Effect of Rotary Instrument Mineral Oil Lubricant on Osseointegration: A Randomized, Blinded Study in Rabbits

Arturo Sánchez-Pérez, MD, PhD1*
Ana Belén Cano-Tovar, DDS2
José Javier Martín-de-Llano, PhD3
Francisco Javier Sarobe-Oyarzun, MD4
Scott Davis, BDS, MDSc5
Carmen Carda-Batalla, MD, PhD3

The mechanisms of early failures in dental implant osseointegration are unclear. A possible cause of low levels of bone formation is lubricant contamination on implants during insertion. To explore the impact of lubricant contamination on dental implants, we used 5 New Zealand rabbits and inserted 2 implants per tibia in each animal for a total of 4 implants per animal (20 implants in total). In general, bicorticalization was achieved. The first implant was placed as suggested by the manufacturer with no lubricant used (control). The second implant was placed using a freshly lubricated contra-angle handpiece, which was used only for the test implants. Implant allocation was randomized, and the examining histologist was blinded to the results. All implants were placed by the same surgeon. The animals were maintained in accordance with animal experimentation guidelines. None of the implants failed to osseointegrate. Moreover, no significant difference was observed between the test and control groups. Based on the results of this study, the use of rotary instrument mineral oil lubricant did not jeopardize the osseointegration of dental implants in New Zealand rabbits.

Key Words: biomaterial(s), experimental design, implantology, osseointegration, risk factor(s)

INTRODUCTION

Osseointegration is defined as a direct structural and functional connection between ordered, living bone and the surface of a load-carrying implant.1,2 Biocompatibility, a critical factor in bone-implant integration, depends on surface physicochemical properties such as surface topography, wettability, and chemical composition.3–5

The surface of an implant must behave as a biologically inert structure to achieve osseointegration,6–9 and the physical and chemical nature of the surface appears to be important.10 To date, one aspect that has not received adequate attention is the possible contamination of the implant surface during insertion. A possible cause of such contamination is the lubricant used to maintain rotary instruments.

Due to precision mechanics, moving internal parts and high strain, rotating instruments, (such as turbines and handpieces) require daily maintenance. The operation of rotatory instruments in the clinic is important, especially with respect to cleaning, disinfection and lubrication. In general, manufacturers recommend regular lubrication of rotary instruments at least twice a day, as well as before each sterilization and after a prolonged period of non-use (eg, holidays).

The lubricants used for rotatory instruments have an oily, hydrophobic component that alters implant wettability, thereby complicating cell recruitment, differentiation, and maturation.11,12

Our clinical question refers to whether the use of a lubricated counter-angle versus the non-lubricated one represents a risk for osseointegration.

The justification for this clinical question is based on the existence of brush counter-angle that require lubrication and those that do not have brushes and are maintenance-free.

The aim of the present study was to compare if the alveoli prepared with lubrication had a lower contact rate between the bone and the implant compared to the beds prepared with brushless and non-lubricated counter-angles.

Our research question is based precisely on the absence of evidence of its effect (positive, neutral or negative) on dental implants.

MATERIAL AND METHODS

Animals used in the experiments

Five adult New Zealand rabbits weighing 3–3.5 kg from the animal housing facilities of the University of Murcia were used, and the guidelines for the use of animals for experimentation purposes were strictly observed (Spanish Royal Decree 53/2013 of 1 February, as published in Official State Bulletin no. 34 of 8
Each rabbit had an ear tab with an identifying number and received 2 implants per tibia for a total of 4 implants per animal (20 implants in total).

The study was carried out following approval by the ethics committee of the University of Murcia. All personnel in charge of the experimental work were completely qualified.

Randomization

The distribution of the sockets and implant insertion sequences was established by computer randomization (https://www.random.org; Random.org, Dublin, Ireland). The result was kept in a closed envelope until the time of the intervention. During this time, an envelope was chosen at random and labeled with the identification number of the animal.

