124. Possibilities of a healing process in the avascular area of menisci

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The feasability of a healing process in the avascular area of the meniscus was investigated both experimentally and clinically. Twenty-eight patients with a torn meniscus in the avascular area were treated between 1980 and 1990 with direct suturing.

In 18 patients the open technique was used and in the remaining 10 the outside-in arthroscopic repair. In both cases the stitching material was dexon O2. Care was taken that the stitches passed through the cut edges of the meniscus and the synovium, on the basis of our previous experimental work. Regardless of the technique used, the intervals between stitches were of 3 to 5mm each. Usually, a plaster cylinder was used for the first 6 postoperative weeks and the patient was advised to put on weight bearing. In cases of plateau fracture the usual principles of treating fractures were employed. After the third postoperative month the patients were allowed to resume athletic activities. The follow-up was between six months and two years. Five patients were lost to follow-up and another two were excluded because they had refused to follow the protocol. In the remaining 21 patients there were 3 recurrencies, 2 fair results (pain with increased activity) and 16 patients with good results based on clinical grounds.

Repair of the avascular area of the meniscus seems feasible, provided that the stitches pass through both the avascular substance and the synovium. There is as yet insufficient information concerning the intervals between the stitches or the strength of the healing substance (scar tissue).

The above mentioned experimental and clinical work goes some way to solving the problem of whether or not a longitudinal rupture of the meniscus within the avascular area can be repaired. Thus, in cases where there is doubt about the vascularity of the injured area of semilunar cartilage, the meniscus can be repaired, provided that the stitches pass through the cut edges and the synovium.

Fractures

125. Colles' fracture—Older type IV—comparison of the results of fixation with 2 K-wires vs a Rush pin

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Introduction: The optimal treatment of severe Colles' fractures is difficult and controversial. In order to evaluate two methods of operative treatment of Colles' fractures we compared fixation with 2 K-wires vs a Rush pin.

Patients and methods: In the period 1.1 1985 – 30.6 1990 a total of 114 patients with a Colles' fracture—Older type IV were treated in the County Hospital of Aarhus, Denmark. 86 (79%) patients (42 patients with K-wires and 44 patients with a Rush pin) participated in the follow-up, 5 patients were dead and 23 did not want to participate. All patients were examined clinically and radiologically.

Results: The radio-ulnar wrist mobility was significantly better in the group operated on with K-wires, but there was no significant difference in flexion-extension or pronation-supination between the two groups.

The range of motion in the nonoperated wrist was better compared to the operated wrist. The two treatment groups were comparable with regard to sex, age, distribution of fracture dominant/nondominant side, radius shortening, dorsal angulation, grip score and subjective symptoms. Two patients treated with K-wires developed sympathetic dystrophy. One patient developed caput ulna syndrome and one patient could not resume work because of reduced pronation-supination movement, both treated with a Rush pin.

Conclusion: No difference in results was found between percutaneous fixation with 2 K-wires and intramedullary fixation with a Rush pin in Colles' fracture—Older type IV.

126. The changes in the blood flow to the tubular bones in rabbits during the healing of shaft fractures by the method of radio-active microspheres

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The precise knowledge of the vascular anatomy of the bone, and more so of the osseous circulation, is of paramount importance for the complete understanding of the various functions taking place in bone, in both health and disease.

This study consists of a series of experiments which were performed in order to look into the blood flow changes occurring in the radius of rabbits during the healing process

of a fracture of the diaphysis. An identical fracture was produced in the middle of the diaphysis of one of the radii in each rabbit, while the other radius was used as a control for estimating the blood flow changes during the healing process. This experimentally produced fracture was treated in the same various ways that are used clinically in the treatment of such fractures, i.e. conservatively, and by internal fixation using either intramedullary nails or appropriate plates screwed to the fractured diaphysis of the bone. A number of animals were sacrificed at the end of each of the six weeks of the whole experiment and the bone blood flow was measured by the method of radioactive microspheres, using which the regional blood flow can easily be estimated.

The results of this experimental work were as follows:

a) The blood flow to the fractured radii was increased during the whole period of the healing process, compared to that of the controls. The blood flow rate was higher by the first week after the fracture and increased further during the second week. During the third and fourth weeks the blood flow remained at this high level, and even showed a small further increase, exceeding double the value in the control radii. At the end of the fourth week the blood flow started decreasing rather abruptly and it returned to almost the level of the controls during the fifth and sixth weeks when repair of the fracture had been completed.

b) The blood flow to the fractured radius was increased during the healing process of all fractures, irrespectively of the way they had been treated. The amount of blood flow increase, however, varied between the fractures in accordance with the kind of treatment used. Thus, the cases in which the fracture had been treated by internal fixation showed a slightly greater increase in blood flow, as compared with that found in the radii treated without osteosynthesis.

127. Delayed union and nonunion—immunopathological and neuroimmunological studies

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We studied the tissue samples of noninfected delayed union or nonunion of diaphyseal bones in ten patients (eight tibia and two humerus fractures) immunopathologically and neuroimmunologically. The samples were obtained from operations and from the area between the cortices and under the pseudocapsule 4 to 25 months after the primary injury. The gross routine histomorphology was uniform in all the samples; in addition to occasional cartilagenous and bony islands, samples mostly consisted of vascularized connective tissue of varying density with the proline-4-hydroxylase-containing fibroblast as the major cell type. The analysis for inflammatory cells showed a few CD2 T-lymphocytes in the connective tissue stroma and occasionally a higher density of these cells perivascularly. Most such cells were CD4 T-lymphocytes and their number was always twice that of the CD8 positive cells. Staining for CD11b positive monocyte/macrophages showed in all patient samples positive cells scattered in the connective tissue stroma with perivascular enrichments and there were in all the sample more monocyte/macrophages than CD2 positive cells. Mast cells were absent or very rare in all samples.

Staining for matrix metalloproteinases MMP-1 and MMP-3 showed that in each sample all the capillary and postcapillary venule endothelial cells were positive; also more than 90% of the cells in the stroma (fibroblasts, monocyte/macrophages and chondrocytes) stained positive.

From the neuroimmunological point of view, the most prominent finding was an almost total lack of peripheral nerves; staining for the general neuronal markers PGP 9.5, neurofilament and synaptophysin did usually not show any free or perivascular nerve endings and the staining for substance P showed an equal absence of local pain fibers in this tissue.

Our findings suggest that delayed union and nonunion tissue consist of vascularized connective tissue, which mostly contains 5B5 fibroblasts, CD11b macrophages and vascular endothelial cells with only few immigrant recently recruited monocytes or lymphoid cells. Almost all resident cells seem to be involved in tissue remodelling as suggested by their content of fibroblast-type MMP-1 and its proteolytic activator MMP-3 or stromelysin. The most striking finding was the sparsity and usually total lack of peripheral innervation, which may be related with the healing disturbance.

128. The effect of fibrin glue on the the union of diaphyseal fractures—an experimental study

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Local application of high concentrations of human fibrinogen is acquiring increasing importance in tissue healing. Thus, the glueing system FAS (Fibrin Adhesive System, or Fibrin Glue, or Fibrin Kleber) was developed, which in

practice mimics and accelerates the final phase of normal blood clotting. Several surgical specialities have used this property.

In orthopedic surgery and traumatology the FAS has been tried experimentally in the promotion of healing, acceleration of bone union and the revascularization of autologous and heterologous bone grafts.

Our own experimental study aimed to investigate the influence of FAS on the union of fractures in the middle of the diaphysis of the ulnar in rabbits. Twenty-five (25) white New Zealand rabbits were studied and evaluated. In all of them, an osteotomy of the mid shaft of the ulna was performed on both sides. Fibrin Glue was applied on the right side, while the left served as a control (right-left experiment).

The evaluation of the results was done on the basis of histomorphology and radiologic appearance. No inflammatory or immunologic reaction was seen in any of the experimental animals.

In the 25 pairs of osteotomies, regardless of the time of union, there was no noticeable difference in bone union in 7 cases, the callus was more advanced on the control side in 3 cases, while in the remaining 15 cases there were definite signs of preponderance on the right side, where the Fibrin Glue had been used. This difference was both quantitative (extent of callus) and qualitative (correct structure of callus) and was clearly noticeable as bone union progressed.

From the findings of this experimental study the positive influence of FAS on bone healing is evident.

129. Delayed union and pseudarthrosis of the carpal scaphoid—treatment by volar inlay bone graft taken from the lower end of the radius or the upper end of the ulna

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Twenty-two patients with painful delayed union or pseudarthrosis of the carpal scaphoid were treated using the Matti-Russe technique with a bone graft taken from the lower end of the radius or the upper end of the ulna.

Osseous union occurred in 19 patients in an average of 4.4 months. The union of pseudarthrosis was associated with increased grip strength and improvement in the range of movement. The success rate of the operation was 86%. Our results are comparable with those obtained using an iliac bone graft.

The advantages of the procedure are that it is simple, the operation is of limited duration and may be performed on an outpatient basis.

130. The results of scaphocapitate intercarpal fusion

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Thirteen patients (10 males, 3 females, aged 18 to 45 years) were followed-up at 18 (8–42) months after scaphocapitate arthrodesis. Surgery was performed for treatment of resistant scaphoid nonunion with avascular necrosis of the proximal pole in 8 cases, and for rotary scaphoid instability due to chronic static scapholunate dissociation in 5 cases. Scaphocapitate fusion with autogenous bone grafting was used to bridge carpal spaces. One patient had nonunion of the scaphocapitate arthrodesis, which required reoperation, while 4 patients with radiographically and clinically successful fusions had diminshed radiocarpal joint space with subchondral sclerosis (2 cases) or diminished but residual scaphoid rotation (2 cases). All these patients reported mild to moderate postoperative pain during work or recreational activities.

