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Department of Orthopedics

Surgical Clinic

Ullevål University Hospital

N-0407 Oslo, Norway

Experimental orthopedics

Single photon absorptiometry (SPA) of the femoral diaphysis correlates with fracture strength of the diaphysis and the neck in rats

L Nordsletten, T S Kaastad, S Skjeldal, J Halse, K P Nordahl, O Reikerås and A Ekland

Institute for Surgical Research, Rikshospitalet, University of Oslo, Norway

Densitometric measurements by SPA of the femoral diaphysis were compared with the fracture strength in the diaphysis and in the neck in rats.

Material and methods: Transverse to the long axis of 15 skeletally mature rat femora triplicate scans with a Gambro® Densitometer were made 18.7 mm from the condyles. Later the diaphyses were tested in 3 point ventral bending with the fulcrum 18.7 mm from the condyles (Fig A), and the femoral necks were fractured in combined compression/bending (Fig B). The results of SPA and mechanical testing were compared by linear regression.

Results: The regression coefficients (r^2) of mechanical parameters on bone mineral content-BMC(g/cm) and density-BMD(g/cm²) showed that BMC and BMD correlated significantly with the ultimate bending moment of the femoral diaphysis ($r^2 = 0.63$ and 0.48). BMC ($r^2 = 0.51$), but not BMD ($r^2 = 0.18$) of the shaft correlated significantly with the ultimate

moment of the femoral neck. Surprisingly, regression of the bending moment of the femoral diaphysis on the femoral neck showed no correlation ($r^2 = 0.005$).

Conclusion: BMC of the femoral diaphysis measured by SPA, correlated strongly with ultimate moment of the femoral diaphysis and neck. BMC rather than BMD should be used for comparison of fracture strength in rat femora.

Bone density and distance of the screws in femoral neck osteotomy in cadaver bones

Gunnar Sydnæs, Antti Alho and Arne Høiseth

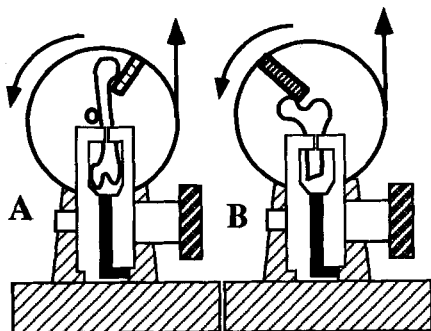
Ullevaal Hospital, Oslo, Norway

We studied femoral neck osteosynthesis in the Lotz-Hayes fracture model (JBJS Am 1990). Theoretically, a maximum distance between 3 screws would increase the strength of the implant bone construct.

Material and methods: 12 pairs of femora were harvested from 3 female and 9 male cadavers, median age 76 (69–94) years, and measured with quantitative computed tomography (Høiseth et al, Acta Radiol 1991) vertical to the neck axis in the neck and trochanter. The bones were divided into 3 groups: 1) control, 2) transverse neck osteotomy and maximal distance between 3 UllevaalR screws, and 3) osteotomy and 80% of the maximal distance. An InstronR Universal Testing Machine was connected to a WatanabeR XY Recorder, AD adapter, and PC with IntelR 386 Processor. The femoral shaft was fixed and the posteroinferior surface of the head loaded against the antero-medial outer trochanteric surface.

Results: The load at fracture (mean (SD)) was 3.24 (1.18) kN in the intact bones and 1.50 (0.50) kN in the internally fixed osteotomies ($p < 0.02$). There were no significant differences between the fixation groups. The maximal loads in the internally fixed bones correlated highly significantly (Pearson) with CT density ($r = 0.71$), bone area ($r = 0.72$) and mass ($r = 0.77$) in the trochanter.

Conclusions: The bone mineral in the femoral neck area has importance for the strength of a femoral neck osteosynthesis while the distance between 3 screws has not.



Structural changes of cortical bone after intramedullary procedures

Olav Reikerås, Oliver Grundnes and Nils Roar Gjerde

University of Oslo, University of Tromsø and University of Bergen, Norge

Intramedullary reaming and nailing have been reported to influence the characteristics of cortical bone. The present study was designed to evaluate changes in cortical bone structure following reaming, nailing and plugging of the femoral canal in rats.

Material and methods: Male Wistar rats were used. The medullary cavity of the left femur was entered via an incision over the trochanteric area. In the control group no intramedullary reaming was performed. In another group reaming of the medullary cavity was performed to 1.6 mm. In a third group reaming was followed by intramedullary nailing with a steel pin of 1.6 mm, while in the last group the medullary cavity was plugged with silicone before nailing. After 12 weeks the rats were killed, and mid-diaphyseal sections of the femur were polished and microphotographed. Furthermore, cortical bone blood flow was investigated by the use of radioactive microspheres.

Results: Reaming and reaming and nailing did not cause any structural changes as compared to the control bones. Plugging of the medullary cavity with silicone and nailing caused, however, some structural changes. The outer area was significantly increased as well as the area of the medullary cavity. The net effect was a significant increase in cortical area. For small pores (diameter less than 10 μ) there were no significant differences in number, nor in porosity per unit area between the groups. For pores with a diameter larger than 10 μ there were no significant differences in number, while the porosity was significantly increased in the bones that had been plugged by silicone and nailing. The increase in porosity was, however, restricted to the outer third of the cortex. Cortical bone blood flow was not affected by any of the intramedullary procedures.

Conclusion: This study shows that plugging of the medullary cavity may have deleterious effects on the endosteal side of the cortical bone which may cause a secondary periosteal reaction.