Implants

Twenty conventional implants (InHex Ticare, Mozo-Grau, Valladolid, Spain) were used without modification. The implants measured 3.3 mm in diameter and 8 mm in length. The implant surfaces had received resorbable blast media (RBM) treatment.

Surgical procedures

Anesthesia

The rabbits were anesthetized with an intramuscular injection of medetomidine (0.15 mL/kg) and ketamine hydrochloride (0.35 mL/kg). Teichoic acid was used to shave the skin in the operating zone, followed by disinfection with 70% ethanol and chlorhexidine. Local lidocaine with 1% adrenaline was then applied.

Surgical Technique

A 5-cm incision was made on the internal surface of the tibia using a number 15 scalpel. The periosteum was raised to allow full visualization of the tibia. A graded metal template was used to perform osteotomies under refrigeration with abundant saline irrigation solution at room temperature. An adequately calibrated (as recommended by the manufacturer) surgical motor was used to prepare the implant beds, and the drill speed was set to 800 rpm with a torque of 20 N. The implants were distributed, and the contra-angle handpiece was lubricated or not, which depended on whether a test or control implant, according to the random envelope opened. Five New Zealand rabbits were used, and each animal received 2 implants per tibia for a total of 4 implants per animal (20 implants in total).

After surgery, suturing was performed with a Vicryl 4/0 suture in two planes (Ethicon, Johnson & Johnson, Somerville, NJ). Adequate analgesia was maintained with slow-release fentanyl patches, and the treatment was continued with a daily maintenance dose. Surgical wound infection was prevented by adequate surgical asepsis, periodic wound cleaning, and the use of penicillin (60 000 IU/kg every 24 hours). All animals were maintained for 2 months after the intervention until sacrifice.

Control Implantation Procedure

The sockets were prepared with a non-lubricated contra-angle handpiece, followed by insertion of the implant with no modification or lubricant-induced contamination, as instructed by the manufacturer. Control handpieces were not lubricated at any time, neither before nor after surgery in each animal.

Lubricant Quantity

To determine the quantity of lubricant applied, we established a standardized time of application. Two consecutive applications of 3 seconds each were performed. To determine the amount of lubricant supplied in each application, we performed 10 sprays on a precision scale with a measurement error of 0.1 g at a controlled, ambient temperature of 20°C. The volume was calculated using the density of the product given by the manufacturer (0.853 g/cm³ DIN 51757). The estimated quantity of lubricant used in terms of weight and volume was determined, and the results are shown in Figure 1.

Contamination Procedure

Before osteotomy, the randomized socket was prepared with a freshly lubricated specific contra-angle handpiece with two consecutive applications lasting 3 seconds each. This contra-angle handpiece was used only to create the socket and insert the corresponding implant. A mineral oil lubricant was used (KaVo Dental GmbH, Wiesbaden, Germany).

Postoperative care

The rabbits were allowed to heal for 2 months in the housing facilities where they received a suitable diet with free access to water.

Sacrifice

The rabbits were sacrificed with intravenous pentobarbital following the administration of ketamine/xylazine. The tibias were then removed and immersed in 10% buffered formalin solution.

Histomorphometry

A small electric saw was used to obtain sections of the tibia containing each implant. Implant samples were dehydrated by sequential solvent exchange in 70% ethanol, absolute ethanol, and xylol (twice) for 24 hours each. Next, the sections were
embedded in methyl methacrylate, followed by methyl methacrylate containing poly (methyl methacrylate; average Mw \( \sim 996\,000 \); 5 g/100 mL) for 5 days each. After the addition of benzoyl peroxide (1 g/100 mL), samples were polymerized at room temperature for several days and sawed using a diamond wheel on a precision table top cut-off machine (Accutom-5, Struers, Cleveland, Ohio). The samples were wet-ground and polished using a LaboPol-21 system (Struers) and SiC foils. After reaching the central portion of the implant, the surface was further polished with diamond paste of decreasing grain sizes and stained for 30 minutes at 55\(^\circ\)C with 0.1% toluidine blue in 0.1 M sodium phosphate, pH 3.5. Digital images of the cortical bone surrounding the implant threads were obtained with a bright field Leica DM4000 B microscope and a DFC420 digital camera using a 10\(\times\) objective. Bone-to-implant contact (BIC) was evaluated using the image processing program ImageJ 1.48 (http://imagej.nih.gov/ij, National Institutes of Health, Bethesda, Md).