Compared with the preoperative motion, scaphocapitate fusion led to an average reduction in wrist extension of 5%, flexion 35%, radial deviation 40% and ulnar deviation 15%. Compared with the nonoperated wrist the differences were: extension 60%, flexion 45%, radial deviation 40% and ulnar deviation 65%. Surgery appears to have had the least effect on extension and ulnar deviation compared with preoperative ROM, but a great effect compared with extension and ulnar deviation in the unoperated wrist, suggesting that presurgery these values were already limited. Strength increased after operation to almost three fourths of the strength of the unoperated wrist and to 100% on average of the preoperative values.

Scaphocapitate arthrodesis was easy to accomplish, it effectively preserved carpal relationships regained at operation, it resulted in a stable wrist and none of our patients actually complained of dysfunction from limited motion.

131. Forearm pseudarthrosis treated by external compression

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Introduction: The classical treatment of pseudarthrosis is resection, open reduction and internal fixation followed by immobilization in a cast or brace. This preliminary study reports the treatment of noninfected hypertrophic pseudarthrosis of the forearm by external fixation with compression (Orthofix®) without open reduction or bone grafting.

Methods: The rigidity of the external fixator is used for stabilization and a compression screw brings the pseudarthrosis under axial compression. Compression is applied by the patients 0.25–0.5 mm a day, until obliteration of the pseudarthrosis is roentgenologically apparent. The compression lasted for on an average 14 days.

Results: 6 patients with hypertrophic nonunited fractures of the ulna/radius have been treated since 1989. The time from fracture to operation was 21 (9–60) weeks. One patient had internal plate fixation, 5 patients underwent conservative fracture treatment before the external fixation. In average the Orthofix fixator was carried for 7 weeks. After an average of 5 weeks obliteration of the pseudarthrosis was observed on roentgen. 5 patients had no problems and good mobility of their forearm, one patient had reduced supination/pronation.

Conclusion: The method of external compression of pseudarthrosis seems to be successful. It is less invasive than earlier techniques and allows early joint motion. The pseudarthorses healed and 5 out of 6 patients had normal joint motion after treatment.

132. Our experience in using of the biocompatible osteoconductive polymers (BOP) in operation traumatology and orthopedics

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From 1985 to 1991 in the Red Cross Clinical Hospital in Kaunas, 70 patients (33 men and 37 women) aged 5-52 years underwent orthopedic-traumatologic operations using BOP. BOP, which stimulated greatly the reparative process, were used for the fixation of bone fragments during osteotomies (26 patients), for the knitting of bones in fractures (11 patients), for filling bone cavities after removal of benign tumors (27 patients) and for the treatment of nonunion (6 patients).

60 patients were followed from 1 to 5 years. Good results (no complaints, full range of motion in the joints) were achieved in 43 (72%), satisfactory (complaints of mild pain, slight deformation, limited motion of the joints up to one third of the normal) in 17 (28%) patients.

133. The healing of tibial plateau fractures —a roentgen stereophotogrammetric study

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After reduction of depressed tibial plateau fractures, a conflict of interest persists between retaining the congruency of the joint surfaces by immobilization, and early mobilization to counteract cartilage, muscle and bone atrophy. Using roentgen stereophotogrammetric analysis (RSA) the migration of the reduced fragment during the healing period was assessed.

Patients and methods: Five grossly unstable knees with a "split-depressed" type of lateral tibial plateau fracture were assessed. At surgery the sagittal split fracture was expanded to gain access to the interior of the condyle. The depressed fragment was elevated to its original position and four tantalum markers were inserted into the subchondral bone. An additional four markers were inserted in the unfractured tibial metaphysis for reference purposes. Ipsilateral iliac crest bone grafts and one or two AO cancellous bone screes for retention were used. Postoperatively, a whole-leg plaster was applied for 1 month after which physiotherapy ensued. No weight-bearing was allowed for three months.

RSA stereograms were taken postoperatively and after 1, 3, 6, and 12 months with the affected knee inside a calibration cage. The stereograms were digitized using a high-precision digitizing table and the x- and y-coordinates were fed into an IBM clone micro computer. Using the appropriate soft-ware first the 3-D coordinates of the patient markers and subsequently the motion of the depressed fragment relative to the rest of the tibia were obtained. Motion was expressed as the maximum total point motion (MTPM), i.e. the 3-D vector of the marker in the fracture fragment which moved the most, or as subsidence of the center of gravity of the fragment. The accuracy of RSA applied to the knee has been determined to be 0.2 mm.

Results: The clinical outcome was satisfactory in all five cases. All fractures were reduced to an anatomical position but all fracture fragments moved from this initial position during the healing phase. In two cases this motion was insignificant and within the plane of the tibial plateau. In three cases subsidence occurred ranging from 0.9 to 2.8 mm.

Discussion: With this rather conservative postoperative regimen the migrations were small and we judge the data to be encouraging with regard to a more aggressive post-operative regimen. However, retention of the fractured fragment seems to be critical and more stable osteosynthesis may be indicated.

134. Pseudarthrosis of the tibia treated by allogenic bone plates

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Introduction: Allogenic bone plates were routinely used in the treatment of pseudarthrosis of long bones in our hospital in the 60s. The purpose of this study was to evaluate the results in tibia pseudarthrosis.

Patients and methods: During the years 1961 to 1968, 20 patients had surgery for pseudarthrosis of the tibia using allogenic bone plates from our bone bank. Thirteen of the patients could be traced, 12 men and 1 woman. One of the patients had no problems with his leg and was not willing to come for re-examination. This patient had the shortest follow-up—5 years. Of the primary fractures 5 were open, 5 closed—for 3 there is no information. 11 of the fractures were caused by high energetic trauma, mainly motorcycle accidents. The primary treatment was osteosynthesis (10) and reduction and plaster casts (3). The median age at operation was 21 (17–54) years. Two of the patients had postoperative infection, one an operation for pseudarthrosis and one a skin transplantation before they were admitted to our hospital.

The time lag between the primary fracture treatment and surgery for pseudarthrosis was median 15 (8–95) months. In all 15 bone plates were used, 8 placed posteriorly, 5 laterally and 2 medially. Five of the patients also had a metal plate implanted. Five of the patients in addition had autologous cancellous bone transplantation and 5 ground allogenic bone.

Results: The median follow-up was 22 (19–27) years. One patient had an osteomyelitis 3 years after surgery. He was successfully treated by antibiotics without removal of the plates. One patient with two bone plates had refractures of both plates. He had two reoperations using new allogenic bone plates and the pseudarthrosis eventually healed. The median healing time was 7.5 (4–45) months.

At re-examination all pseudarthroses were healed, 12 had no pain, two had moderate pain on the fracture side. The physical activity was unreduced in 6 cases and slightly reduced in 7. One had a short foot syndrome. A leg length discrepancy of median 0.8 (0–3.5) cm was found. Median varus deformity was 0° (0°–15°), median valgusdeformity 0° (0°–7°).

The bone plates were fully incorporated in all cases. In 9 there was advanced remodelling but in 3 the plates had preserved their shapes.

Conclusions: Surgery using allogenic bone plates was an effective method for treating pseudarthrosis of the tibia. All 13 cases healed. At re-examination radiographs showed extensive remodelling in 9 out of 12 cases.

135. Delayed or missed diagnosis in multiply injured patients

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Study aim: To examine the full spectrum of injuries missed upon admission, reasons injuries are missed, with recommendations to minimise this problem.

A one year prospective study of 16 admitting hospitals identified 658 patients with an injury severity score (ISS) > 16 arriving alive. 171 (M=119; F=52) patients (26%) had a significant injury missed. Mean age was 51.8 (0–92) years. Median ISS = 30.

115 (67.3%) patients died in hospital. Significantly increased incidence of missed injuries in fatalities, (p=0.0000005). 17 (9.9%) patients had 2 missed injuries, 4 (2.3%) had 3 missed injuries. Total of 196 injuries were missed.

Distribution of missed injury: 44.9% head, 29.6% thorax, 15.2% abdomen.

Significance of missed injury;

36.8% of injuries were life threatening, 48.5% caused death, 14% were potential causes of significant morbidity and 0.6% minor morbidity.

60 (35.1%) patients had missed injuries diagnosed at postmortem. 65% of these injuries caused death.

Significantly greater incidence of missed blunt injury by A&E staff, general surgeons, and neurosurgeons for survivors versus fatalities, and preventable versus non-preventable deaths. Unexpected deaths from TRISS analysis had significantly increased incidence of missed injury.

Reasons injuries missed: Altered level of consciousness due to head injury/alcohol, poor clinical assessment by junior staff, inadequate roentgen facilities, admission to inappropriate setting, reluctance to investigate elderly, low incidence of polytrauma with multiple admitting units.

Conclusion: High incidence (26%) of missed injuries, 85.4%, of which threaten life.

Recommendations: Senior personnel, ATLS treatment protocols, tertiary trauma survey, rationalisation of trauma facilities.

136. Salvage protocol for major orthopedic trauma associated with severe vascular injuries

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The purpose of this study is to report on a prospective study with a specific treatment protocol for fractures, soft tissue trauma or combined injuries associated with a concomitant serious vascular injury of the upper or lower extremity.

