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Fixation of femoral osteotomies with fibrillated, self-reinforced poly-L-lactide (SR-PLLA) intramedullary nails

Mikko J Manninen[1], Timo Pohjonen[2], Ritva Taurio[2], Unto Päivärinta[1] and Pentti Rokkanen[1]

[1]Department of Orthopaedics and Traumatology, Helsinki University Central Hospital and [2]Biomaterials Laboratory, Tampere University of Technology, Finland

Right femoral, diaphyseal osteotomies of 42 rabbits were fixed with SR-PLLA intramedullary rods, 4.55–4.60 mm in diameter. The rods were manufactured by fibrillation method and they were gamma-sterilized. They had 136-MPa shear and 245-MPa bending strength, measured after sterilization. Follow-up times were from 3 to 48 weeks. None of the rods broke during this period. There was one non-union at 3 and one at 12 weeks. Radiographic studies showed normal healing and callus formation, visibility of the osteotomy line decreased within the follow-up time. Histologic, microradiographic, and oxytetracycline fluorescence studies showed normal healing, a mild foreign-body reaction was observed from 3 to 36 weeks. Shear strength of the osteotomy plane was measured from 30 bone samples; it increased during the follow-up time from 3.0 MPa at 3 weeks to 10.0 MPa at 48 weeks (Figure 1). Before shear tests of the bones, the SR-PLLA rods were taken away from the medullary cavities of the femurs. The rods were tested mechanically, too. At 12 weeks 115-MPa shear and 245-MPa bending strength were still left (Figure 2). Also in vitro hydrolysis studies on bending and shear strength of the rods were performed; it was noticed that the strength retention was better in vitro than in vivo. The results show that fibrillated SR-PLLA rods are strong enough to be used in intramedullary nailing of femoral cortical bone osteotomies in rabbits.

Repair of a skull trephine defect substituted by porous hydroxy-apatit—experiments in rabbits

Tom Lindholm, Jari Peltonen and T Sam Lindholm

Department of Clinical Sciences, University of Tampere, Tampere, Finland

Introduction: Synthetic porous hydroxyapatite (HA) has been shown to incorporate into bone. The osteoconductive properties of HA have brought up clinical applications such as filling bone defects in combination with bone grafting, and coating endoprostheses.

Material and methods: A trepine defect, 8 mm in diameter, was drilled on both sides of the median suture of the skull in 11 adult rabbits. The defect was filled either with HA-block, 7x1.3 mm) or with porous HA (Interpore 200, CA/USA) gran-

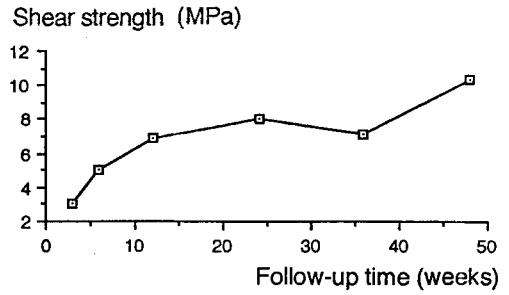

Figure 1. Shear strength of rabbits' femurs after osteotomies (MPa)

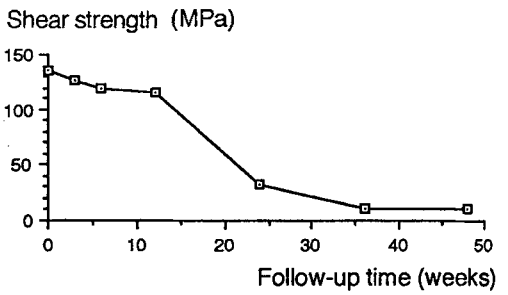

Figure 2. Shear strength of SR-PLLA rods after intramedullary nailing (MPa)

ules mixed with autogenous bone marrow. The other cranial defect was left unaugmented. Follow-up times varied from 8 to 26 weeks postoperatively. Histomorphometry was used to quantitate the new bone formation into the defects.

Results: There was no bone bridging across the unaugmented skull defects within the follow-up period of up to 26 weeks. The defect was composed of fibrous tissue. Both the HA-block and the HA-granule bone marrow filled defects were repaired by bony ingrowth to the HA. Morphometric studies revealed that the amount of the new bone in proportion to the original defect area varied from 55 to 73% after follow-up time of 8 to 26 weeks. Partial remodeling of the consolidated defect area occurred within that time. No side effects related to the HA material were noted.

Conclusions: Both HA blocks and HA granules can be used as bone substitutes in cranial defects, which normally will be replaced by fibrous tissue. The biological adaptability of HA is obviously good.

