrke et al. 2019; Scarano et al. 2020).

In the presence of bone defects, several regenerative procedures have been proposed using different surgical approach by resorbable and non-resorbable membrane, bone miniplates, and biomaterials in forms of bone particulate and blocks (Malchiodi et al. 1998; Scarano et al. 2011; Gehrke et al. 2019; Mendoza-Azpur et al. 2019; Tumedei et al. 2019). In these clinical conditions, the obtaining of primary stability is more complicated (Möhlhenrich et al. 2015).

Moreover, different techniques for implant site preparation have been proposed such as calibrated implant drills, bone expanders and compactor devices, piezoelectric device (Zizzari et al. 2015; Bogovič et al. 2016; Falisi et al. 2017).

An approach using osteocondensing implant drills has been successfully proposed for the treatment of

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these critical areas, demonstrating *in vivo* on animal models an increase of 30% of the bone volume as well as a significantly higher implant removal torque (RT) in the treated sites prepared with the osteocondenser drills when compared to sites prepared with standard drills (Trisi et al. 2016).

Other methods proposed for implant stability evaluation are the IT, Pull out test (PO), and micromovements implant analysis by Periotest (Al-Jetaily and Al-Dosari 2011).

These measurements are strongly determined by the compression produced in the surgical site during the implants insertion and by the micro- and macrogeometry characteristics of the implant threads.

According to American Society Testing Materials (ASTM), polyurethane foam block is an ideal synthetic material for *in vitro* biomechanical tests, as it has effective physical and mechanical characteristics

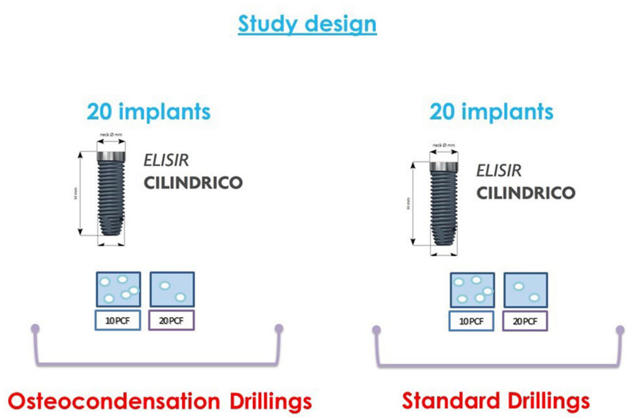

Figure 1. Graphical summary of the investigation design.

to simulate different bone tissue densities in a standardized and calibrated way excluding all the anatomical and structural variables typical of the *in vivo* model (Comuzzi, Iezzi, et al. 2019).

The aim of the present investigation was to evaluate on polyurethane sheets two different drilling techniques for dental implant positioning using osteocondensing burs compared to a standard type protocol.

Materials and methods

Implants

The sample size calculation was based on mean and standard deviations of a previous study (Comuzzi, Tumedei, Pontes, et al. 2020; Comuzzi, Tumedei, Piattelli, et al. 2020), with an alpha error of 0.05, an effect size of 0.79, and power (1-beta) of 0.95. The minimum amount was 36 implants.

A total of 40 Elisir implants (F.M.D., Rome, Italy) with conical shape and internal hexagon connection (diameter 4.8 mm and length 10 mm) were used for the present *in vitro* experimental study (Figure 1), Moreover, 20 control implants were inserted with a standard drilling following the protocol of the manufacturer: implant lance drill, cylindrical drill 2.3-, 2.5-, 2.8-, 3.2-, and 3.7-mm drill (800 rpm) with a forward rotation. A total of 20 test implants were inserted with osteocondensation drillings following the protocol of the manufacturer: implant lance drill, cylindrical drill 2, 3, and 4 mm at 800 rpm in reverse rotation (Figures 2 and 3). Test and control implants