Between 1985 and 1989, 17 patients, aged 33 (11–67) years, with major vascular lesions in either the upper or lower extremity, associated with traumatic orthopedic injuries, were operatively treated in the authors' institution. The most common mechanism of injury was fall from a height (35%). Among these patients there were 6 polytraumatized patients (35%) with concomitant other system injuries.

The management protocol consisted of shock evaluation and aggressive resuscitation. After stabilization of global body perfusion, Doppler examination was performed in all patients and operating room angiography was performed in 8 (47%). After mechanical control of hemorrhage was achieved (direct compression, clamping of injured vessels), orthopedic stabilization was performed using either external fixation (8 patients, 47%), internal fixation (1 patient, 6%) or plaster splinting (5 patients, 30%).

The vascular repairs performed were: arterial end-to-end anastomosis in 8 patients (47%), saphenous interpositional graft in 4 patients (24%), vascular decompression by fracture distraction in 1 patient (6%), xenograft interposition in 1 patient and venous repair in 3 patients (18%). In 12 patients with vascular lesions located in the lower extremity (71%), fasciotomy of all four compartments was done prophylactically.

137. Applications of the forearm flap in upper and lower extremity reconstruction

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Purpose: This study was undertaken to evaluate the usefulness of the forearm flap in the reconstruction of skin defects in severe injuries of the upper and lower extremities.

Material and methods: 34 patients with extensive skin defects of the upper and lower extremities were treated using radial forearm flaps during the last four years. Twenty patients had lower extremity injuries, while the remaining 14 had upper extremity reconstruction. In 2 patients, the radial forearm flap was used as an island flap in retrograde direction for coverage of skin defects of the dorsum of the hand. In 2 patients, the palmaris logus tendon was included in the flap to reconstruct the extensor tendon of the index finger. In 1 patient the flap was used as an inervated flap to cover a skin neurotrophic defect of the sole of the foot. In none of the flaps was a bone portion of the radius included.

Results: Of the 34 flaps, 29 survived. Of the remaining 5, 3 were totally and 2 partially failed. The 2 flaps which were partially failed required reoperation and revision of the venous anastomosis, which was found to be occluded. The patients, 8 women and 26 men, were examined and questioned regarding the cosmetic appearance of the donor site. The final cosmetic appearance was acceptable to all of them.

Conclusions: We conclude that the forearm flap is a useful, easily elevated flap, suitable for skin defects on the upper or lower extremities. The advantages of the flap are that it can be used as an island flap in retrograde direction and that surgery can be performed under regional anesthesia.

138. External fixation with "The Orthofix System" in dislocated fractures of the lower extremities in children

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Introduction: External fixation is a well-established technique. Conventional external fixation systems neither inhibit motion at the fracture sufficiently to permit optimal primary bone healing, nor do they allow sufficient motion to encourage adequate external callus formation. This combination results in an overall prolongation of healing time. In this investigation we used a light weight dynamic axial fixator—"The Orthofix System". The apparatus comprises a single bar with articulating ends which clamp self-tapping conical screws and can be locked at an angle appropriate for axial alignment. Telescopic facility allows easy conversion from rigid to dynamic fixation. We introduced the method in October 1988, and in this paper we present the results from our first 18 patients.

Material/methods and results: From October 1988 to December 1991, 18 children with a fracture of the lower extremity were treated with Orthofix external fixation—7 girls and 11 boys with an average age of 11 3/4 years. The material comprised 10 femur and 9 tibia fractures—one girl suffered both a femur and a tibia fracture. All fractures were dislocated. We operated 13 patients primarily, whereas 5 patients were operated secondarily after unsuccessful conservative treatment. Closed reduction was possible in 11 cases - open reduction was necessary in 8. Physiotherapy for the adjacent joints was begun on the first postoperative day. In 14 of the 18 patients also partial weight-bearing on crutches started at this time. Daily "pin-track hygiene" was performed. 15 of the 18 patients were discharged from hospital within the first 3 weeks postoperatively, and our average hospital stay was 13 days. All fractures except one where re-reduction was easily performed with the screws left "in situ"—revealed good alignment during the whole treatment period. At the first radiographic indication of periosteal callus, the central locking screw was loosened and dynamic loading began. The fixator was removed after an average of 9 weeks as an out-patient procedure. We observed 7 superficial pin-hole infections—5 healed after antibiotic treatment while 2 required revision—none were followed by pin loosening. We observed no cases of nonunion or malalignment. In all patients we achieved fracture healing with less than 10° angular deviation or rotation and less than 1/2 cm shortening/lengthening, with the patient restored to full weight-bearing without need for external support, and a full range of associated joint movements.

Conclusions: Evaluated from these results, we find "The Orthofix System" to be a safe, sufficient and easy method for treating fractures of the lower extremities in childhood. In this study we achieved very good postoperative results with overall success for all patients. The system offers the obvious advantages of maximal stability during primary

healing and permits partial weight-bearing during that period and later easy conversion to a dynamic modus once there is radiographic evidence of callus formation. The fixator can be removed as an out-patient procedure without anesthesia.

139. Torsional deformity after intramedullary nailing of femoral shaft fractures

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The aims of the study were to find the extent of torsional deformity after intramedullary (IM) nailing of femoral shaft fractures and to evaluate the complaints associated with such deformity.

Patients and methods: We examined 100 patients with unilateral femoral shaft fracture treated consecutively from 1982 to 1990. All fractures were healed at follow-up. The femoral anteversion (AV) angles were measured by ultrasound using the tilted transducer technique.

Results: The mean (SD) side difference in AV angles was 9° (7.5°). Eighteen patients had a true torsional deformity with AV difference exceeding 15° (17 in external and one in internal rotation), but only six of these patients had any complaints. 23 patients had a possible torsional deformity (AV difference 10°–14°), only four had complaints. Patients with complaints associated with torsional deformity had a significantly greater AV difference (mean 18°) than those without such complaints (mean 8°). Most of the patients with torsional deformity were operated on by static locking.

Conclusions: 1. Torsional deformity after locked IM nailing of femoral shaft fractures seems to be a significant problem. 2. A torsional deformity exceeding 15° is often associated with complaints and efforts should be made during the operative procedure to avoid such deformity.

140. Early experience with the nonreamed IM locked tibial nail

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Fractures of the tibia, the most commonly fractured long bone, have historically been fraught with problems. It is largely a subcutaneous bone with a poor soft tissue envelope. Infection, malunion, delayed union, nonunion remain formidable obstacles to successful treatment, especially for open fractures. Despite a variety of reported treatment protocols, there is no uniform agreement on the most efficacious approach. We feel that the nonreamed, interlocking tibial nail offers a reliable and safe treatment for most tibial shaft fractures.

The nonreamed tibial nail, however, is not without its own pitfalls. We have analyzed our early results in 32 patients followed from 3–15 months in an effort to identify these problems more completely and modify our treatment to improve the long term results. Technically, we found the location and preparation of the entry portal to be as or even more critical than in the reamed tibial or femoral nails. Intraoperative complications due to improper entry portal include bursting of the anterior cortex, penetrating of the lateral and posterior cortices, fracture of the tibial plateau and avulsion of the patella tendon. Other intraoperative complications include displacement and angulation of the fracture site.

Postoperatively, failure of interlocking screws secondary to early weigthbearing can result in loss of position requiring revision with another rod or plate and screws and/or bone graft. Additionally, unlike the femur, the incidence of delayed or nonunion appears higher with static locking than in dynamic mode or without locking. This increases the need for subsequent procedures, including: dynamization, fibula osteotomy, bone graft and electrical stimulation. This may be balanced, however, by the maintainance of alignment and length so frequently lost without static locking. There is a further advantage with regard to Gustillo grade I, II, IIIa, and IIIb open fractures. Using a nonreamed nail, locked or not, obviates the problems of pin tract infection and sequestra associated with external fixation. This allows the option of treating a delayed or nonunion with revision to a reamed rod without the fear of spreading a pin tract infection throughout the medullary canal.

In conclusion, tibial fractures pose formidable treatment problems. A good understanding of tibial anatomy, a keen appreciation of the fracture pattern and proper positioning of the entry portal will minimize intraoperative complications. After balancing the advantages and disadvantages of the current treatment options, we strongly encourage the use of the nonreamed interlocking nail for both complicated and simple tibial fractures.

141. Acute compartment syndrome after tibia fracture

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Introduction: This retrospective study evaluates the outcome of acute compartment syndrome after tibia fracture and compares the results before and after introduction of tissue pressure measurements.

Patients and methods: 17 patients with acute compartment syndromes after closed and open Grade I–II tibia

fractures during a 6-year period were reviewed. During the first 4 years the diagnosis was assessed clinically by examination of pain, swelling and neuromuscular deficit; Group A—12 patients. The next 2 years the diagnosis was confirmed with continuous tissue pressure monitoring (Camino 420, US); Group B—5 patients. Pressure above 30 mmHg for 2 hours was an indication for fasciotomy.

The two groups were matched according to age, type of injury and fracture treatment. Nine patients had primary treatment with cast and 8 patients were operated on, mostly with locked intramedullary nail. Double incision technique with four-compartment decompression was used at the time of fasciotomy. Primarily cast-treated fractures were now fixed externally or with intramedullary nail.

