Healing at implant sites prepared conventionally or by means of Sonosurgery®. An experimental study in dogs

An atraumatic osteotomy preparation that avoids an increase in temperature is essential to achieve optimal healing outcomes in implant therapy [Eriksson & Alberksson 1983]. Increasing the temperature above 47°C in fact may produce necrosis and hence may inhibit bone repair [Eriksson & Alberksson 1983]. The temperature produced during drilling with conventional instruments may be influenced by the thickness of the cortical bone [Eriksson et al. 1984], the depth [Wiggins & Malkin 1976; Ercoli et al. 2004; Sener et al. 2009] and the speed of drilling [Costich et al. 1964], the sharpness of the drills [Lavelle & Wedgewood 1980], and the pressure applied to the drills [Matthews & Hirsch 1972]. Consequently, irrigation for cooling is considered to be an important prerequisite to maintain the temperature to a proper level aiming to avoid damage to the hard tissue structures [Eriksson et al. 1984; Brägger et al. 1995, Benington et al. 2002]. A comparison on heat production was made among different osteotomy preparations: conventional drilling, Piezosurgery® and SONICflex® [Heinemann et al. 2012]. The Piezosurgery® is an instrument that uses ultrasonic frequencies of 25–29 kHz, while the SONICflex® is an instrument that uses sound frequencies of 6 kHz at maximum. This in vitro experiment was performed in porcine mandibles under similar conditions of cooling with saline. An increased temperature of about 1.5°C, 18.2°C, and 2.3°C was found during osteotomy preparations for conventional drills, Piezosurgery® and SONICflex®, respectively.

Several clinical and experimental studies on the healing after using Piezosurgery® for implant recipient site preparation have been published [Preti et al. 2007; Di Alberti et al. 2010; Bengazi et al. 2014; Stacchi et al. 2013]. Only clinical studies [Agabiti 2011; Geminiani et al. 2011, 2013; Papadimitriou...
et al. 2012; Agabiti et al. 2014; Schmidt et al.
2013) have been published on the use of
sonic devices. Yet, there is a lack of histolog-
ic documentation of healing in recipient
sites prepared with instruments applying
sound frequencies.

Hence, the aim of this was to compare
peri-implant tissue healing at implants
installed in sites prepared with conventional
drills or with a sonic device.

Material and methods

The research protocol was submitted to and
approved by the local Ethical Committee for
Animal Research at the University of São
Paulo (protocol number 06.1.573.53.9).

Clinical procedures

Six Beagle dogs, each approximately 13–14 kg
and 1 year old, were selected. The animals
were pre-anaesthetized for any surgical proce-
dures with Acepran® 0.2% (0.05 mg/Kg –
Univet-vetnil, São Paulo, Brazil), sedated
with Zoletil® 10 mg/Kg (Virbac, EUA), and
the maintenance of the anesthesia was per-
formed with inhalation of Isoflurane® (Baxter
Hospitalar Ltd.).

The mandibular premolars and first molars
were extracted bilaterally, and 3 months after
tooth extraction, a crestal incision was bilat-
erally performed, and full-thickness muco-
periosteal flaps were elevated. Two experi-
mental sites were selected, in both sides of
the mandible. In the right side [control site],
the cortical bone was first perforated with a
guide drill, and then, osteotomies were pre-
pared using the first two drills of the prepara-
tion set [Medentis Medical GmbH, Dernau,
Germany]. Finally, a stop drill was used to
widen the coronal portion of the recipient
sites (Fig. 1). In the left side, the Sonosur-
gery® system (Dr. Ivo Agabiti, Pesaro, Italy)
was used [test site]. The system for implant
sites preparation includes the use of a sonic
instrument [Sonosurgery® Air Power, TKD,
Calenzano, FI, Italy; Fig. 2a], and of six
sequential inserts [Komet, Lemgo, Germany;
Fig. 2b]. After having perforated the cortical
bone with a guide drill, the preparation was
performed using sequentially all inserts
(Fig. 3 a-d).

Time of preparation of the recipient sites
from the first perforation to the end of
the site preparation including changes of drills/
inserts was recorded.

In both sides of the mandible, two
implants [ICX-Gold®, Medentis Medical
GmbH, Dernau, Germany] were installed
with the rough/smooth interface [M] flush
with the buccal bony crest [Fig. 4a]. In a low-
pressure plasma process, ICX-Gold implants
are equipped with a super-crystalline titanium
oxide layer. This ultra-thin nanostructured
layer provides the ICX-Gold implants with a
super-hydrophilic surface with a contact
angle of 0–5°.

Titanium healing cups (Bottle size, Meden-
tis Medical GmbH, Dernau, Germany) were

Fig. 1. The preparation set of drills. The first two drills on the left were used to prepare the osteotomies at the con-
trol sites.