Healing of a segmental tubular bone defect and its replacement by tricalciumphosphate: Experiments in sheep

Jari Peltonen, Pekka Ala-Mononen, Arto Ranta and Jarmo Rintasalo

Department of Clinical Sciences and College of Veterinary Medicine, Department of Surgery, University of Tampere, Tampere, Finland

Introduction: Bone defects can be replaced by new synthetic biomaterials, e.g. hydroxyapatite and tricalciumphosphate (TCP) as such, or combined with bone grafting. The ceramic bone substitutes probably have clinical applications in repair of large bone defects.

Material and methods: We performed a segmental, mid-diaphyseal defect in 11 adult sheep tibiae. The size of the defects was 1 or 2 cm. The legs were stabilized by either a circular, or bilateral external fixation. In 4 sheep the 2 cm defect was replaced by a TCP block of the same size. The follow-up time of the sheep varied from 4 to 48 weeks postoperatively. The legs were examined radiographically and samples were taken for histomorpholoic studies.

Results: The 1 cm defects tended to heal spontaneously. The 2 cm defects remained radiolucent, a non-union developed, and this was even more pronounced if the periosteum was excised from the defect area. The TCP-augmented defects were gradually consolidated, partly by external callus, which surrounded the block and bridged the gap as seen in the 8 week specimen. Resorption of the block was noted from the fifth week postoperatively. Complications included transient pin tract infections in 9 cases, 2 deep infections of the proximal tibia and some problems with the stability of the fixation.

Conclusions: It is possible that in vivo TCP acts osteoconductively and at the same time is biodegraded and replaced by bone.

Bone strength in experimental osteoporosis

Vesa Lepola, Kalervo Väänänen and Pekka Jalovaara

Department of Surgery and Department of Anatomy, University of Oulu, Oulu, Finland

Introduction: Torsional testing is considered a good method for measuring the mechanical properties of long bones. In this study, the effect of immobilization on the strength of rat bone was examined by means of a torsion machine.

Materials and methods: Rats were immobilized by casting. After 3 weeks, ash weights were determined from femurs and tibias were submitted to torsonial testing. The results were compared to those of the non-treated contralateral legs.

Results: Immobilization decreased the femur ash weight compared to the contralateral leg. The maximum torque capacity and the rigidity of the tibia were also decreased in the immobilized leg. There was a high correlation between the maximum torque capacity and the ash weight.

Conclusion: 3 weeks of immobilization produce noticeable reduction in the strength of rat tibia and also in the ash weight of the femur.

Fixation of a femoral shaft osteotomy by an intramedullary self-reinforced absorbable rod or metallic rod—an experimental study on growing dogs

Hannu Miettinen[1], E Antero Mäkelä[2], Pentti Rokkanen[2], Pertti Törmälä[3] and Jyrki Vainio[1]

[1]Department of Surgery, Kuopio University Hospital, Kuopio, [2]Department of Orthopedics and Traumatology, Helsinki University Hospital, Helsinki and [3]Biomaterials Laboratory, Tampere University of Technology, Tampere, Finland

Introduction: RUSH-pins are manufactured of stainless steel. Polyglycolic acid (PGA) and polylactic acid (PLA) are synthetic, biodegradable materials. The self-reinforced polyglycolic acid (SR-PGA) and poly-L-lactic acid (SR-PLLA) implants are manufactured of biodegradable polymeric matrix reinforced with fibers of the same material.

The purpose of this study was to find out the effect ot an intramedullary SR-PGA, SR-PLLA and a metallic rod on growing bone and applicability of these rods to the fixation of a femoral shaft osteotomy in a growing dog.

Material and methods: In 5 12-week-old beagle dogs osteotomy of the right femur was fixed with an intramedullary (4.7 mm in diameter, 60 mm in length) SR-PGA rod (PGA-group). In another 5 beagle dogs group and in a third 5 beagle dogs group fixation of the osteotomy was achieved with an intramedullary SR-PLLA rod (PLLA-group) and RUSH-pin (RUSH-group) of equal size, respectively. The radiographic follow-up intervals were 1, 3, 6, 12, 24, and 48 weeks. At 48-week follow-up the dogs were killed and femurs and tibias from the operated and the control side wer dissected free. Both femurs

were taken as single specimens and prepared for histological, microradiographic and OTC-fluorescence studies.

Results: Solid union of the osteotomy without secondary displacement was seen 6 weeks after fixation in all groups. Histologically, well-organized lamellar bone was seen at the previous osteotomy site at 48-week follow-up, and this was confirmed by microradiography and OTC-fluorescence studies. Narrowing of the femoral neck and a slight valgization of the proximal femur without any functional disability was seen 48 weeks after the operation.

Conclusion: An intramedullary SR-PGA-, SR-PLLA- and a metallic rod provided equal and sufficient stability for rapid healing of a femoral shaft osteotomy in growing dogs. Neither the intramedullary SR-PGA-, SR-PLLA- nor metallic rod caused any significant disturbance of the longitudinal growth of the operated femur.