Results: Group A: Fasciotomy was performed on an average of 36 (8–100) hours after the injury. Necrotic muscle tissue had to be removed in two patients. The wounds were closed after 2–16 days in 8 patients, while 4 patients needed skin grafting after 12–18 days. Four patients with delayed union/pseudarthrosis were operated on 8-28 months after the injury. Short foot deformities in 2 patients were corrected by soft tissue release and bony fusion after 9 and 40 months. One patient had severe sensory and muscular loss, while 3 patients had moderate sequela with muscular weakness.

Group B: Fasciotomy was performed within an average time of 26 (17–46) hours after injury and all wounds were closed 2–8 days later. Two patients had a moderate muscular sequela, one due to delayed fasiotomy despite measurements of increased pressure during 4 hours, the other because of the surgeons delay in responding to the clinical signs of compartment syndrome.

Conclusions: Continuous tissue pressure recordings after tibia fractures resulted in earlier diagnosis and improved treatment of acute compartment syndrome.

142. Long-term results after traumatic hip dislocation without fracture

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Traumatic dislocation of the hip without fracture has been considered an injury with no long-term complications, if reduced within six hours.

Between 1974 and 1989, 50 patients with a simple dislocation of the hip were treated. There were 34 men and 16 women. The average age at the time of injury was 33 (5–62) years. Four fifths of the dislocations were the result of a traffic accident.

There were 38 posterior and 12 anterior dislocations. 47 patients had associated injuries. The injury severity was determined by the Polytrauma Score (PTS: average 19, maximum 69).

All dislocations primarily treated in our hospital were reduced by closed methods within three hours, average 85 (10–180) min. Early complications included two sciatic nerve palsies and one capsular interposition, that required open removal. Early functional treatment and partial weight bearing for only a few days were recommended in patients without further injuries.

43 patients were evaluated after an average follow-up period of 8 (2–16) years. Five patients with a PTS >40 had died in the hospital, two patients failed to attend for follow-up.

The clinical results were classified as excellent or good in 39 patients. Radiological signs of a partial necrosis were seen in two patients. Mild arthrosis was found in seven patients, moderate arthrosis in two hips. Heterotopic ossifications were seen in 16 patients (12 BROOKER I, 2 BROOKER II, 1 BROOKER III, one hip was ankylosed). 29 of 33 MRI examinations were normal. A subjective self-assessment revealed excellent and good results in 74% of the patients.

Contrary to the widely held view that there is an excellent outcome after isolated hip dislocation that is reduced within six hours, we found a significant number of complications.

143. The contribution of the lateral collateral ligament to the stability of the elbow joint during varus stress

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The stability of the elbow joint is reinforced by the presence of the medial and lateral collateral ligaments. During the last decade extensive work has been done on the medial collateral ligament, whereas the role of the lateral collateral ligament has not been clarified.

In this study, 25 fresh cadaveric elbows were examined. Following varus stress, the opening (angle) of the lateral compartment was recorded prior to and after the selective division of the lateral collateral and the ulnar collateral ligaments of the elbow.

The results were analysed using the one tailed paired t-test and showed that there was a statistically significant difference ($p<0.005$). We therefore conclude that division of the lateral collateral ligament allows the opening of the lateral compartment of the cadaveric elbow joint during varus stress. This is in direct contrast with the literature (Tullos 1981) which suggests that the elbow joint is stable in full extension, because of the relation of its articular surfaces.

144. 20-year follow-up of nonoperated on patients with chronic lateral instability of the ankle

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Introduction: The clinical status of patients with chronic lateral instability of the ankle is often mentioned in connection with operative procedures. However, the long-term outcome of patients who were not operated is rarely studied. Does long-standing chronic lateral instability lead to degenerative arthritis? How many ankles remain unstable?

Material and methods: By analysing 744 hospital records 1969-1973 with the diagnosis "distorsio pedis" 51 patients were found who had sought medical attention for ankle instability with a duration for at least half a year. Thirty-seven patients (mean age 45 yrs) could be traced and asked about their symptoms. In 34 patients (12 initially with bilateral problems) 46 ankles were radiographically examined and compared with a sex and age-matched control group. Osteoarthritis was classified according to Cedell/Magnusson.

Results: At follow-up, 23 years after onset of symptoms, 22 patients (32 ankles) still suffered from instability. Osteoarthritis was found in six ankles in the patient group (three with and three without instability) and four ankles in the control group. Comparing the ankles in patients with unilateral instability at follow-up the average joint space in the talocrural joint (measured at three points in the dome of the talus) was significantly greater in the unstable ankle.

Conclusion: Osteoarthritis was not diagnosed to a greater extent in our patients with long-term instability of the ankle than in a control group. A majority of the patients still suffered from unstable ankles.

145. The importance of repair of a ruptured deltoid ligament in ankle fractures

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Ankle fractures of Weber types B and C caused by a pronation-abduction trauma of the ankle are commonly associated with rupture of the deltoid ligament or avulsion fracture of the medial malleolus. The clinical importance of suture of the deltoid ligament in such ankle fractures is unclear.

Material and method: Fifty patients (median age 38, range 17–75 years) with fracture of the lateral melleolus and demonstrating radiological signs of ruptured deltoid ligament were randomized into two treatment groups; 1: osteosynthesis of the fracture (n=25) and 2: osteosynthesis of the fracture and exploration and suture of the deltoid ligament (n=25). All patients were treated with a cast for 2-3 days postoperatively, followed by mobilization without full weight-bearing until 6 weeks after surgery. Peroperative data, complications and long-term result were recorded.

Results: In two patients in the group allocated for suture of the deltoid ligament no total rupture of deltoid could be found. The two treatment groups were comparable with regard to age, sex, anesthesia, classification according to Weber and rupture of the syndesmosis. The median duration of the operation was 75 (20–138) minutes in the nonsuture group and 95 (29–175) minutes in the ligament repair group (p=0.04). Two patients treated with osteosynthesis without exploration of the medial side of the ankle had a post-operative superficial wound infection and 2 were reoperated because of slipping of the syndesmosis screw. In the ligament repair group 1 patient was reoperated and 1 had a superficial wound infection, successfully treated with antibiotics. There were no significant differences in hospitalization time (median 6, range 2–19 days) or absence from work (median 7, range 2–13 weeks) between the two treatment groups. The follow-up period was 5–35 (median 17) months, and there were no significant differences in clinical instability of the ankles nor subjective complaints between the two treatment groups.

Conclusion: The present study suggests that in an ankle fracture a suspected deltoid rupture can be left unexplored without any effect on the early mobilization or long-term results.

146. Mechanoreceptors of the interosseous talocalcaneal ligament

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A modification of the gold chloride technique was used to characterize the mechanoreceptors of the interosseous talocalcaneal ligament.

Three morphological types of receptors were identified. Type II and Type III seem to be activated by movements of the joint and send messages into the motor circuit. Type IV (free nerve endings for pain) constitute a pain receptor system which sends messages to sensitive areas of the brain.

The presence of mechanoreceptors in the subtalar region explains certain pathological situations.

Disruption of the interosseous talocalcaneal ligament not only deprives the foot of a strong stabilizing element, but also results in some degreee of denervation of the joint.

147. Jones' fracture—surgical versus non-surgical treatment

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Introduction: Jones' fracture is reported to be associated with a high rate of healing problems and in the largest series available so far—23 patients—there was delayed union in 2/3 and refracture in 1/2 of the patients.

Material and methods: There were 3,676 foot fractures recorded in our department of diagnostic radiology from 1981 to 1990. All the radiographs were scrutinized for Jones' fractures, defined as a transverse two-fragment fracture of the proximal end of the shaft of the fifth metatarsal. Only fractures distal to the joint between the fifth and fourth metatarsals were included. Out of 71 fractures 67 in 64 patients were available for follow-up.

Results: In 34 fractures, callus was seen at the time of diagnosis although the injuries were less than three days old. This suggests stress fractures with minor symptoms prior to a final injury. The primary surgical treatment in 23 injuries involved medullary screw fixation. The nonsurgical treatment in 44 fractures was elastic bandage for 35 and plaster cast for 9.

There was no difference in age at the time of injury, rate of sports injuries or time of follow-up between surgical and nonsurgical groups. Delayed surgical treatment was required in 10 fractures of the nonsurgical group - in two cases because of refracture and in 8 delayed union. These patients were operated with medullary screws on an average 214+207 (49-730) days after the initial injury.

At follow-up evaluation 5±3 (1–10) years after initial injury all the patients had returned to full physical activity including sports. Thirteen patients had had the screws extracted and in three of these refractures had occurred.

Conclusion: Primary as well as delayed medullary screws are safe methods resulting in healed fractures and full physical activity for all patients in this study. However, we believe that the rate of complications in nonsurgical treatment does not justify primary surgical treatment for nonathletes and recreational athletes. For these patients we suggest elastic bandage as primary treatment.

148. Surgical treatment of pilon fractures

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For pilon fractures, just as for all other intraarticular fractures of the lower extremities, a complete or near anatomic reduction and restoration of the articular surface of the lower end of the tibia is needed for a satisfactory and long-standing functional outcome. This accurate reduction is extremely difficult to accomplish by conservative management. Surgical treatment is thus indicated for the great majority of these fractures.

66 patients with 67 fractures and a mean age of 41.6 years were treated surgically and evaluated after 7 (2–12) years. They were classified into three types according to the Ruedi and Allgoewer method and 59 of them were type II and III fractures. Eleven (16.4%) were open fractures.