Fig. 2. The Sonosurgery® system composed of [a] a hand-piece [Sonosurgery® Air Power] and [b] a set of six conical
inserts of increasing diameter.
affixed to the implants, and the flaps were sutured to allow a non-submerged healing in both sides of the mandible (Fig. 4b).

After the surgeries, the animals were given antibiotics for 10 days [Stomorgyl 10%, one tablet/10 Kg daily – Merial Saude Animal Ltd., Paulinia, Brazil], anti-inflammatory drugs were administered for 5 days [Maxicam® 2.0 mg, one tablet/20 Kg daily – Ouro Fino Saude Animal Ltd., Cravinhos, Brazil], and analgesics were given for 3 days [Tramal 50 mg®, 4.0 mg/Kg subcutaneous, every 8 h – União Química Farmaceutica Nacional S/A, Pouso Alegre, Brazil]. The animals were kept on concrete runs in kennels at the university's field facilities with free access to water and feed of moistened balanced dog's chow.

A daily inspection of the wounds for clinical signs of complications and healing abutment cleaning was performed. The sutures were removed after 2 weeks. The animals were euthanized 8 weeks after the surgery applying overdoses of Thiopental® [Cristalia Ltd., Campinas, Brazil].

**Histological preparation**

Individual blocks containing the implant and the surrounding soft and hard tissues were fixed in 4% formaldehyde solution followed by dehydration in a series of graded ethanol solutions and finally embedded in resin [LR White® hard grade, London Resin Company Ltd, Berkshire, UK]. The blocks were cut in a bucco-lingual plane using a diamond band saw fitted into a precision slicing machine [Exakt®, Apparatebau, Norderstedt, Germany] and then reduced to a thickness of about 50 μm using a cutting-grinding device [Exakt®, Apparatebau].

From each block, one or two histological slides from the central part of the implants were prepared and then stained with Steve-nel’s blue and alizarin red and examined under a standard light microscope for histometric analysis.

**Histometric evaluation**

In an Eclipse Ci [Nikon Corporation, Tokyo, Japan], equipped with a digital video-camera [Digital Sight DS-2Mv, Nikon Corporation] connected to a computer, the following landmarks were identified [Fig. 5]: the abutment/fixture connection (AF), the most coronal bone-to-implant contact (B), the top of the adjacent bony crest (C), and the top of the peri-implant mucosa (PM).

The following measurements were performed in μm at a magnification of ×100 using the NIS-Elements 4.1 [Nikon Corporation]: the vertical distance parallel to the long axis of the implant between AF and B (AF-B), AF and C (AF-C), and PM and AF (PM-AF). The rough/smooth coronal interface (M) was located 1.7 mm apically to AF. Consequently, M-B and M-C were calculated.
between test (sonic device) and control (drills) sites were analyzed using Wilcoxon signed rank test using IBM SPSS Statistics V.19 (SPSS Inc. Chicago IL, USA). The level of significance was set at $\alpha = 0.05$.

Results

In one dog, only one instead of two implants was installed in the right side of the mandible. After 8 weeks of healing, none of the implants were lost or mobile, and no complications occurred during the healing period. No artifacts were generated during histological processing, nor were any tissue blocks destroyed. Hence, test and control sites yielded an $n = 6$.

The time for the preparation of the two osteotomies was $315 \pm 44$ s. ($5^\prime 15^\prime$) for the test and $147 \pm 45$ s. ($2^\prime 27^\prime$) for the conventional drill sites, the difference being statistically significant (Table 1).

Histological evaluation

Figures 6a–b illustrate histological outcomes after 8 weeks of healing. Table 1 also reports data regarding hard tissue levels.

All implants appeared to be embedded into bone, and no major signs of inflammation were seen within the peri-implant soft tissues. The distance M-B was $0.7 \pm 0.7$ at the test and $0.5 \pm 0.3$ at the control sites. M-C was $0.3 \pm 0.3$ and $0.5 \pm 0.3$ at the test and control sites, respectively. None of the differences were statistically significant.

The MBIC% at the test sites was $65.4 \pm 11.4\%$, while, at the control sites, it was $58.1 \pm 10.1\%$, the difference not yielding statistical significance.

The distance PM-B was $3.1 \pm 0.4$ mm at the test sites and $3.6 \pm 0.3$ mm at the control sites. Again, no statistically significant difference was identified.

Discussion

The aim of the present study was to compare peri-implant tissue healing at implants installed in sites prepared with conventional drills or a sonic device.

The time to prepare the osteotomies was more than double for the Sonosurgery® compared to the conventional using a preparation set of the implant system used. This outcome is in agreement with another experiment in dogs (Bengazi et al. 2014), in which the time required for site preparation applying a Piezosurgery® instrument or conventional drills was compared. The time needed was 4–5 times longer for the Piezosurgery® compared with the conventional drill preparations. However, it has to be emphasized that, in that experiment, the time included also the change of the Piezosurgery® inserts. Furthermore, no drills were used to perforate the cortical bony layer at the Piezosurgery® sites.