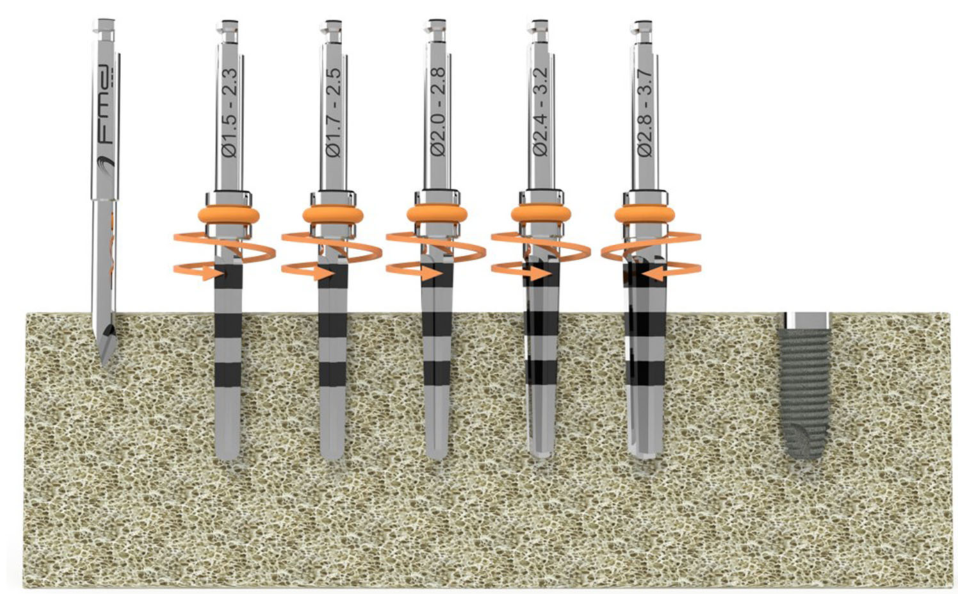

Figure 2. Osteocondensing drilling protocol sequence.

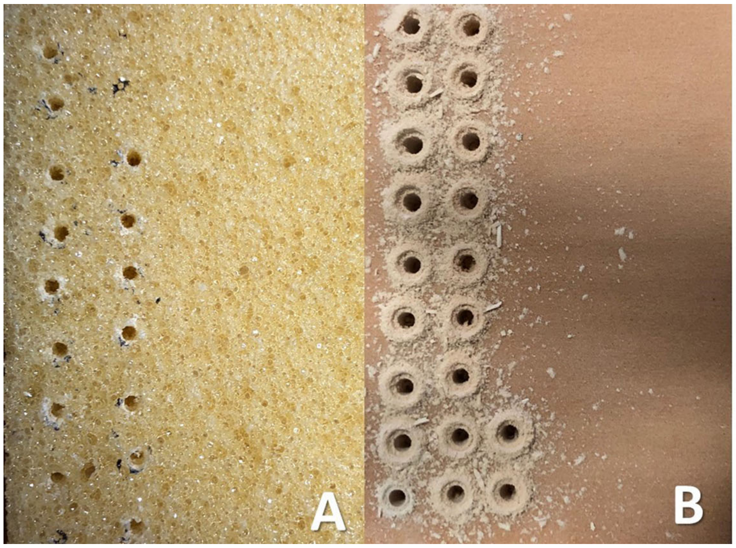

Figure 3. A) Detail of the osteocondensing implant site preparation on polyurethane block (10 PCF) after the drilling preparation. B) Detail of the osteocondensing site preparation on polyurethane block (20 PCFs) after the drilling.

were inserted in two different types of solid rigid polyurethane foam (SawBones H, Pacific Research Laboratories Inc, Vashon, WA, USA) with homogeneous densities. The block densities of the samples used in the present *in vitro* study were as follows: 16.01 kg m^3 (10 Pound Per Cubic Foot [PCF]), analogous to D3 bone quality, and 32.02 kg m^3 (20 Pound Per Cubic Foot [PCF]), analogous to D2 bone. Ten implants for group were inserted in each block; the distance between them was 3 mm. The randomization was not applicable in this study model due to the different preparation protocol and the drill sequence used for the implant positioning.

Insertion torque and removal torque

Each implant was positioned by a surgical motor, and the IT was measured. The removal strength was assessed by dynamometric analysis of the extraction of the implant from the block. The RT was measured by the calibrated electronic torque meter.