50 of these 67 fractures were treated according to the AO method, 9 by minimal osteosynthesis, usually after internal fixation of the fracture of the fibula, and the remaining 8 cases by external fixation. The outcome of the treatment was evaluated on the basis of the subjective, objective and radiographic results of each case, according to the method used by Burwell and Charnley (1965). These results were greatly influenced by the type of the fracture, the quality of surgical reduction achieved in the operation and, to a lesser extent, the method of treatment.

In type I fractures, the results were good in 90% of the cases and in all the separate evaluations; in type II the clinical results were good in more than two thirds and the radiographic results in just over one half of the cases; while in type III fractures the clinical results were good in less than one half and the radiographic results in only 15% of the cases.

Good reduction on operation was accomplished in 33 out of 59 cases of type II and III fractures and more than two thirds of them had good clinical and radiographic results. The reduction was evaluated as moderate in 9 and as poor in the remaining 17 cases: less than one half of these had a good clinical outcome and none a good radiographic result. This disagreement between the clinical and radiographic results in the ankle has been found in many reported series of pilon fracture.

The results were also evaluated according to the method of treatment and the A.O. technique was found to be much better than the other methods of treatment. Good clinical (subjective) results were seen in 36 cases (72%) with the AO treatment, but in only 9 (53%) of the cases treated by the other methods.

Complications which influenced the results of treatment were deep infection in 9 cases (13.4%) and pseudarthrosis in 4 cases, in two of which deep infection was also present.

149. The biodegradable polymer polyhydroxybutyrate—an evaluation of its biocompatibility and degradation using titanium mosaic coated implants in the rabbit femur

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The use of biodegradable polymers for fracture fixation remains problematic. Their advantages have been offset by the inherent limitations in the materials available, as regards

strength and speed of degradation. Polyhydroxybutyrate (PHB) is a naturally occurring degradable polyester of ô-hydroxybutyric acid that may provide a solution. This study, utilising in situ control implants with a thin titanium mosaic coating, assesses the molecular weight changes and tissue responses to PHB implanted in an intramedullary site.

The implants used were cylindrical rods (65mm x 3.6mm diameter) of PHB. Half of them were given a thin titanium coating applied as a mosaic pattern to their central area. The remaining implants were either left uncoated or given a complete titanium coating. Prior to implantation a 5-mm portion was removed from an uncoated region of each implant and saved for molecular weight analysis.

The resulting 6-cm implants were introduced into the femoral canals of 22 male, skeletally mature, sandy lop eared rabbits. Each animal received a titanium mosaic implant in one femur and either an uncoated PHB implant (14 animals) or a completely coated implant (8 animals) in the other. Femora were retrieved at intervals of 1 week, 6 weeks, 4 months and 1 year after implantation and subjected to molecular weight analysis and histological analysis.

The acute inflammatory response to both uncoated PHB and titanium coated PHB was minimal. By 1 week, all implants were bordered by normal marrow cells.

Direct bone contact was observed at 6 weeks on both uncoated PHB and titanium coated surfaces. The morphology of the interfacial response to both surfaces was similar, with encapsulation by an incomplete fibrocellular membrane. Bone contact had increased by 4 months and was further increased after 1 year. Bone remodelling was more extensive at the interface with uncoated PHB than with titanium coated PHB. No chronic inflammatory response was evident for either uncoated or titanium coated PHB at any implantation period.

After 4 months, some areas of the uncoated PHB implants showed surface changes. There was also a reduction in molecular weight that by 1 year of implantation had become significant, with a 46% fall in mean weight average molecular mass (Mw). The fall in Mw for both types of implant was accompanied by a significant reduction in number average molecular mass (Mn) and polydispersity (Mw/Mn), confirming polymer degradation.

The results of this study indicate that PHB is a true biocompatible material with a slow degradation time and could thus have a potential application as a biodegradable fixation device.

150. Seven-year experience of the use of totally absorbable fracture fixation devices

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Totally absorbable internal fracture fixation devices were clinically introduced in the treatment of fractures in the extremities in the mid 1980s.

At the authors' department a total of 1696 patients were managed using fracture fixation devices made of self-reinforced (matrix and fibers of same polymer) absorbable alpha-hydroxy polyesters, mainly polyglycolide during a seven-year period 1985-1991. The devices used included cylindrical rods or pins in 993 patients, screws in 614, tacks in 82 patients, plugs in 4 patients and wires in 3 patients. The chemical composition of the devices was polyglycolide in 1369 cases, polylactide in 274 and lactide-glycolide copolymer in 53 patients.

The most common indication for the absorbable implants was displaced malleolar fracture of the ankle, 888 patients, rupture of ulnar collateral ligament of the thumb, 82 cases, fracture of the radial head, 65 patients, and fracture of olecranon, 55 cases. Transphyseal fixation with small-diameter polyglycolide pins was used in 34 children. Absorbable implants were used in the fixation of a chevron osteotomy in addition to the fracture fixations of the first metatarsal bone for hallux valgus in 229 patients.

The postoperative clinical course was uneventful in over 90% of the patients. The complications included bacterial wound infection in about 1% and failure of fixation necessitating reoperation in about 1%. A noninfectious foreign-body reaction two to three months postoperatively has markedly decreased over the years. These inflammatory tissue responses often required minor surgical procedures to resolve but did not influence the ultimate functional or radiographic result of treatment.

Thanks to the biodegradability of these internal fixation devices it can be estimated that some 800 implant removal procedures were avoided during the seven-year period under review. Consequently, resource requirements were diminished and these facilities could be directed to other operations.

151. Pharmacokinetic study of the Fibrin-Ciproflaxin complex—an in vivo experimental investigation

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Chronic osteomyelitis is difficult to treat because of the characteristics of bone tissue. The necessity for local antibiotic treatment has been recognised and various methods have been developed for delivering antibiotics.

We prepared a composite of fibrin clot and ciprofloxacin complex, a biodegradable antibiotic system with sustained effect. The composite was implanted in the medullary canal of the tibia in rabbits and the effective concentration was measured in bone tissue, muscles, fat tissue and skin.

In all tissues around the implant the concentration of antibiotic exceeded the minimum inhibitory concentration (MIC) against the common causative organisms of osteomyelitis (e.g., *Staph. aureus, Ps. aeruginosa,* Enterobacter) for 10 days.

We concluded that the high release of ciprofloxacin in vivo from fibrin clots is very promising, since the obtained levels in all tissues are twenty times higher than the required MIC against the pathogens implicated in soft tissue and bone infections.

Although it will be necessary to perform similar experiments using bones in pathological states, these experimental results suggest the clinical applicability of this drug delivery system.

152. The rat bone chamber—a new model for studies of bone formation

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Titanium bone chamber techniques for studies on bone formation have been used for decades. So far, the chambers have mostly been implanted in rabbits. In order to allow larger series and easier handling, we have developed a bone ingrowth chamber that can be applied in the rat. This chamber consists of a threaded dividable cylinder with two small openings for bone ingrowth at one end, which is anchored in the proximal end of the tibia. The other end is closed and covered by the overlying subcutis. Chambers were inserted in 35 rats. The rats were killed after 3, 4 and 6 weeks. The amount of bone inside the chambers was measured on histological sections using a histomorphometry computer. Bone ingrowth had penetrated 1.1, 1.5 and 2.4 mm into the chamber after 3, 4, and 6 weeks, respectively. Bone formation appeared to take place by membranous ossification and seemed to be completed after 6 weeks. This chamber may be used for comparing osteoconductive properties of various materials inside the chamber and for local treatment of the ingrowing bone with injected substances.

153. Polylactide pins in the fixation of small-fragment fractures and osteotomies

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Introduction: Absorbable rods and screws made of polyglycolide have been in clinical use for several years (Böstman 1991). Because polyglycolide implants lose their mechanical strength within a few weeks, small-diameter pins made of polyglycolide have a limited field of applications. Polyactide, another absorbable polyester suitable for fracture fixation devices, has a considerably longer degradation time. In this prospective clinical study small-diameter pins of polylactide were used to fix a variety of small-fragment fractures and osteotomies.

Patients and methods: From August 1988 a total of 32 patients have been operated on using pins made of poly-levo-lactide of a molecular weight of 250 000. The most common indications were fixation of chevron osteotomies of the first metatarsal and displaced fractures of the radial head. The pins measured 1.5 or 2.0 mm in diameter and from 10 to 70 mm in length. Twenty-seven patients, with a follow-up time ranging from 8 to 37 months, could be regularly followed clinically and radiographically. In 2 patients a biopsy of the implantation site could be obtained for histological examination.

Results: No redisplacements were seen. Wound infections or sterile inflammatory tissue reactions did not occur. On computerised tomographic scans as well as on microscopic examination of the biopsy specimens the implants had degraded after 2 years. In a biopsy specimen obtained 37 months after the operation the implant channel was filled with fibroconnective tissue but showed no signs of restoration of the bony architecture.

Conclusion: The mechanical properties of the polylactide pins seemed to be sufficient for the fixation of small-fragment fractures and osteotomies. Consequently, in certain indications the pins may be a useful alternative to Kirschner-wires. Further research is required to evaluate the ultimate tissue replacement patterns of the implant channels.

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154. Polytrauma in the elderly

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A one year prospective study compared and contrasted trauma patients >60 years (n=309) with adults <60 (n=677) presenting with Injury Severity Score >16.