In the present experiment, instead, two hand-pieces were used. While the surgeon was proceeding with the osteotomies using one hand-piece, an assistant was changing the insert in the other hand-piece hereby saving time. Furthermore, an initial drill was used to perforate the cortical layer at the test sites (Sonosurgery®). Both these procedures have speeded up the time for site preparation in the present study. In the aforementioned study (Bengazi et al. 2014), the time was taken for the preparation of a single site, while in the present study, the procedures were timed for multiple sites. This, in turn, means that the change of the inserts substantially prolonged the time spent for site preparation.

The use of the two different site preparations did not yield statistically significant differences in buccal bony crest resorption and in the location of the coronal level of osseointegration. This means that the use of the two systems did not affect the biological aspects of osseointegration. In the study mentioned above (Bengazi et al. 2014), a similar bony crestal resorption was observed between the two site preparations (Piezosurgery® and conventional drills). However, a statistically significant difference was found for the buccal coronal level of osseointegration.

Table 1. Time of preparation for two recipient sites and histological measurements of hard and soft tissue dimensions

<table>
<thead>
<tr>
<th></th>
<th>M-B buccal (mm)</th>
<th>M-C buccal (mm)</th>
<th>MBIC%</th>
<th>PM-B buccal (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test (Sonic device)</strong></td>
<td><strong>Control (drills)</strong></td>
<td><strong>Test (Sonic device)</strong></td>
<td><strong>Control (drills)</strong></td>
<td><strong>Test (Sonic device)</strong></td>
</tr>
<tr>
<td>Time (s)</td>
<td>315 (44)</td>
<td>335</td>
<td>0.7 (0.7)</td>
<td>0.8</td>
</tr>
<tr>
<td>M-B buccal</td>
<td>284; 314;</td>
<td>0.4; 0.5</td>
<td>0.3 (0.3)</td>
<td>0.3; 0.3</td>
</tr>
<tr>
<td>M-C buccal</td>
<td>147 (45)</td>
<td>0.6</td>
<td>0.5 (0.3)</td>
<td>0.5; 0.5</td>
</tr>
<tr>
<td>MBIC%</td>
<td>65.4 (11.4) 62.6; 67.9;</td>
<td>72.4</td>
<td>58.1 (10.1) 51.3; 57.2;</td>
<td>3.1 (0.4) 2.8; 3.1;</td>
</tr>
<tr>
<td>PM-B buccal</td>
<td>64.7</td>
<td>3.8</td>
<td>3.6 (0.3) 3.5; 3.7;</td>
<td>3.6 (0.3) 3.5; 3.7;</td>
</tr>
</tbody>
</table>

Mean values, standard deviations (SD) and percentiles 25th, 50th (median), and 75th in millimeters. M, coronal rough/smooth limit; B, coronal end of osseointegration; C, top of the bony crest; PM, peri-implant mucosa.

* $P < 0.05$ between test and control.
the position being more coronal at the conventional drill compared to the Piezosurgery® sites.

The bony crestal resorption at the marginal aspect of the implants is a healing phenomenon occurring already in the early phases of healing (Rossi et al. 2014) and that may be related both to the surgical trauma for the elevation of the flaps as well as to the establishment of the biological width. The detachment of the periosteum from the bone during flap elevation, in fact, may decrease the capability of the periosteum for deposition of new mineralized bone matrix (Melcher 1969; Melcher & Accursi 1971) and may compromise the blood supply to the bony surface, hereby leading to osteoclast activation and bone resorption (Wideman 1963; Staffileno et al. 1966; Wood et al. 1972). Moreover, during healing, a biological width will be established within 6–8 weeks, reaching a vertical dimension of about 3.5 mm in 8–12 weeks (Berglundh et al. 2007). At the time of implant installation, the implant surrounding mucosa usually revealed a width that may be thinner in dimension than the biological width established after complete morphogenesis of the soft tissue surrounding the implant. This, in turn, means that at least a part of the marginal alveolar bone may be resorbed to allow the development of proper dimensions of the peri-implant soft tissues (Berglundh & Lindhe 1996; Bengazi et al. 2014, 2014a,b; Baffone et al. 2013).

The MBIC% was slightly higher at the test (65%) compared to the control (58%) sites. However, the difference did not reach statistical significance. This, in turn, means that osteotomies performed with the Sonosurgery® allow adequate osseointegration at implants. This is in agreement with another study (Bengazi et al. 2014), in which no statistically significant differences were found in osseointegration at implants installed in sites prepared conventionally or with a Piezosurgery® instrument. Moreover, the fact of very similar osseointegration outcomes resulted from preparations with conventional drills or Sonosurgery® documented the biological basis for the application of the latter in implant therapy.

Although optimal healing outcomes with high proportions of direct bone-to-implant contact and maintained coronal levels of osseointegration were documented in the present study, it has to be realized that very little is known about the sequential events in the early phases of healing. Such healing sequences were only studied in two animal sequences were only studied in two animal
References