Micromovement evaluation

The Periotest method is carried out by an electromechanical measurement (Figure 4), an electrically and electronically controlled device on implant or tooth for a total of 16 times. The entire measurement process takes about 4 seconds. The Periotest presents a pressure-sensitive device that records the contact time with the object. If the tooth or implant is mobile, the more the contact time and therefore the Periotest value is increased. On contrary, short contact times are related to reduced Periotest values are measured from stable teeth or implants.

The Periotest scale is closely related to dental mobility through a scale of values between −8 and +50 that correspond to the following (Al-Jetaily and Al-Dosari 2011):

1. From –8 to 0: Good osseointegration; the implant is well integrated and can be loaded.
2. From +1 to +9: Clinical control is required.
3. From +10 to +50: Absent/partial osseointegration; the system cannot be loaded.

The Periotest measurement was performed after the implant positioning and prior to the screw removal from polyurethane.

Statistical analysis

The IT and RT means and Periotest means were statistically analyzed between the study groups. The normality distribution of the study data has been evaluated by the Kolmogorov–Smirnov test. The one-way ANOVA followed by the Dunn-Sidak *post hoc* test for heterogeneous variances GraphPad 6.0 (Prism San Diego, CA, USA) statistical package. The level of significance was set as $p < .05$.

Results

The IT means were higher for condenser drill preparation if compared to standard drills for all groups ($p < .01$) (Figure 5).

The removal peaks showed a statistically significant difference is shown between the condenser drills versus standard preparation ($p < .01$) (Figure 6).

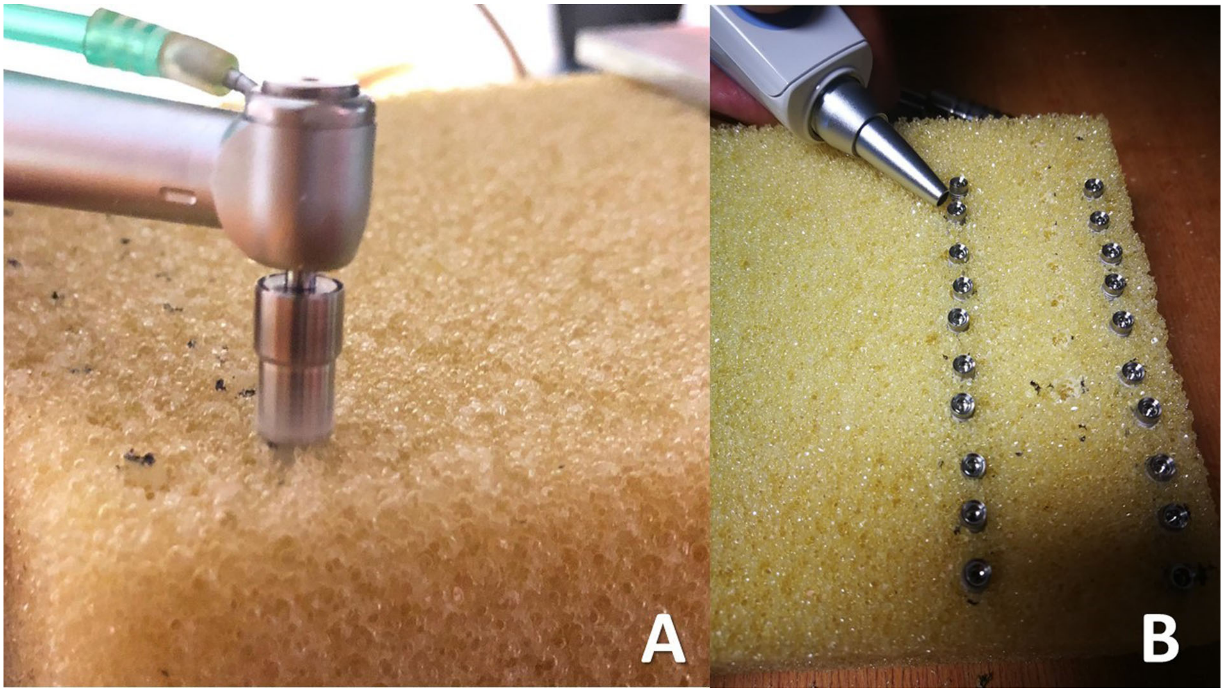

Figure 4. A) Detail of the implant drilling site preparation on polyurethane block. B) Periotest analysis on the implant positioned.