In the elderly 77% sustained blunt trauma. 127 (41%) were injured on the roads, 62 (20%) as pedestrians. 135 (43%) were injured at home, 76 (24.6%) by falls. 126 (41%) were women, 116 (37.5%) died before arrival in hospital, 142 (46%) in hospital and 51 (16.5%) were discharged.

44% had poor airway management, 17.7% delayed surgery. Significant injury was missed in 46.7%. 21.1% of

hospital deaths occurred on day one. 44.6% of the elderly brought in alive were admitted to the ITU. Maximum AIS = 4.52 for in-hospital deaths. Revised Trauma Scores for blunt injured was 7.25 (survivors) versus 6.06 (fatalities) ($p<0.0005$).

TRISS methodology gave 57.8% unexpected deaths and 14.3% unexpected survivors. In hospital the death rate was 73.6%. There were significant differences for all these factors in the adults.

A highly significant difference in median ISS existed between the two groups for in-hospital deaths; elderly=29, adult=41 ($p=0.000005$).

For ISS <40 there was a highly significant difference in mortality between the two groups ($p<0.0005$–0.0000005). No significant difference was observed between the two groups, survivors versus fatalities, in length of ITU stay and number of patients ventilated.

No differences were seen in the incidence of body region injury for blunt trauma. Head=72%, thorax=56%, abdomen =21%.

Conclusion: Polytrauma is uncommon, the incidence will increase as the population ages. Elderly die of lesser injuries compared to the young. Our ability to save the injured elderly is poor. Injury scoring systems need to take account of age, pre-injury illness and function.

155. In vitro assessment of proximal resistance arteries isolated from cancellous bone

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Introduction: Present knowledge of vascular physiology of bone tissue has been derived from in vivo perfusion studies. However, in such experiments it may be difficult to distinguish direct effects of vascular reactivity in bone from hemodynamic changes in bone secondary from effects in other organ systems. The perfused tibial nutrient artery model is the only isolated bone perfusion model currently available. This model allows direct assessment of normal vascular physiology in the tibia, but information on the vascular pathophysiology in localized bone disease is difficult to obtain. We have therefore established an in vitro method for direct investigation of vascular reactivity in resistance vessels isolated from cancellous bone.

Material and methods: The distal end of the femur was removed from anesthetized pigs (approximately 80 kg). The condyles were sliced sagittally and stored in a physiological saline solution. Proximal resistance arteries were dissected from cancellous bone (1 to 4 vessels per pig) under a stereomicroscope and mounted as ring preparations on a small vessel myograph (1, 2). The diameter (1100) the vessels would have had in vivo when relaxed and exposed to a pressure of 100 mmHg (13.3 kPa) was determined. The vessels were stimulated isometrically with a solution containing 125mM potassium and 10μM noradrenaline (NAK), or with increasing concentrations of noradrenaline, vasopressin, or potassium. From the force development measured, active tension and active pressure were calculated. The active pressure represents the pressure against which the vessel would have been able to contract under in vivo circumstances (1).

Results: The success rate of dissection and mounting was about 95%. Thirty-nine viable vessels (l_{100} = 250 μm (range 159–401 μm)) were studied. The force development was maximal at 0.9 x l_{100}, and this setting was used in all subsequent experiments. When activated with NAK, the maximal tension was (mean ±SEM, n=9) 2.92±0.33 N/m and the active pressure 198±19 mmHg (26.4±2.5 kPa) (25 vessels, 9 pigs). This is consistent with values obtained from vessels isolated from other vascular beds (2) and suggests that bone vessels are fully viable using this technique. When stimulated with noradrenaline, vasopressin, and potassium, dose-dependent responses were found. There was no difference in force development, agonist sensitivity, or reproducibility between vessels investigated on the first and the second day after dissection. Contractile responses remained constant for 10 hours after mounting.

Conclusions: With the establishment of this technique, controlled in vitro investigations of small trabecular arteries have been made possible, allowing direct assessment of vascular physiology and pathophysiology in bone tissue.

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156. Fractures after epileptic seizures

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Fractures and dislocations after epileptic seizures were first described in 1907 by Lhendorf. The most common locations for fractures after epileptic seizures are compression fractures of the spine, fracture of upper end of the humerus and the hip but other sites are known. Epileptic patients, especially those treated with anticonvulsants, are more likely to sustain fractures than the general population. Anticonvulsants seem to alter bone metabolism and osteomalacia is a well known complication.

We have recently treated six patients that sustained fractures or fracture dislocations after epileptic seizures. Some of these injuries seem to be very rare.

Fractures after epileptic seizure can be both bizarre and multiple although fracture of the spine is most common. Four of our patients sustained multiple and/or severe

injuries and one was initially misdiagnosed. Bilateral posterior shoulder fracture dislocations and central fracture dislocation of the hip seem to be very rare injuries after epileptic seizures.

Fractures were frequent during ECT procedures before the introduction of muscle relaxants. The most common fractures were, as after epileptic seizures, compression fractures in thoracic spine but all types of fractures and dislocations occurred. The incidence of fracture of the vertebral spine may be up to 16% after seizures. Four of our patients had vertebral fractures. Two of our patients had osteoporosis and this diagnosis was suspected in a third.

We conclude that epileptic seizures may cause bizarre fractures and/or fracture dislocations. Fracture should top the differential diagnostic list when a patient complains of musculoskeletal pain after an epileptic seizure.

157. Torsional strength of bone in immobilization osteoporosis

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The mechanical properties of rat bone after limb immobilization were examined using torsional testing.

Rats were immobilized by casting a hind limb. After three weeks femur ash weight was measured and tibias were submitted to torsional testing with a specially constructed torsion machine. The results were compared to those of the weight-bearing legs.

Torsional strength and rigidity of tibia were reduced in immobilized legs compared to the contralateral. The maximum angle of deformation was not significantly influenced by immobilization. The ash weight of the femur was clearly decreased after immobilization. There was a high correlation between the maximum torque capacity of the tibia and the femur ash weight. .

These results indicate that in rats three weeks of immobilization produces noticeable reduction in the maximum torque capacity and the rigidity of tibia, which is correlated with a decrease in femur ash weight.

158. Posttraumatic osteopenia—a life long condition?

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There is always a local loss of bone after an injury to a limb. It has earlier been shown that one year after a tibial fracture the net loss is 25% in the fractured limb and one year after a knee ligament injury the net loss is 10% in the injured leg, measured with single photon absorptiometry in the tibial condyle. With the introduction of the DPX technique we have a precise way of examining the bone mineral content in different regions in the once injured extremity and to compare with the uninjured side.

Sixty-two patients with tibial shaft fractures (n=38) and knee ligament injuries (n=24), 39 men (30–83 years at the time of the follow up) and 23 women (30–83 years) were examined. All had after their original injury in 1950–1975 been examined by single photon absorptiometry. A re-evaluation was performed in 1991 using the DPX technique. Total body, hips, femur condyle, tibia condyle and tibia diaphysis were measured. All patients with fracture after their original injury were excluded. The aim of the study was to see if posttraumatic bone mineral loss is reversible and also if patients sustaining these two types of injuries have lower regional or total bone mineral content (BMC) than age-matched noninjured controls.

We found a remaining difference in the bone mineral content between the injured and uninjured legs, most obvious in the femur condyle ($p<0.001$). The same result was found when patients with ligament injuries ($p<0.01$) and with tibial fractures ($p<0.05$) were examined separately. Also, patients with fractures 28–38 years ago, still retained their posttraumatic osteopenia in the femur condyle in the once involved tibia ($p<0.05$). Separated in sexes, the result remained significant in men ($p<0.001$) but not in women.

There was no significant correlation between the initial loss of bone one year after the injury compared with the loss of bone at the time of follow-up. There was no BMC difference in any of the nonfractured regions comparing the injured group with age and sex-matched controls.

We conclude that a tibia fracture or a knee ligament injury leaves behind a decreased bone mass in the injured leg that is never completely replaced, and that the injured group otherwise has the same bone mineral mass as the age and sex-matched nonfractured controls.

159. Thromboprophylaxis with LMW heparin in immobilized orthopedic outpatients

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Introduction: Immobilisation following trauma is a major risk factor for deep vein thrombosis. The aim of our trial was 1. to investigate the incidence of DVT in conservatively treated out-patients with plaster cast immobilisation and 2. to prove the efficiency and safety of LMW heparin prophylaxis in these patients.

Material and methods: In a controlled, randomized and prospective study 259 patients with minor injuries of the

lower extremity were allocated to two groups (n=129 receiving 1 s.c. injection of a LMW heparin daily, n=130 being treated without anticoagulant prophylaxis). Before and after plaster cast immobilisation a noninvasive screening program (strain gauge plethysmography, CW doppler and Duplex ultrasound) was performed in all patients. Cases of suspected venous thrombosis were verified by phlebography.

Results: In the control group 5 cases of deep vein thrombosis were detected. None of the patients in the prophylaxis group suffered a thromboembolic complication during the study. Only minor adverse effects of LMW heparin were observed in 4 patients.

Conclusion: We conclude that thromboprophylaxis with LMW heparin once daily is safe and effective in preventing DVT in out-patients with plaster cast immobilisation.

160. The in vivo and in situ perfused tibia —a model for the study of vasoactive substances in the pig

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Introduction: This model was developed to study the role of various peptides in bone blood flow regulation. The aim of the model was primarily to serve as a screening tool prior to more elaborate studies.

