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Bone welding – A histological evaluation in the jaw

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Summary

The expansion of biodegradable osteosynthesis systems in clinical application correlates well to the progress in development of new materials as to the improvement of application methods. One of those new application methods is the ultrasound-aided insertion of Resorb-X® pins. The aim of this study was the histological evaluation of possible thermal damage to bone due to the ultrasound insertion.

For this purpose, condylar neck fractures in 12 sheep were produced, repositioned and fixed by Resorb-X® plates and pins. The animals were sacrificed in two groups, one after 2 weeks and one after 9 weeks.

The bone–pin interlinkage and the structure of the bone were histologically evaluated. After 2 weeks a tight bone–polymer interlinkage was seen. Neither a pronounced foreign body reaction nor an interposition of fibrous tissue at the interface or a thermally induced necrosis was observed. The late phase of wound healing after 9 weeks showed pathomorphological characteristics within the normal range of bone healing. The bone seemed to be free of any alteration caused by process engineering.

We conclude that thermal stress caused by ultrasound-aided pin insertion does not lead to cellular reaction in the bone. The fast and easy application of this improved biodegradable osteosynthesis system will bring a clear advantage in clinical use.

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Introduction

Biodegradable osteosynthesis materials are not estimated being toxic for the surrounding tissue. In recent times, these biodegradable osteosynthesis systems have been used increasingly frequent in traumatology as well as in plastic and reconstructive surgery. The expansion of these materials in clinical application correlates well to the progress in development of new materials as well as to the improvement of application methods.

The application of biodegradable screws is limited by various factors. As there is low mechanical stability of the material, difficult handling and the time-consuming fixation of screws. The need of cutting threads is a time-consuming factor and limits easy handling especially for smaller screw diameters. Furthermore, the insertion of conventional biodegradable osteosynthsis systems is limited by shear forces between screws and plate due to non-axial, angular drill holes (Ricalde et al., 2005; Neff et al., 2004). Another limitation for the use of biodegradable screws is the difficult relation between screw axis, osteosynthesis plate and the drill hole in the bone.

The general suitability of poly-L-lactide/polyglycolide (PLLA-PGA) copolymers as a biodegradable osteosynthesis material with regards to resorption and biocompatibility has been shown (Becker et al., 1999). Aim of the development of an ultrasound-aided pin fixation was the creation of a new method of interlinkage between osteosynthesis plate and bone. So the mentioned limitations in application could be avoided. A specially designed pin is inserted in the drill hole with the aid of ultrasound. The pin surface is fixed by a melting (welding) process into the trabecular bone structure. At the same time, the pin and the osteosynthesis plate are welded together (Fig. 1).

Due to this welding, the pins can be applied even in cases of difference in axis between the pin, the osteosynthesis plate and the drill hole. Critical torque forces on screw heads can be avoided. Furthermore, there is no more need for threads. These advantages lead to improved handling and shorten osteosynthesis operations (Eckelt et al., 2005).

The aim of this study was the histological evaluation of the newly developed ultrasound-aided pin osteosynthesis system for the therapy of condylar neck fractures. Because of the rise in temperature while inserting the pins, a potential thermal impairment of the bone should be evaluated. Focus of interest was the cellular reaction caused by a possible thermally induced initial inflammation.

Figure 1. Welded pin in bone (Resorb X).

Material and methods

By authority of the Regional Commission Dresden in Saxonia-Germany (animal experiment application AZ 24-9168.11-1-2003-10) the *in vivo* tests were performed under strict compliance with the high standards of ethics in animal experiments.

Operations were performed on 12 sheep. For initial sedation, each sheep was given Dormicum© (midazolam) at a dose rate of 1 mg/kg body weight via an i.v. canula. Anaesthesia was induced by the application of the anaesthetic agent propofol. Immediately afterwards a tracheal tube was placed and anaesthesia was maintained using a volume-controlled inhalation of isofluran and nitrous oxide. The depth of anaesthesia was often reduced by a supplementary i.v. application of the analgesic agent fentanyl. To assure a post-operative pain prophylaxis, the animals were given buprenorphine during the operation.

The left mandibular ramus was dissected via a cutaneous and sub-cutaneous approach (periangular approach) from the posterior edge of the ramus. The facial nerve was prevented from damage.

Deep collum fractures were produced by subperiosteal preparation and osteotomy with an oscillating saw (Fig. 2). After dislocation of the fractures they were re-positioned and fixed by a combination of resorbable miniplates and ultrasound inserted pins (Resorb-X-System: 2.3 mm pin and four hole plates). Osteosynthesis was performed with two plates. The anterior and posterior plates were fixed on the lateral face of the condylar neck with four pins per plate (Fig. 3).

One titanium miniscrew was placed at each end of a plate for histological analysis and radiological detection of the resorbable plates. After performing osteosynthesis in the above-mentioned pattern a multilayer wound closure was done with resorbable sutures.