Effects of medullary reaming on fracture healing

Tibial osteotomies in rabbits

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Unilateral, midshaft tibial osteotomy was made in 16 rabbits. Reaming of the medullary canal was performed in half the animals, while the other half were operated on without reaming. Intramedullary fixation was accomplished with multiple Kirschner pins in both groups. Bone healing occurred with abundant peripheral callus in both groups. Mechanical testing after 6 weeks revealed higher strength of the osteotomized bones where reaming had not been performed compared with bones with reaming.

We conclude that bone healing is delayed by medullary reaming, whereas the pattern of healing is similar in bones with and without reaming.

Reaming before intramedullary nailing causes destruction of vessels in the medullary canal (Rhinelander 1974, Eitel 1981). These vessels supply the nutrition to the inner two thirds of diaphyseal cortex. Hence, necrosis of this part of the cortex occurs after reaming (Trueta and Caladias 1964, Rhinelander 1974).

Nonreamed intramedullary nailing causes less damage of medullary circulation, and revascularization of the medullary canal is completed earlier (Rhinelander 1974, Eitel 1981).

We investigated the influence of reaming on the speed and quality of bone healing after intramedullary nailing.

Materials and methods

Sixteen adolescent male Chinchilla rabbits, weighing 2.7 to 3.6 kg, were operated on. The animals were anesthetized with intramuscular injections of Hypnorm® Vet (Janssen). An open, unilateral, transverse, midshaft tibial osteotomy was made with an oscillating saw, while the other leg served as a control. Before intramedullary fixation, the marrow canal was successively reamed up to 4.0 mm using dental drills (Group A), whereas no reaming was done in Group B. Kirschner pins with a diameter ranging from 1.0 to 1.6 mm were used for fixation. The pins were inserted from the anterior aspect of the proximal tibia between the tuberosity and the knee joint. As many pins as possible (usually 4–6 pins) were inserted in each bone. Both legs were radiographed postoperatively (Figure 1).

The postoperative course was uneventful in all the animals of Group B. In 1 animal in Group A, a proximal protrusion of pins occurred, but the skin was not penetrated. Weight bearing of the operated on leg started on the first postoperative day; full weight bearing was observed after 1–2 weeks.

The animals were killed after 6 weeks. The tibias were dissected free of all soft tissue, and the nails were extracted through the proximal hole. After removal of the nails, the bones were radiographed (Figures 2 and 3). The bones were then stored at –18 °C until testing.

Evaluation of bone healing

The outer anteroposterior and transverse diameters at the osteotomy site and at the corresponding level of the control bones were measured with a sliding caliper. The cross-sectional areas were calculated, assuming them to be triangular. The difference in cross-sectional areas between the test bone and the corresponding control bone was regarded as the amount of peripheral callus.

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Figure 1. Fixation of osteotomy with multiple intramedullary pins.

Figure 2. Anteroposterior (left) and lateral (right) radiographs at 6 weeks. Bone healing with abundant peripheral callus in nonreamed intramedullary nailing.

Figure 3. Anteroposterior (left) and lateral (right) radiographs at 6 weeks. Bone healing with abundant peripheral callus in reamed intramedullary nailing. Osteotomy line still visible.

Table 1. Peripheral callus (mm^2), bending strength, and elastic stiffness. The mechanical properties of the healing bones are expressed as percentages of the corresponding values for the control bones. Mean (range)

	Nonreamed	Reamed
Callus	49 (27-85)	47 (28-77)
Strength	97 (75-109)	58 (10-88)
Stiffness	148 (97-205)	113 (11-186)

Rotational deformity was measured as the angle between the posterior aspects of the tibial condyle and the distal tibia.

Healing was evaluated radiographically after 6 weeks. Solid union was defined as callus bridging the osteotomy gap, regardless of whether the osteotomy line was still visible.

The mechanical properties of the bones were tested by four-point bending in the anteroposterior direction in an Instron testing machine as previously described (Terjesen and Apalset 1988). The stiffness in bending was defined by the slope of the linear part of the load-deformation diagram, and the bending strength by the load at which refracture occurred. Stiffness and strength were given as percentages of the corresponding properties for the control bones

Wilcoxon's two-sample test (two-tailed test) was used to evaluate the differences in mechanical properties and peripheral callus between the two groups. Differences were considered significant at P-values below 0.05.

Results

After 6 weeks, all the osteotomies had healed radiographically. There was a trend towards more rotational deformity in the reamed group. Healing with equally abundant peripheral callus took place in both groups (Table 1).

The median strength and stiffness were greater in the nonreamed group; however, the difference was significant for strength only (P = 0.01; Table 1). There were no differences in the mechanical properties between bones with pronounced (above 10°) and slight (below 10°) rotational deformity.

Discussion

Healing of fractures after intramedullary nailing proceeds with the formation of peripheral callus since there is considerable micromotion at the fracture site (Allen et al. 1968, Tencer et al. 1984). The vascular supply of peripheral callus after intramedullary nailing is initially developed from periosteum and soft tissue adjacent to the fracture (Rhinelander 1974). According to Kessler et al. (1986), damage of medullary circulation does not impede peripheral callus formation. This is consistent with the present results, as the amount of peripheral callus was not influenced by whether or not reaming had been performed.

Although destruction of intramedullary circulation takes place after reaming, revascularization later occurs and contributes to the remodeling of bone (Rhinelander 1974, Trueta 1974, Kessler et al. 1986). In rabbits, it takes about 4 weeks until revascularization is completed after reaming (Kessler et al. 1986). The process towards complete revascularization is faster after nonreamed nailing (Rhinelander 1974, Eitel 1981).

There is scant information in the literature as to whether the speed of bone healing is influenced by medullary reaming. A recent study on osteotomized rat femora concluded that reaming did not affect the mechanical properties of the healing bones (Reikerås et al. 1988). This is not in accordance with the present results, as the strength was greater in the nonreamed bones, indicating a more rapid healing in this group.

Previous investigations have confirmed that high rotational instability is detrimental to bone healing, while slight rotational instability hardly has any negative effect (Cameron 1966, Mølster 1984). In the present study, the nonreamed bones, as well as the reamed ones, were rotationally relatively stable by visual impression and manual testing after intramedullary fixation. Hypothetically, the bones with the greatest rotational deformity after healing have had the greatest initial instability. There was, however, no differences in the mechanical properties between bones with pronounced and slight rotational deformity. We therefore assume that the higher strength in the nonreamed group hardly could be explained by differences in rotational stability.

According to Wang et al. (1985), considerable differences in initial bending stiffness after intramedullary nailing is required to detect differences in mechanical properties of healed bones. In the present study the initial bending stiffness was relatively high in both groups, because the maximal number of steel pins were inserted in the medullary canal of all the animals. Consequently, any minor difference in initial bending stiffness of the fixation between the groups could hardly explain the difference in strength of the healing bones.

The most likely explanation of the differences in mechanical properties is the effect of reaming on the medullary blood supply. In the nonreamed situation, cortical regeneration probably proceeded faster due to better preservation of the medullary circulation. Provided that the same effects of reaming are present in human bones, the clinical implication is that efforts should be made to developed nail designs which do not require reaming.

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