Material and methods: Danish breed pigs of both sexes weighing 60–76 kg were used. After premedication with midazolam (Dormicum) and intravenous injection of Hypnodil the pigs were intubated and ventilated on a volume controlled ventilator with atmospheric air and oxygen (33%). Anesthesia was maintained by continued infusion of ketamine (Ketalar), pancuronium (Pavulon), pethidine and midazolam. The animals were initially heparinized with a dose of 400 IE/kg and maintained with 100 IE/kg/hour. The brachial artery and vein served for arterial (AP) and central venous pressure (CVP) monitoring, respectively. Intraosseous pressure (IOP) was recorded through an intraosseous Radner bone cannula in the proximal diaphyseal marrow by means of a liquid filled electromanometric pressure recording system. The nutrient artery of the tibia (NAT) was dissected free by isolation and elevation of the anterior tibial muscle. An extracorporal blood supply was delivered to NAT from the right carotid artery via a peristaltic pump. The perfusion pressure was recorded simultaneously. The bone perfusion rate was selected to produce a flow which produced a perfusion pressure equal to the mean arterial blood pressure. Steady state was controlled by the central pressures, core temperature and blood gases. Steady state values were maintained at least 4 hours and served as baseline control.

Results: Mean arterial pressure and central venous pressure were 86 mmHg and 9 mmHg, respectively. The mean perfusion pressure of NAT was 91 mmHg, with a mean perfusion rate of 1 ml/min. The mean IOP was 22 mmHg. In the 4 hours observation period slight systemic pressure changes and metabolic disturbances had to be adjusted. After 4 hours perfusion pressure of NAT was 95 mmHg and the concomittant flow was unchanged. The IOP and CVP remained normal.

Conclusion: This model is the first developed in pigs. We have established an in situ perfused bone model with peristaltic nutrient artery perfusion and IOP and CVP pressure recordings. The model appears suitable as an in vivo screening tool for vasomotor effects in the bone vascular bed.

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161. Avascular necrosis of the femoral head treated by vascularized iliac periosteal flap graft—experimental study and clinical application

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Avascular necrosis of the femoral head presents the orthopedist with a major dilemma concerning treatment. From March 1983 to June 1987, we used vascularized iliac periosteal flap grafts to treat six patients suffering from avascular necrosis of the femoral head with satisfactory results on 3 to 7′ years' follow-up. They experienced no hip pain, could walk freely and resumed work after the treatment. Roentgen showed that the original femoral head pit had been filled up and its outline had become clear and smooth. The bone density of the femoral head and neck had become normal.

Experimentally, 32 adult dogs were randomly divided into three treatment groups: vascularized iliac periosteal flap grafts, vascularized iliac bone grafts, and controls. The animals were sacrificed at intervals 2, 6, 12, and 20 weeks after surgery. The specimens were studied by routine histology and gross examination, tetracycline and alizarin red uptake assay, microangiography with micropaque and bone density examination by single photon absorptiometry. The results indicated that vascularized periosteal flap grafts have excellent osteogenic capacity even in necrotic beds and without weight-bearing or stress. The necrotic femoral head could be revascularized by the transfer and be promoted to repair by the grafts.

The ability of osteogenesis and revascularization of the vascularized periosteal flap grafts is superior to those of vascularized bone grafts. This technique is suitable for

treating avascular necrosis of the femoral head of stage II and stage III.

162. Predicting risk factors of infection in complicated wounds of hands and feet

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We have conducted a randomized, double-blind study of traumatic wounds on hands or feet with underlying lesion of one or more of these structures: bone, tendon or joint. The patients were allocated to one of three groups: A: 2 MIU of penicilline i.m. as soon as possible after trauma, B: 1 MIU of penicilline orally twice a day for 6 days, starting after surgery and C: placebo only. The treatment had to be commenced within 6 hours after trauma. A total of 599 patients were included. The patients were followed for at least 3 months. In group A the wound in 10 patients (4.9%) became infected compared to 13 patients (6.6%) in group B and 20 patients (10.2%) in group C. Thus there is a therapeutic gain of 5.3% (95% confidence interval 0.1–10.4) of an early one-dose injection of penicilline compared to no antibiotics.

To investigate the influence on infection of different factors commonly considered clinically important, a logistic regression analysis was performed. By a backward stepwise procedure the following factors were found to have no independent significant influence on the infection rate: osteosynthesis, deep sutures, the time interval from injury to treatment, the type of wound (i.e. incision or contusion). In addition to treatment with penicilline, the following factors have influence on the infection rate:

Factor	Compared twith	Odds ratio	95% CI
Diabetes	No diabetes	36.5	5.3–252
Skin suture	No skin suture	8.4	1.1–64
Age >38 years	Age <38 years	1.9	0.9–3.8
Bone lesion	Tendon lesion	6.2	2.3–16.8
Two structures	Tendon lesion	6.2	2.1–18.7
Three structures	Tendon lesion	16.8	2.5–115

This means that for instance patients with lesion of three structures (i.e. bone, tendon and joint) have a nearly 17 times higher infection rate than patients with tendon lesion alone. The age of the patient is marginally significant. Thus the model predicts that the main risk factors for infection is the presence of diabetes and the structures involved in the lesion, i.e. factors beyond the control of the surgeon.

163. Fractures of the humeral capitellum fixed with absorbable polyglycolide pins

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Introduction: Absorbable 2-millimeter polyglycolide pins have been successfully used in fractures of the lateral head (Hirvensalo et al. 1991). Transarticular fixation of the small, totally intra-articular fragments avoiding secondary operations to remove the implants have been the major advantages of the method. Consequently, polyglycolide pins were introduced in several other clinical applications to small intra-articlar fractures.

Patients and methods: From 1987 eight adult patients with a displaced fresh type I (major part of the capitellum) fracture of the humeral capitellum were operated on in the authors' department. The trauma was in all cases a fall on the outstretched hand.

At the operation the fracture was exposed through a lateral approach. The fragment was reduced and the fragment was fixed with at least 2 diverging 2-millimeter pins tapped into predrilled channels through the fracture surfaces. The head of each pin was recessed below the articular surface. All the patients were immobilized in a plaster cast for 3 weeks.

Results: No failures of fixation were seen. An anatomic position of the fragment could be achieved in all cases. In 2 cases osteoarthritic changes were observed in the radiographic evaluation after 1 year. There were no intraoperative complications. No infections were ensued. In one case a sterile synovitis of the elbow joint emerged 8 weeks postoperatively—a few milliliters of grayish fluid was aspirated. The bacterial cultures were negative. The aspiration was repeated afer one week and the synovitis subsided clinically within 3 weeks. The final functional outcome was excellent or good in all the cases. Four patients had some restriction of extension. All the patients were painless.

Conclusion: Although the number of patients was limited the results of the present study indicate that treatment of fractures of the humeral capitellum with absorbable polyglycolide pins is possible.

Reference

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164. Intramedullary polyactide rods in fixation of cortical bone osteotomies

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Introduction: Polylactide (PLA) has been studied as a fixation material from the sixties, and has been proven to be well tolerated by tissues. The results of cancellous bone fracture and osteotomy fixations with PLA devices have been good (1), while results of fixations of cortical bone osteotomies have been less satisfactory (2). The aim of this study was to find out, whether the novel, fibrillated, self-reinforced poly-L-lactide (SR-PLLA) rods are suitable for fixation of cortical bone osteotomies.

Materials and methods: The 4.5 mm rods were manufactured from Mw 700,000 PLLA by a fibrillation method (3), and gamma sterilized by a 2.5 MRad dose. The bending strength of the rods was 245 MPa, bending modulus 8.2 GPa, and shear strength 136 MPa. A medial parapatellar arthrotomy was made of the right knee of 42 rabbits in ketamine-medetomidine anesthesia. The patella was dislocated laterally and the diaphysis of the femur was exposed. A 4.5 mm hole was drilled from the intercondylar space to the medullary canal. A cortical bone ostetomy was made in the distal third of femur and the SR-PLLA rod was tapped in to fix the osteotomy. The rod was cut to match the shape of the patellar joint. The wound was closed in layers. No external support was used after the operation. Follow-up times were 3, 6, 12, 18, 24, 36, and 48 weeks. The rabbits were killed and the femurs were dissected and radiographed. Two bone specimens from each follow-up group were prepared for histologic evaluation, while five bones were tested mechanically for shear strength of the osteotomy line. The SR-PLLA rods were removed from intramedullary cavities before mechanical testing. In addition, SR-PLLA rods were incubated in phosphate buffer and mechanically tested between three and 48 weeks.

Results: None of the rods broke during follow-up. There was one nonunion after three and one after 12 weeks. Radiographical studies showed normal healing and callus formation—visibility of the osteotomy line decreased. Histologic, microradiographic and oxytetracyline fluorescence studies showed normal healing, a mild foreign-body reaction was observed from three to 36 weeks. Shear strength of the osteotomy was measured in 30 bone samples; it increased from 3.0 MPa after three weeks to 10.0 MPa after 48 weeks (Figure). After 12 weeks, in vivo SR-PLLA rods had a 115 MPa shear and a 245 MPa bending strength; and after 48 weeks a 10 MPa shear strength (Figure). In vitro hydrolysis studies on shear strength of the rods revealed that the strength retention was better in vitro than in vivo.

Conclusion: Fibrillated SR-PLLA rods are strong enough for intramedullary nailing of femoral cortical bone osteotomies in rabbits.

