THE EFFECT OF DUAL ACID TEXTURING IMPLANTS ON BONE ONGROWTH -
AN UNLOADED IMPLANT MODEL IN AN EXPERIMENTAL CANINE STUDY

INTRODUCTION:
Treatment of osteoarthritis and rheumatoid arthritis by total joint replacement generally shows a high success rate; however challenges remain, particularly in improving revision implant fixation. Prostheses with a roughened surface inserted without cement are popular worldwide, especially for younger more active patients. Early bone ongrowth is known to be critical to long-term fixation of implants, and it is known that new bone forms better on a textured surface than on a smooth surface. Acid etching is a method of surface roughening whereby material is removed without applying stress on the adjacent metal and without leaving embedded particles. Experimentally, surface texturing by acid etching appears to induce bone formation in vitro and enhance the potential for implant integration in vivo (Keller). The resulting topography of an etched implant relies on the acid mixture, etching time, temperature and roughening prior to etching. Depending on the etching conditions, the process can create pits of depth and roughness on the micrometer scale.

In this study we compare titanium alloy implants with a surface that has a primary coarser texture made by a chemical milling process, to implants with a secondary dual acid etched texture surface. We hypothesize that a dual-acid-etched textured surface superimposed on a non-particulate roughened implant surface will improve the bone ongrowth at the bone-implant interface.

METHODS:
A paired and controlled experimental canine study was carried out following approval of our Institutional Animal Care and Use Committee. Cylindrical plasma sprayed titanium (Ti-6Al-4V) implants 12 mm in length and 6 mm diameter were used. Two different implant surfaces were investigated: (1) Dual acid etched micro-textured implants (DAE) and (2) Chemical milled textured implants (control). The dual acid etching process was time and temperature controlled using HF/HF-HCL. The control implants were textured by forming a random irregular pattern through repetitive masking and chemical milling. The dual acid etched microtexture was superimposed on the central 6 mm section of the control implants.

In 8 skeletally mature dogs, bilateral implants were inserted unloaded and press-fit in the extraarticular cancellous bone site of the proximal tibia (Figure 1). The implant bed was under-drilled 0.1 mm. Animals were allowed unrestricted weight-bearing and play time. There were no postoperative complications. Specimens were obtained at 4 weeks, and were frozen until preparation.

RESULTS:

Figure 2: Histomorphometry

Histomorphometry: Using stereological methods, unbiased vertical sections were obtained after random rotation of the central 5.0 mm blocks. Four serial sections of 20 µm were secured from the centre of the implant. Computer assisted histomorphometry was performed blindly in random specimen order using a CAST-grid system (Olympus Denmark). Tissue ongrowth was defined as tissue directly at the implant surface, and was determined using linear intercept technique. Ongrowth was expressed as tissue fraction.

Statistics: A non-parametric analysis was applied since differences between pairs did not follow a normal distribution. After Kruskal-Wallis on Ranks, the Wilcoxon sign ranks test was used to compare specimens pairwise. P-values less than 0.05 are considered statistically significant. Data are accordingly presented as median and interquartile ranges.

DISCUSSION:
In this study we aim to determine whether a positive bone response is observed around a titanium alloy implant with a surface that is textured by a dual acid etching (DAE) superimposed on a surface primary roughened by a chemical milling process (control).

A significant two fold median increase was seen for bone ongrowth on the acid etched surface (median 36.1%, interquartile range 24.3%-44.6%) compared to control (18.4% (15.6%-20.4%). All the dual etched implants showed more bone ongrowth than their contralateral control implants. The fraction of fibrous tissue at the implant surface was significantly less for dual acid textured implants.

In accordance with our hypothesis, the implants with a dual acid etched surface showed more bone formation. Osseointegration of implants depends on a number of factors such as implant metal and topography, loading conditions and implant bed, and osteoblasts are known to be sensitive to subtle differences in surface roughness and surface chemistry. It is unclear from our study whether the acid etching process stimulates bone formation by topographic roughness alteration of the surface or if the etching process alters the electrochemical properties of the implants surface.

In conclusion, this study showed promising results with increased bone formation of titanium alloy implant surface textured by a dual acid etching process. These results are limited to an unloaded pressfit setting, in a four week observation period in a canine model. The potential for dual acid etched implants to improve implant fixation warrants further experimental study.

REFERENCES:

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