**Statistical Analysis**

Two statistical analyses were performed for BIC. The first analysis was performed for the entire surface of the implant (total BIC), and the second was performed only for the cortical area (cortical BIC). We performed two analyses to avoid a confounding variable, the large cavity of the fat marrow in a rabbit tibia. We decided to use a Mann-Whitney \( U \) test as a nonparametric alternative test because an independent variable BIC is not normally distributed.

SPSS version 19.0 (SPSS Inc, Chicago, Ill) was used for statistical comparisons and calculations. Statistical significance was set at \( P < .05 \). Mann-Whitney tests were used with an estimated power of 95%.

Results were reviewed by an independent statistician (http://estadisticamurcia.com/web/#2).

**RESULTS**

All animals completed the healing phase, and there were no postoperative complications. No inflammation was detected in any of the 20 samples. BIC was successfully measured in all samples.

The weight and volume of each lubricant application were calculated using the following formula: \( W \times D = V \) (\( W = \) weight, \( D = \) density, \( V = \) volume). The density at 20\(^\circ\)C was provided by the manufacturer (\( D = 0.853 \)). No significant difference was found among lubricant applications.

The histometric images show the position of the implant in the tibia, especially the cortical zone, which interests us here (Figures 2 and 3).

The average total BIC of the entire sample was 25.03% (IC 19.29–30.77). The total BIC values for each group were as

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**FIGURES 2 AND 3.** Figure 2. Morphometric analysis of the bone-to-implant contact (BIC) length of a lubricant-contaminated implant in animal 3’s left tibia. The left and right thread images showed correspond to merged microphotographs obtained with a 10\(\times\) objective. The contact (red) and no contact (yellow) lines used to calculate BIC are highlighted (note that the widths of the original lines used to calculate the contact length were much thinner). Toluidine blue staining. Bar = 200 \(\mu\)m. Figure 3. Microscopic image of the cortical region of a control implant in animal 3’s right tibia. Toluidine blue staining. \( \times 1.6 \) objective. Bar = 500 \(\mu\)m.
follows: control = 24.78% (IC 16.23–33.33) and test = 25.27% (IC 15.82–37.72; Figure 4).

The average cortical BIC of the entire sample was 26.03% (IC 20.23–31.83). The cortical BIC values for each group were as follows: control = 26.83% (IC 17.70–35.96) and test = 25.24% (IC 16.19–34.28). No significant difference was found between the two groups (Figure 5).

No significant difference was found among the different lubricant applications for the total BIC or cortical BIC. The results are presented in the Table.

**DISCUSSION**

The early loss of dental implants is often due to failed bone healing.13 This failure is considered to reflect the existence of inflammation, which is incapable of evolving toward regeneration.14 Berglund estimated that the frequency of these early failures prior to functional loading was approximately 2.5%.15 In a recent literature review, the early failure rate varied between 1.2% and 3%,16 although other authors found a much lower failure rate frequency of 0.6%.17

The causes and mechanisms of early implant failure are unclear, and different studies have found a variety of statistically significant factors associated with implant failure, including age, gender, systemic diseases, smoking,18 edentulism type, implant location,19 bone quantity and quality,20 and implant length and diameter.21 Immunological and genetic factors are also associated with early implant failure.16,22–27 Furthermore, the surface features of implants influence healing of the surrounding bone. According to a previous study, the bone-implant interface is positively correlated with the increasing roughness of the implant surface.28 For example, the use of rough surfaces showed that osseointegration can be achieved in 6 weeks.29,30 Wettability and chemical composition, both of which influence the first phases of cell-material interactions,4 are directly affected by surface topography.3–5 That said, since we used the same implants in this study, none of these variables were affected.