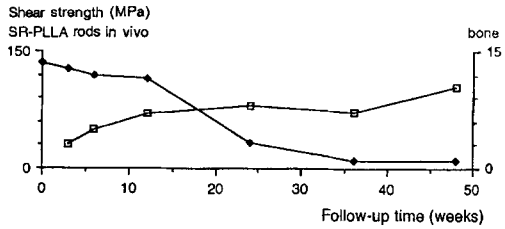

Figure. Shear strength of femurs (open symbols) and SR-PLLA rods in vivo (solid symbols).

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165. Bending strength of the femur in relation to bone mineral

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Reduced bone mineral may be important for the overrepresentation of distal femoral fractures in the elderly and for the problems in their treatment. The stability of the bone/implant construct depends on the strength of the implant and the bone, the latter being the variable factor. To obtain basic data about the mechanical properties of the femur as a structure, we subjected cadaver femora to 3-point bending after having examined their mineral content by quantitative computerized tomography (QCT) as well as dual energy X-ray absorptiometry (DXA).

Material and method: 14 cadaver femora, procured at autopsy from 10 men and 4 women, were examined for their mechanical strength by 3-point bending of the distal end of the shaft. Bone mineral was determined at 4 different sites of each femur by QCT and DXA and correlated with the mechanical parameters achieved by the 3-point bending test.

Results: The femora fractured at very different loads (median 4820 (1400–8000) Newton). All fractures were located in the distal infraisthmic part of the femoral shaft. The correlations between mass values by QCT, density and content values by DXA, and the mechanical properties of the femur were good. The QCT density values, however, showed less good correlation with the mechanical parameters of the femur assessed by the 3-point bending test.

Discussion: The decreased structural strength of the femur due to loss of bone mineral increases the risk of fracture. The present study extends the earlier observations about the correlation between mechanical properties and bone mineral in cancellous bone to diaphyseal cortical bone. The discrepancy between the density values assessed by

QCT and DXA, and the mechanical parameters, is explained by the fact that DXA density values do not represent true densities as they reflect bone mineral per projected area and take the geometry of the bone into account like QCT mass and DXA content values.

Bone mineral assessments may become an important modality in prediction of risk of fracture in the diaphyseal bones in the elderly and for choice of implants in fracture treatment.

166. Triglyceride histochemical observations during mineralization in in vitro cultures of osteoblasts

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An experimental study was carried out on cultures of the isolated bone cells from the calvaria of newborn rabbits. In the early stage of the culture, proliferation of bone cells increased cell density in a confined space. Some cells, such as osteogenic cells, marrow stromal cells and osteoblasts (function-reverted cells due to loss of bone matrix) appeared to differentiate. Localized regions of mineralization were found in confluent cultures of bone cells. The mineralized tissue was observed in the living cultures with a fluorescence. Investigation with the triglyceride histochemical methods under light microscope demonstrated that within these sites there were many triglyceride droplets. Foci were always surrounded by many cells. The results suggest that the triglycerides take part in in vitro osteogenesis. This paper also discuss possible mechanism of triglyceride-induced effect.

167. Ender's nailing in the treatment of open tibia fractures

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146 patients with 151 open tibia fractures, classified according to the modified Gustilo and Anderson and the OTA, I A, I B, I C, II A, and II C 107, III B III D, III A, IV B 44 with Ender nail immobilization and early weight bearing were reviewed to re-evaluate the results and compare with plate-spiral, plaster, traction and Chinese small splint.

The advantages of this method are 1) extensive indications, 2) simple technique and small operative trauma, 3) it reduces the application of additional external fixation, 4) less disturbance to blood supply of fracture ends, 5) early weight bearing and movement, 6) normal knee and ankle movement are possible during healing, 7) relatively rapid restoration of bone continuity, 8) greatly facilitating the care of the soft tissue, 9) low infection rate—osteomyelitis or pin-tract infections, 10) low delayed union and nonunion rates, no refracture.

The disadvantages are 1) not useful for fractures near the ankle or the knee, 2) sometimes the pin tail may perforate the skin, 3) the reduction of fractures are always unsatisfactory—a posterior angulation may occur.

The authors conclude that Ender nailing is the best way to treat open tibia fractures.

168. Photoelastic study of the ankle joint—an experimental study

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We studied the forces applied to the loaded ankle joint by means of photoelasticity, focusing on the forces applied to the posterior malleolus.

The model used consisted of two parts, one representing the lower end of the tibia and the other the talus, as drawn from lateral radiographs. Between these parts a rubber sheet was inserted to represent the articular cartilage. These models were made from Araldite plates, 1cm in thickness, and simulated the normal ankle and ankles with fractures of the posterior malleolus equal to 1/4 of the joint space, with and without anatomical reduction and screw fixation.

The loading forces were applied to each model in three different ways, neutral position, dorsiflexion and plantal-flexion.

To facilitate our qualitative study, the articular surface was divided into four quarters, starting from the anterior margin.

The models were loaded with 55kg and 105kg and the isochromatic patterns were set up. Then, the isoclinins pattern was built up from 0° to 90°, in steps of 10° for each isoclinin, and from these the pattern of isostatics was drawn.

The following findings emerged:

1. The isochromatic patterns for the tibia were more or less the same with only slight variations in all experiments.
2. The posterior malleolus remained completely unloaded in 8 of the 9 experiments.
3. In one experiment, using the ankle joint with fracture of the posterior malleolus and anatomical reduction under 105kg load in dorsiflexion, the anterior part of the posterior malleolus gave 4 orders of isochromatic, while the rest remained unloaded.
4. The isochromatic pattern for the talus was almost the same in all the experiments.
5. There was no shift or displacemant of the posterior malleolus in any of the experiments.

6. The screw fixation used for the posterior malleolus was not broken in any of the experiments.
7. The main loaded areas of the tibia surface were the 2nd and 3rd quarters.
8. The 1st quarter of the tibia was partially loaded.
9. The main loaded areas of the talus surface were the 2nd and 3rd quarters.

169. Similar pattern of injuries in two patients involved in the same road traffic accident

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A 48- and a 25-year-old female were involved in the same road traffic accident. They were the rear seat passengers in a motor vehicle which was involved in a rear-end collision. On admission to hospital the younger patient complained of pain in her lower neck, diffuse abdominal discomfort, right hip, left thigh and left leg pain. During examination she was fully conscious, neurologically intact, had a decreased range of movement in the cervical spine, right hip and left knee, and there were clinical signs of a fracture in the left femur and lower tibia. Plain radiography revealed C6–C7 subluxation, an undisplaced fracture of the right acetabulum, a fracture of the left femur, an avulsion fracture of the medial intercondylar tubercle left upper tibia and a fracture of the mid shaft of the left tibia. Diagnostic peritoneal lavage was positive for intra-abdominal hemorrhage and a laparotomy followed by splenectomy was performed as a matter of emergency.

The older patient was fully conscious but tetraplegic (neurological level C6) with contusions of the forehead, a painful neck and virtually nil movements of the cervical spine. Further clinical examination revealed an obvious left thigh, left leg and left forearm deformity. The radiological examination showed a C6 burst fracture-dislocation, a fracture of the right acetabulum, a fracture of the left radius and ulna, a fracture of the left femur and a fracture of the left tibia and fibula. Again, splenectomy was performed in this patient shortly after her admission.

As regards the orthopedic operations for both patients, they were deferred until their general condition became stable.

Hip fracture

170. Walking ability is better after osteosynthesis than after hemiarthroplasty in femoral neck fractures

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Introduction: Femoral neck fractures can be primarily treated with osteosynthesis or arthroplasty. Both methods have well known early and long term complications. A 50% five year survival makes long time functional capacity following different procedures important in the difficult choice of method.

Patients: In the Lund Department of Orthopedic Surgery, 1,066 consecutive patients were primarily treated by osteosynthesis. 124 survivors with a mean follow-up of 7.7 years were available as potential matched controls.

At the Oulu Department of Surgery 401 consecutive patients over 65 years of age were treated with an uncemented Austin Moore hemiarthroplasty through a postero-lateral incision. A few patients older than 65 had been treated with osteosynthesis and a few patients younger than 65 had hemiarthroplasty on special indications. Of 75 patients without revision surgery for complications, 33 (5 men and 28 women) with a mean follow-up of 6.6 years were available for the investigation.

In the hemiarthroplasty group, 5 men, 69 (64–75) years old at follow-up, and 28 women, 81 (63–99) years old, were matched with 5 men, 68 (62–74) years old, and 28 women, 81 (62–98) years old, with osteosynthesis.

Method: All patients were sent a questionnaire concerning social circumstances and walking capacity. The Swedish version of the Nottingham Health Profile (NHP) was mailed to the Swedish group and a Finnish translation to the Finnish group. Matching was considering age and sex as well as living alone and heart disease.

Results: In the osteosynthesis group 7/33 and in the hemiarthroplasty group 14/33 patients were confined to wheel chair, rollator or other person's assistance when walking outdoors (p=0.02), 14/30 patients in the osteosynthesis group could walk at least a block as compared to 3/33 in the hemiarthroplasty group (p=0.002). No difference was found in the patients' opinion on pain at rest and pain on walking. In the osteosynthesis group 12/32 considered their walking ability unchanged compared to prefracture, only 5/32 in the hemiarthroplasty group (p=0.05).

According to the NHP the osteosynthesis group had better physical mobility than the hemiarthroplasty group (p=0.01). The scores for social isolation (p=0.005) and motion (p=0.001) were also better while the difference in other aspects was not significant.

Conclusion: In a long term follow-up (4–12 years) this study indicates that walking capacity is better following a