

# THE EFFECT OF DIAMOND LIKE CARBON AND HYDROXYAPATITE COATINGS ON SOFT TISSUE REACTIONS TO EXTERNAL FIXATION SCREWS UNDER LOAD

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## INTRODUCTION:

The most common problem in external fixation is failure at the pin-bone interface which manifests as pin loosening and may lead to pin tract infection<sup>(1)</sup>. A soft tissue seal between the implant and the epidermis would prevent infection<sup>(2)</sup>. Prevention of biofilm formation by selecting surfaces that prevent bacterial colonisation would also be beneficial. Diamond like carbon (DLC) is a low surface energy coating that can be applied to the implant, which may reduce biofilm formation and subsequent infection.

Hydroxyapatite (HA) has been used as a suitable coating for external fixation pins. However, there is limited information about soft tissue reactions to HA coated pins and these have not previously been compared to DLC and uncoated stainless steel pins.

## HYPOTHESIS:

DLC and HA coatings on stainless steel pins will modify integration of the implant with soft tissues.

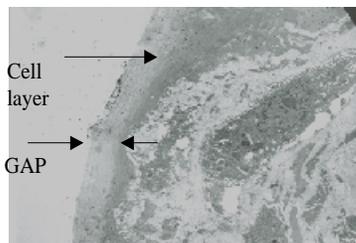
## MATERIAL AND METHODS:

An Orthofix ovine external fixator was used to insert six self-tapping pins (numbered 1 to 6) in a proximal to distal direction trans-cortically into the right tibia of 32 skeletally mature Friesland ewes. The fixator was used to stabilise a 3 mm osteotomy made between pins 3 and 4. Animals were divided into four groups comprising of; stainless steel (Group 1, n=8), fully coated HA (Group 2, n=8), DLC (Group 3, n=8) and HA coated threads (Group 4, n=8).

Animals underwent euthanasia at 10 weeks and tibia specimens were harvested from pin site 2 for routine resin sectioning and histology to determine the extent of soft tissue integration of the implants. Samples were harvested from pin site 3 for transmission electron microscopy (TEM) of the soft tissue pin interface. Samples were also harvested from pin site 5 for scanning electron microscopy (SEM) to assess the presence of biofilm formation and from pin site 6 for microbiology analysis. For microbiological analysis, immediately after sacrifice, the soft tissue interface around the pin was removed aseptically and the pin surface in this region was swabbed. The number of bacteria within the swab was determined. Data are presented as mean  $\pm$  SD.

## RESULTS:

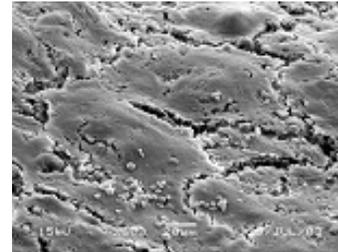
TEM results showed that there was no indication of direct contact of any implant with epithelium (Fig. 1). In all cases there appeared to be a layer of protein deposited on the surface of the pin with cellular debris attached. A 20 $\mu$ m gap exists between the tissue and this deposit.



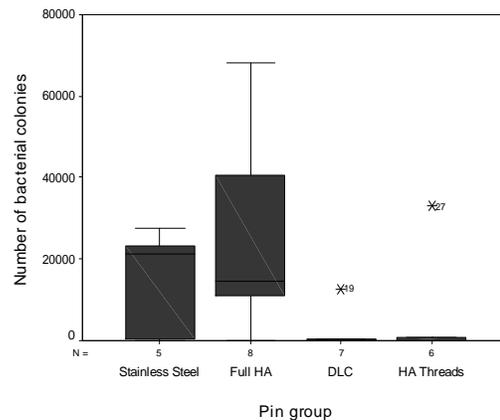
**Figure 1:** TEM image showing soft tissue interface. (Mag X 3 000)

Histology results showed that there were no significant differences between groups for percentage of epidermal downgrowth (Group 1; 31  $\pm$  9, Group 2; 28  $\pm$  11, Group 3; 29  $\pm$  15, Group 4; 40  $\pm$  14) or percentage of dermal contact with the pin surface (Group 1; 43  $\pm$  25, Group 2; 58  $\pm$  21, Group 3; 47  $\pm$  28, Group 4; 38  $\pm$  20). SEM results showed the presence of a biofilm on stainless steel, fully coated HA, and HA coated threads (Fig. 2). DLC coated pins were the cleanest with many

keratinocytes present. Microbiology results (Fig. 3) showed that the surface of DLC coated pins had a significantly lower number of bacterial colonies in culture compared to the stainless steel (p=0.028) and fully coated HA pins (p=0.005).



**Figure 2:** SEM image of a fully coated HA pin showing the presence of a biofilm and bacteria. (Bar represents 20  $\mu$ m)



**Figure 3:** Number of bacterial colonies in culture.

## DISCUSSION:

The results of this study demonstrate that a well organised tissue layer directly attached to the pin is rarely seen. A small gap is usually present between the implant and the soft tissue. If epithelium is present a keratinised layer is not present. HA seems to induce the most beneficial interface. Specific coatings do not appear to have a significant effect on epidermal downgrowth or dermal attachment to the pin surface, although HA coated pins appeared to have slightly better dermal attachment than other pin coatings.

A biofilm was present on most pin surfaces. Fully coated HA pins also had the largest number of bacteria isolated. DLC coated pins had the cleanest surface with no biofilm present and a significantly lower number of bacteria present. It therefore appears that DLC coated pins have the potential to be used to prevent biofilm formation and bacterial colonisation which may reduce subsequent infection.

## ACKNOWLEDGEMENTS:

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## REFERENCES:

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