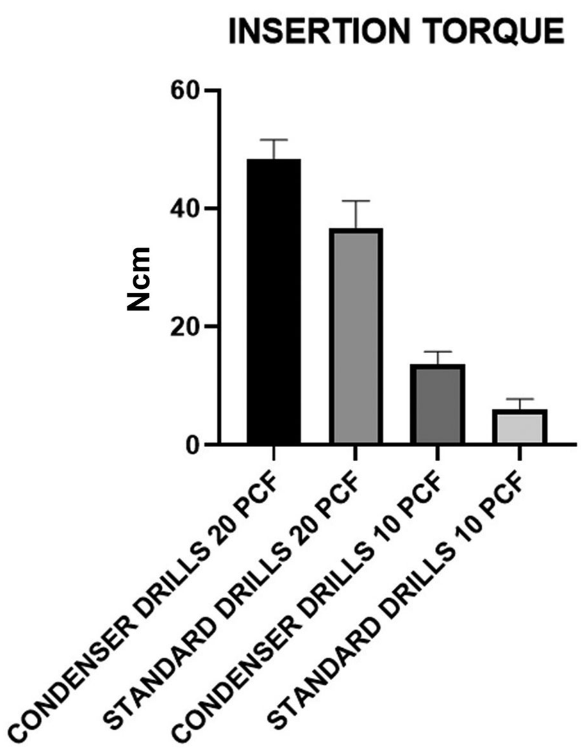

Figure 5. Insertion torque means of the two different drilling preparation techniques.

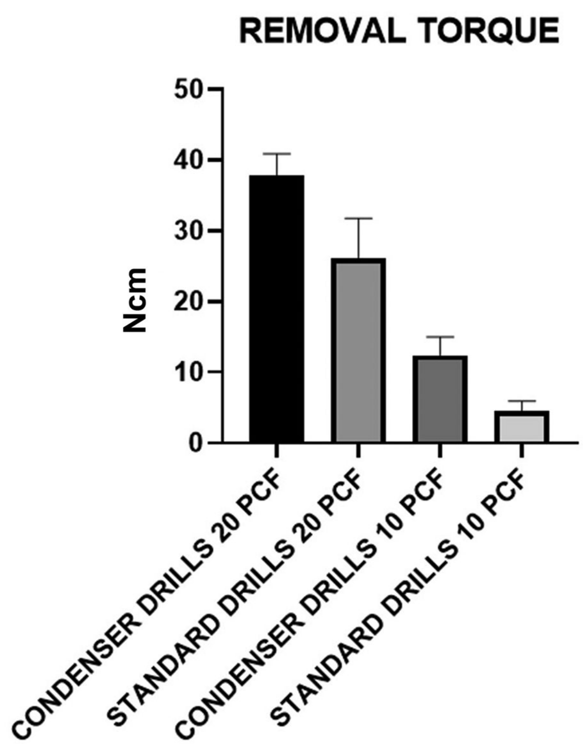

Figure 6. Removal torque means of the two different drilling preparation techniques.

The implant micromovement analysis by periotest showed a significant difference between the condenser and standard drills at 10 PCF (Figure 3). No differences were presented at 20 PCF between groups (Figure 7).

Discussions

The dental implant success demonstrated their effectiveness due the high survival rate reported in the literature, also in region with a non-optimal bone density (Del Fabbro et al. 2004; Pjetursson et al.