However, this increased reactivity of the implant surface also involves greater susceptibility to contamination and colonization, which paradoxically impairs the final result. Several factors, such as bacterial contamination31 or the adhesion of endotoxins32–34 and other external contaminants35,36 could jeopardize osseointegration. A possible cause of external contamination of the implant surface may be related to the use of lubricants. The lubricant used during the manufacturing process and the oil used during implant insertion may be responsible for contamination.

The lubricants used in the machining of implants are among the most important contaminants of the implant surface36, the chemical compounds observed on the implant surface correspond to fatty acids and amides found in the lubricant used. In this respect, ultrasonic treatment is very important in the cleaning process because it improves clearance of organic contaminants.37

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**TABLE**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD*</th>
<th>CI**</th>
<th>Median</th>
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</thead>
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<tr>
<td><strong>Total BIC</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>24.78</td>
<td>11.94</td>
<td>16.23–33.33</td>
<td>22.66</td>
</tr>
<tr>
<td>Lubricated</td>
<td>25.27</td>
<td>13.21</td>
<td>15.82–34.72</td>
<td>26.59</td>
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<tr>
<td><strong>Cortical BIC</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>26.83</td>
<td>12.76</td>
<td>17.70–35.96</td>
<td>24.02</td>
</tr>
<tr>
<td>Lubricated</td>
<td>25.24</td>
<td>12.64</td>
<td>16.19–34.28</td>
<td>25.55</td>
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</table>

*SD indicates standard deviation; CI, 95% confidence interval; BIC, bone-to-implant contact.
The second type of contamination may be related to the use of rotary lubricants during insertion. Dye-marked oil tests have revealed that oil may be discharged for at least 40 minutes from high-speed air turbines in the direction of the bur. Gravimetric tests showed that oil continued to be discharged up to at least 240 minutes and that the usual practice of removing excess lubricant by running the device for 1–2 minutes was ineffective in preventing cut-surface contamination. In another study that focused on the possibility of transmitting cross infections, it was impossible to completely eliminate the bacterial load present in the handpieces. For this reason, an additional heat treatment is recommended. Thus, comprehensive maintenance should be carried out after each use.

Based on the results of our study, the use of a lubricant posed no risk to the osseointegration of dental implants in rabbits. Because there are no similar studies in the literature, our results cannot be compared with other studies. Two months after implantation, none of the negative effects of the lubricant used in the rabbits reached statistical significance.

The limitations of this study include the use of a rabbit as an experimental model. The wound-healing abilities of rabbits are high speed and much faster than those of humans; rabbit wound healing is between 2 to 3 times faster than human wound healing. Other limitations include the large, fatty medullar spaces in the rabbit tibia—spaces not similar to human bone and thus complicated to evaluate. We attempted to avoid this limitation by taking both the cortical BIC and total implant surface into account. Another limitation is the final quantity of lubricant applied over the implant surface or bone preparation. We cannot be entirely certain of the lubricant quantity that exited the contra-angle spray and can be certain only regarding the amount of lubricant administered. The final limitation is that we determined that only one specific mineral oil lubricant did not alter bone healing around the dental implant. We cannot conclude whether natural or synthetic oil lubricant did not alter bone healing around the dental implant. We cannot be entirely certain of the lubricant quantity applied over the implant surface or bone preparation. Therefore, an additional heat treatment is recommended. Thus, comprehensive maintenance should be carried out after each use.

Finally, this study was conducted with a single implant that received surface treatment with RBM. Other surfaces or marks may behave differently.

CONCLUSIONS

Based on the results of this study, the fresh lubrication of handpieces with a specific mineral oil had no detrimental effect on osseointegration.

ABBREVIATIONS

BIC: bone-to-implant contact
RBM: resorbable blast media

ACKNOWLEDGMENT

We thank Dr Carlos Cachazo Jiménez for assisting in the completion of surgeries.

NOTES

This study was funded by a contract between the Office of Transfer of Research Results and the company Mozo Grau. The authors report no conflicts of interest.

REFERENCES


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