Mineralized Tissue Formation Associated With 2 Different Dental Implant Designs: Histomorphometric Analyses Performed in Dogs

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The clinical success of dental implants might be associated with such factors as installation technique, implant shape, size, material, and screw threads. Therefore, the aim of this study is to analyze mineralized tissue formation on the screw threads of conical and cylindrical dental implants. This study includes 7 beagle dogs that had the lower premolars extracted. Three months after bone and soft tissue repair, 2 different designs of dental implants (1 conical and 1 cylindrical) were installed in each hemimandible using a nonsubmerged technique. Both implants when installed had different shape and thread, as revealed by scanning electron microscopy. Six weeks after implant installation, animals were killed and submitted to histomorphometric analysis. Cervical, middle, and apical areas were analyzed. Statistical analysis was carried out using Student t test at a significance level of $P < .05$. Statistically significant differences were not found between the conical and cylindrical implants. The conical implants presented fewer threads, a smaller area, and more bone formation when compared with the cylindrical ones, without significant differences ($P = .1226$). The highest values concerning bone formation were observed for the cervical area ($P = .4005$), and the lowest for the apical area ($P = .1899$); however, no statistically significant difference was observed. In conclusion, no statistically significant difference was observed in thread bone formation between the cylindrical and conical implant designs when placed using the nonsubmerged technique.

Key Words: implant design, osseous repair, histomorphometric analysis

INTRODUCTION

New dental implant designs and improvement in clinical techniques have led to dental implant clinical studies reporting success rates exceeding 90%.1 Implant designs and other surface
characteristics are known to provide enhanced bone anchorage. Various implant systems aimed at improving bone integration have been developed.\(^2,3\)

Siegele and Soltesz\(^4\) reported that conical and stepped implants might result in distinctly higher stress to the bone than cylindrical and screw-shaped implants. Stress is dissipated more evenly along the stepped implant when compared with straight implants. However, Del Valle et al\(^5\) demonstrated that implants with different geometries, but similar diameter, demonstrate no differences in strain levels on surrounding bone. Furthermore, Sakoh et al,\(^6\) in an in vitro study, investigated the difference between conical and cylindrical screw designs regarding primary stability, concluding that better stability was achieved with conical implant systems.

Osseointegration is a dynamic process that can be associated with implant design.\(^7\) Büchert et al\(^8\) demonstrated that bone/implant interface association is related to the combination of final burr and the self-threading properties of the implant. Electron microscopy examination at day 28 of implant/bone interaction with a conical implant system demonstrated advanced mineralized tissue contact on the implant surface. Several investigators have described the use of instrumentation such as the Periotest and resonant frequency analysis to quantify osseointegration and micromobility of dental implants. However, histomorphometric analysis is more efficient in quantifying mineralized tissue or bone formation surrounding implants.\(^9,10\)

The present study is aimed at analyzing mineralized tissue formation with screw thread conical and cylindrical dental implants.

**Materials and Methods**

**Experimental model**

Seven male beagle dogs, aged 3–5 years, with body weight ranging from 10.4–21.3 kg, were offered water (ad libitum) and a commercial diet. Lower premolars on both sides were extracted, and the extraction sites were allowed to heal for 3 months before implant placement. Two cylindrical (Neodent, Curitiba, Brazil) and two conical (Conexa, Sào Paulo, Brazil) implants, 11 mm in length and 3.75 mm in diameter, were installed in each hemimandible. This study was approved by the Ethics Committee for Animal Research at the State University of Campinas (#1261-1).

**Surgical procedures**

All surgical procedures were performed in a veterinary surgical room under general anesthesia: intramuscular ketamine (10 mg/kg), atropine (0.06 mg/kg), and xylazine chlorhydrate (0.03 ml/kg). Analgesic medication was administered with metamizole (25 mg/kg) after surgery. The first and second surgeries (extraction of bicuspid teeth and implant installation) also involved the systematic removal of tooth debris and calculus.

Before implant placement, a mucoperiosteal flap with a linear incision was created to expose the bone area. Sockets were drilled using a handpiece at 1500 rpm with continuous external saline irrigation. The final burr used was 3.0 mm in diameter for each implant, as per the manufacturer’s instructions. Manual tapping into the sockets was performed while the implants were placed. The shoulder of each implant was 1 mm below the ridge crest. The healing collar was inserted, allowing permucosal exposure a nonsubmerged technique. Postoperatively, animals were placed on soft, commercially available diets. The dogs were sacrificed 6 weeks after implant insertion by induction of deep anesthesia followed by an intravenous overdose of sodium pentobarbital.

**Histomorphometric analysis**

Specimens were immersed in 4% formalin and embedded in resin using a routine histologic technique. Cuts were made longitudinally to the implant and were stained...
with hematoxylin-eosinophil solution for polarized light microscopy analysis. Histo-
morphometric analyses were reported as percentage obtained on linear analysis. The
mineralized tissue around the threads (valleys) in the cervical, middle, and apical areas
was measured at ×50 magnification.

**Scanning electron microscopy**

Scanning electron microscopy (SEM) analysis (JEOL-JSM, 5600LV model, Electron Micros-
COPY Center of Piracicaba Dental School, Campinas, Brazil) was done before implant
installation at ×25 and ×30 magnification; implant morphology was analyzed by exam-
ining the thread morphology of cervical, middle, and apical areas separately.