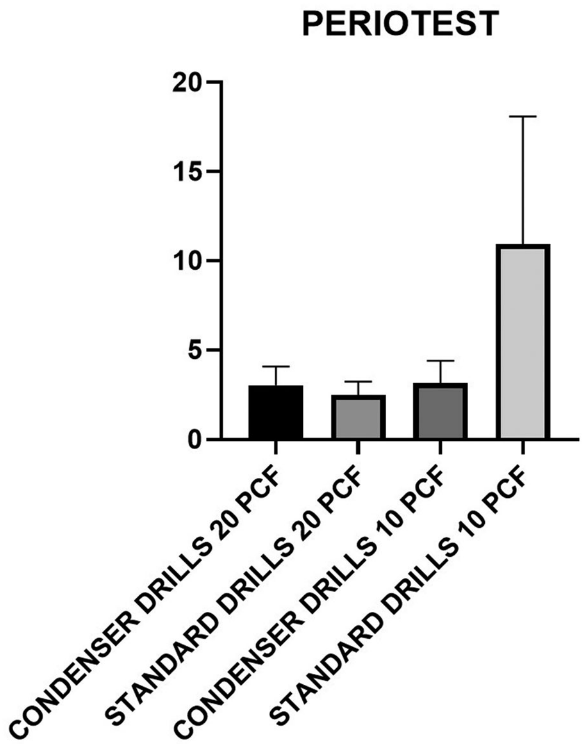

Figure 7. Periotest micromovement analysis means of the two different drilling preparation techniques.

2014). Nevertheless, the poor bone quality present in the posterior maxilla could represent a challenge for the obtaining of the primary stability of the implant fixture (Iezzi et al. 2005; Möhlhenrich et al. 2015).

In fact, as described in the literature, this anatomical region is often related by the presence of a poor corticalized bone and fine trabeculae and characterized by large marrow spaces (Iezzi et al. 2005).

Specific protocols, such as the under-preparation drilling technique, have been proposed for the implant site preparation in this region (Falisi et al. 2017). This is an operator-dependent technique that needs a very sensitive capability by the clinician during the procedure, with a careful control of the preparation depth (Falisi et al. 2017).

As reported in literature, the osseodensification drilling technique is a surgical procedure that induces the deposition of crusts of bone with a size of 0.1–0.3 mm (Huwais and Meyer 2017). On the contrary, the osteocondensation is a technique based on a plastic deformation of the bone walls around the implant site (Huwais and Meyer 2017; Huwais et al. 2018).

Both surgical techniques are generally proposed for the implant positioning in low-density bone, but in the present investigation, the experimental condition was also tested in D3 bone, while clinically and in case of immediate loading protocol could be necessary to achieve an optimal primary stability (Iezzi et al. 2005; Degidi et al. 2008).

In this investigation, an osteocondensing drilling protocol was evaluated *in vitro* on polyurethane blocks. As reported in a previous study by Comuzzi et al., the mechanical insertion of dental implant on different density of polyurethane blocks is able to standardize the site preparation and to successfully simulate the fixture stability after the positioning (Comuzzi, Iezzi, et al. 2019; Comuzzi, Tumedei, et al. 2019; Comuzzi, Tumedei, Pontes, et al. 2020; Comuzzi, Tumedei, Piattelli, et al. 2020).

The polyurethane model study is able to provide a standardized simulation for implant site preparation and fixture primary stability. On the contrary, the human bone is naturally characterized by anatomical and density variability, natural response to temperature and humidity that could represent potential limitations, and determinant factors for a translational comparison to the clinical condition (Cordioli et al. 2000).

In this study, a significant increase of stability of implant positioned by osteocondensing technique was reported; in fact, increased values of IT, RT were associated with the test group. An increased primary stability is related *in vivo* with higher survival rate in immediate implant (Olate et al. 2010).

Clinically, the lack of stability due to implant micromotions is considered in the literature a negative evidence that could be related to lower implant survival rate (Olate et al. 2010).

Moreover, higher level of fixture stability assessed by many very sensitive techniques, such as resonance frequency analysis (RFA) and Periotest, has been correlated with increased levels of implant bone-to-implant contact (BIC) *in vivo* on humans.(Scarano et al. 2006).

In fact, micromovement above 50–100 micrometers could negatively evaluate the osseointegration and bone remodeling, with the proliferation of soft and fibrous tissues producing bone resorption at the level of the bone-implant interface (Albrektsson et al. 2003).

Conclusions

According to these findings, the using of a systematic protocol sequence of osteocondensing drill could represent a clinical advantage for the clinician, in order to predictably achieve implant primary stability obtained in poor density bone regions.

Disclosure statement

The authors declare no conflict of interest for this research.

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