Effect of polishing of titanium internal fracture fixation plates upon infection resistance.

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Introduction: Polishing the surface of fracture fixation implant materials alters fibroblast[1] & osteoblast[2] behaviour *in vitro* and reduces soft tissue adhesion[3] & bony overgrowth *in vivo*[4]. Thus, surface polishing may decrease complications such as, allowing tissues to freely glide over the implant (e.g. tendons in distal radius fractures and muscles in orbital fractures) and easing implant removal. However, surface polishing may also influence the susceptibility of an implant to bacterial colonization. Since infection is still the most important limiting factor of success in internal fracture fixation, the effect of surface polishing on *in vivo* infection rates needs to be ascertained. In this study, the local infection rate associated with clinically available titanium (Ti) ISO 5832/2 and titanium aluminium niobium (TAN) ISO 5832/11 in their standard microrough form is compared with that of their test polished equivalents and also to clinically available electropolished stainless steel (EPSS) ISO 5832/1.

Materials and methods: Approval to perform this study was granted by the Cantonal animal ethics committee. Standard 4-hole 2.0 mm Synthes® locking compression plates (LCPs) made of standard and polished Ti and TAN in addition to EPSS were used. The surface roughness was evaluated by non contact profilometry and SEM. The surface chemistry and wettability were characterised by XPS and water contact angle. For the *in vivo* infection study, plates were fixed on the medial tibial diaphysis of healthy, mature, female New Zealand White rabbits using unicortical screws. Immediately after implantation, a human-pathogenic, beta-haemolysing *Staplylococcus aureus* strain was added at the implantation site. Twenty eight days after implantation surgery, the rabbits were euthanized and evaluated for the presence of bacteria. To use as few animals as possible, we performed consecutive investigative phases. In each phase the bacterial concentration was adjusted towards the intended ID_{50} (bacterial concentration causing a 50% infection rate) at which the differences in infection rates is most evident[5].

Results: The mean Ra is shown for each test material in Table 1. Roughness differences were observed between the materials with standard Ti and TAN showing comparable roughness, polished Ti and TAN were smoother and EPSS was the smoothest.

Implant description	Ra µm	Contact Angle (°)
Standard Ti	0.708	91.3 ± 0.37
Polished Ti	0.322	87.9 ± 0.17
Standard TAN	0.737	103.8 ± 0.07
Polished TAN	0.334	100.9 ± 0.24
EPSS	0.124	88.7 ± 0.54

Table 1. Surface roughness and contact angle of each LCP type.

The water contact angle measurements (Table 1) were measured on the slightly curved surface of the LCP and showed no large differences in wettability between standard and polished LCPs of either Ti or TAN. XPS data showed that polishing followed by subsequent anodisation did not affect the final surface chemical properties of the test materials.

After six sequential investigative phases 104 rabbits were included in the study. The inoculum was sequentially adjusted to expose maximum number of animals at the concentrations spanning the ID_{50}. ID_{50} values were determined based on cumulative frequency and were, in rank order from most infection resistant to least; polished TAN ($7.1x10^6$ CFU), standard TAN ($6.3x10^6$ CFU), standard Ti ($3.9x10^6$ CFU), EPSS ($3.2x10^6$ CFU) and finally polished Ti ($2.7 x10^6$ CFU) Table 2). The rate of infection for each LCP type is shown in Table 2.

LCP Type	*n* (rabbits)	Rate of infection (%)	ID 50 (CFU)
EPSS	22	54	3.2×10^6
Polished TAN	22	45	7.1×10^6
Standard TAN	21	38	6.3×10^6
Polished Titanium	20	50	2.7×10^6
Standard Titanium	19	42	3.9×10^6

Table 2. Infection rates of the five implants at the different bacterial challenges.

The differences in infection rate were not significantly different based on analysis with the Chi-squared test with $p < 0.05$ as level of significance. The Fischer-exact test for the pair wise comparison of the five implants demonstrated no significant differences between the five groups ($p < 0.05$).

Discussion: Surface polishing of Ti and TAN plates reduced the roughness of the plate surface without change in surface chemistry. The polishing of standard Ti and TAN has been shown to have considerable benefits in relation to reduced bone adhesion and bony overgrowth *in vivo*[3, 4] and has been shown in the present study not to influence infection rate. Clinical implementation of polished Ti and TAN LCPs is not expected to result in an increased infection rate according to the results of this study.

References:

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Acknowledgments: Synthes for kindly providing the LCPs and screws. Urs Schlegel for discussions, Pamela Furlong for her technical support and Dr. V. Frauchiger (Robert Mathys foundation) for XPS.