Influence of degradable intramedullar implants on fracture healing

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Introduction: Internal fixations like plates, screws, and nails are commonly used in orthopaedic and trauma surgery to fix fractures. In recent years, several studies report of degradable implants used for different surgical indications (e.g. in craniomaxillofacial surgery: polyglycolide (PGA), polylactide (PLA), and their copolymers (PLGA and PLDLA); in orthopaedic and trauma surgery: degradable implants e.g. in hand surgery, re-fixation of the anterior crucial ligament, and foot and ankle surgery; in veterinary surgery: intramedullary nails and pins of polylactide). Furthermore, in experimental research magnesium-alloys have recently been proved to be an adequate alternative to other degradable implants (1). The mechanical properties of several degradable implants were comparable with cortical bone and enabled a direct transfer of stress on the healing bone to stimulate bone remodelling. In this study, the biomechanical influence of different degradable (PLA, magnesium alloy) and non-degradable implants (titanium) on bone healing was investigated during the consolidation period in New Zealand White Rabbits. Therefore an in vivo bending stiffness measurement device was used which has proven its high precision and accuracy in vitro (2).

Materials and Methods: 24 adult female New Zealand White Rabbits were operated under regulations of the local government. The right limb of each rabbit was equipped with an uniplanar, bilateral external fixator (Synthes Inc., West Chester, USA) via Kirschner wires. The proximal and distal part of the fixator was connected with one security rod on the lateral and medial side during periods with no measurements. The pins were fixed to the tibiae using a drilling template to maintain constant conditions; two pins distal and two proximal to the planned osteotomy. Afterwards, an osteotomy was performed distal to the tibiofibular synostosis between the inner two pins producing a gap of 1.5 mm. Different intramedullar implants were inserted in the intramedullar cavity through the osteotomy bridging the osteotomy gap (group 1 (without implant), group 2 (PLA pin), group 3 (magnesium calcium 0.8% alloy pin), and group 4 (titanium pin). After 21 days latency, all animals underwent weekly in vivo 4-point-bending stiffness measurement in general anaesthesia for further 34 days. The animals were sacrificed and the tibiae were subsequently tested in a material testing system (MTS) in a 4-point-bending setup. The in vivo stiffness progress of each group and the final in vivo and in vitro stiffness data were analysed statistically.

Results: Significant differences were found between the four groups during the healing period: significant difference of stiffness in group 4 (titanium) compared to group 1 (control, p < .001) and 3 (MgCa 0.8, p < .05) on the second measurement day. Group 4 (titanium) had a significant higher stiffness than group 1 (control, p < .001) on the sixth measurement day. On the eighth measurement day group 4 (titanium) was found to have a significant difference compared group 1 (control, p < .05) and 3 (MgCa 0.8, p < .001). Furthermore group 3 (MgCa 0.8) showed a significant difference compared to group 2 (PLA, p < .05), and group 2 (PLA) was significant different to group 1 (control, p < .05) (Fig. 1). The linear regression of

Fig. 1: Stiffness data during bone healing of different intramedullar implants.