**Statistical analysis**

The data were recollected in specific tables for descriptive analyses. Comparative study be-
 tween implants and the cervical, middle, and apical areas was performed with Student t test
for paired analysis, with BioStat 5.0 software (AnalystSoft, Vancouver, British Columbia,
Canada). Mineralized areas surrounding implant threads were submitted to statistical
analysis at a significance level of $P < .05$.

**Results**

No fibrous tissue or mobility was observed for any of the 11 cylindrical and 13 conical
implants. None of the implants demonstrated signs of tissue infection or other complica-
tions. Soft tissue reparation occurred normally.

Histologic analyses of the cylindrical and conical implants were comparable, with
bone presence in cervical, middle, and apical areas of the implants. All samples demon-
strated bone repair, with quantitative differences in collagen fibrous and mineralized
tissue. Some samples presented clear differences between old bone and new bone.
Osteoblast activity with signs of osseous apposition was observed.

**Scanning electron microscopy**

Cylindrical and conical dental implants demonstrated several differences. Conical im-
plants presented 3 mm on cervical area without threads and 19 threads in total, show-
ing a shallower groove when compared with cylindrical implants (17 threads) (Ta-
ble 1). Conical implants showed greater depth valleys in the apical areas, when
compared with the middle and cervical areas (Figure 1). For both implants, the manufac-
turer provided surface treatment by removing titanium via acidification.

**Histomorphometric analysis**

Bone formation within threads had mean values of 29.0% ($\pm$12%) for conical implants
and 22.7% ($\pm$9.1%) for cylindrical implants; no statistically significant difference ($P =
.01226$) was observed.

Conical implants demonstrated mean values of 31.3% ($\pm$22%), 28.6% ($\pm$18.1%), and
27.0% ($\pm$23.6%) for cervical, middle, and apical bone formation, respectively; cylindri-
cal implants showed mean values of 24.7% ($\pm$14.9%), 26.3% ($\pm$10.8%), and 17.1%
($\pm$6.3%) for cervical, middle, and apical bone formation, respectively (Table 2). The highest
values concerning bone formation were

<table>
<thead>
<tr>
<th>Unit Analysis</th>
<th>Number of Threads</th>
<th>Depth of the Valley</th>
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<tbody>
<tr>
<td></td>
<td>Conical</td>
<td>Cylindrical</td>
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<tr>
<td>Cervical area</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Middle area</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Apical area</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>

**Table 1**

Scanning electron microscopy morphology differences between 2 dental implant designs
observed in the cervical area ($P = .4005$; Figure 2), and the lowest in the apical area ($P = .1899$; Figure 3).

**DISCUSSION**

New bone formation is often attributed to implants’ biomechanical factors (eg, shape, length, diameter, material, surface characteristics) and to patient characteristic (eg, bone quality, occlusal forces, systemic health).11–13 More mineralized tissue was observed in the cervical area of conical implants with minor depth valleys; minor mineralized tissue was observed in the apical area of cylindrical implants, also showing minor depth valleys. Cylindrical implants demonstrated the same thread morphology in the

<table>
<thead>
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<th>Table 2</th>
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<tr>
<td>Percentage and statistical results of bone presence within threads in 2 dental implant designs on histomorphometric analysis</td>
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<tr>
<td>Unit Analysis</td>
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<tr>
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</tr>
<tr>
<td>Implant</td>
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<tr>
<td>Cervical area</td>
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<td>Middle area</td>
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<td>Apical area</td>
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The effect that threads have on bone remodeling and on bone density might be related to an increase in the length of tips and a decrease in their groove depth. Less dense bone is found to be formed around implants without threads, when compared with those having threads. The overall contour of an implant affects the bone density distribution. Tada et al. showed that threads serve as an auxiliary for tension distribution. However, in the present study, it is unclear whether thread characteristics might increase or decrease bone formation. Minor threads in cervical areas and major threads in apical areas apparently show better results regarding bone formation. Therefore, implant shape might be of greater importance than thread morphology.

Bone formation was more consistent in the cervical areas when compared with the apical areas. This can be associated with force direction and stress distribution. Quaresma et al., in an in vitro study, reported similar von Mises stresses for both cylindrical and conical implants, in accordance with results reported by Holmgren et al.; however, other studies have suggested that conical and stepped implants might impart distinctly higher stresses than cylindrical ones. Petri and Williams showed a homogeneous stress distribution with greater stress concentration in cervical areas.

When excessive stress is distributed to the bone, bone loss may occur. This may be associated with the normal bone resorption observed around the implant cervical area after loading for a short time. Hermann et al. associated the cervical normal bone resorption effect with bone adaptation.
through a self-limiting phenomenon. Because of this, initial bone formation in cervical areas can provide better support and hopefully can decrease the postloading phenomenon of bone loss in this area. Minor thread architecture with a conical design in cervical areas offers a potential solution for this issue.

CONCLUSION

The shape of implants and their threads had no influence on bone formation; no statistically significant difference was observed between cervical, middle, and apical areas of cylindrical and conical implants.

ABBREVIATIONS

HE: hematoxylin and eosin
SEM: scanning electron microscope

REFERENCES