Interlocking intramedullary nailing of rat femur with rigid or flexible nail

Sissel Torgersen, Otto Schnell Husby, Nils Roar Gjerdet and Anders Odd Mølster

Department of Dental Materials and Surgery Research Laboratory, University of Bergen, Norway

Introduction: Intramedullary nailing after osteotomy of rat femur has been used as an experimental model to study bone healing. The aim of the present investigation was to study mechanical properties of bone healing using rigid and flexible nails with interlocking threaded pins.

Material and method: A unilateral transverse osteotomy on femur was made in 35 male Wistar rats (250–300 g). 20 rats were treated with a solid stainless steel (rigid) nail, and 15 received a polyacetal (flexible) nail. The nails (diameter 1.8 mm) were introduced from the site of the greater trochanter after reaming. Interlocking pins were used both in the proximal and distal end. A composite resin cement around the interlocking screws and nail ends secured the locking. Unprotected weight bearing was allowed immediately after recovery. After 8 weeks the rats were killed and radiographed. Both femora were taken out, and the bone diameter in the osteotomy region was measured. Mechanical properties of all femora were tested by a three-point bending test after removal of the nails.

Results: Radiographically, healing occurred in 13 out of 20 osteotomies in the steel group, and in all 15 of the polyacetal group (C^2 -test, $p < 0.02$). The median strength (ultimate load) of the femora with steel nails was 26% compared with the unoperated femora, and 57% in the polyacetal group (Mann-Whitney test, $p = 0.05$). The median stiffness was 39% of that of the intact femur in the steel group and 71% in the polyacetal group ($p = 0.03$). The callus area (median) of the operated femora compared with the unoperated side was 150% in the steel group and 170% in the polyacetal group. The difference was not statistically significant ($p = 0.4$).

Conclusions: In this study on intramedullary nailing with interlocking pins, there were significantly higher rate of healing and higher values for mechanical properties with flexible nails compared with rigid ones 8 weeks after nailing. Interlocking pins minimize movement of the fragments relative to the nail, thus the mechanical situation is simplified. Consequently, the flexibility of the nails becomes decisive for the rigidity of the osteosynthesis. There were no differences in callus area between the groups with rigid and flexible nails, indicating that the interlocking pin system does not establish absolute rigidity in the osteotomy region. The results support the notion that flexible nailing is more favourable with respect to healing of shaft fractures than is rigid nailing.

The effect of short-term treatment with local growth factors and antibodies against platelet-derived growth factor on the healing of femur fractures in rats

H E Høgevold¹, B Grøgaard¹ and O Reikerås²

¹Department of Surgery, Ullevaal Hospital and ²Sophies Mindes Orthopedic Hospital, University of Oslo, Norway

Introduction: In the different phases of fracture healing, the cytokine network and local growth factors as well as native inhibitors of these systems seem to be important regulators of cell proliferation and differentiation, chemotaxis, fibrogenesis and bone formation and remodeling. In previous studies with indomethacin we have shown that cellular events in the very early stages of fracture healing are extremely important for normal progression of the process. In wound healing platelet-derived growth factor (PDGF) and transforming growth factor (TGF)- β , released from alpha granules of aggregated plate-

lets in the initial thrombogenesis as well as from monocytes, endothelial cells and macrophages, increase formation of granulation tissue and improve wound healing. Platelet releasate has been used in this context as a source of PDGF, TGF and other locally active growth factors, as the individual effects of these factors are possibly potentiated and more in vivo-like. In this study, the effects of locally applied platelet releasate and anti-PDGF on healing of unstable fixated fractures of rat femora were evaluated by mechanical testing 6 weeks after fracture.

Material and methods: In 27 male Wistar rats (323–359 g) the medullary cavity of the left femur was reamed gradually to a dimension of 1.5 mm through an exposure of the greater trochanter. Thereafter, the femur was manually broken after percutaneous weakening of the mid shaft of femur using an awl. The fracture was then reduced and a pointed inoxidable 1.6 mm stainless-steel pin was then driven into the medullary cavity and the wound closed in layers. The rats were randomly allocated to 3 treatment groups, each of which were treated by a local injection of 200 µL/day at the fracture site:

1. Rats treated with 500 µg/day of Blood Platelet Extract (Norgrowth platelets) (n=8)
2. Rats treated with antibodies against PDGF (n=8)
3. Rats treated with saline local injections (n=9)

6 weeks after the fracture, macroscopic and radiographic examination as well as mechanical testing were performed of fractured and intact bones.

Results: Fractures treated with local anti-PDGF showed significantly higher moment than fractures treated with local injections of saline or platelet extract containing PDGF and TGF ($p=0.03$). There was a tendency for inferior healing of femora treated with platelet extract than those with saline. Further, the amount of callus was somewhat higher when the fractures were treated with platelet extract.

Conclusion: Short-term treatment with growth factors as PDGF and TGF-beta in the form of platelet extract did not seem to improve fracture healing of unstable fixated fractures of rat femora. However, local therapy with anti-PDGF increased the strength of the healing fracture. One may wonder whether application of local PDGF/TGF increase the formation of granulation tissue without improving the osteogenic potential and that the endogenous level of PDGF/TGF in the early phases of fracture healing of unstable fixated fractures may be too high.

Fibrinolytic and antifibrinolytic response in relation to coagulation activation induced by orthopedic surgery

O E Dahl^{1,5}, T Pedersen¹, P Kierulf⁴, Å-B Westvik⁴, H Amesen², I Seljeflot², M Abdelnoor³ and T Lyberg¹

Research Forum, ¹Traumatological, ²Cardiovascular and ³Biostatistical section and ⁴Department of Clinical Chemistry, Ullevaal University Hospital, Oslo, Norway
Previous address: ⁵The Norwegian Lutheran Hospital (Diakonhjemmet sykehus), Oslo, Norway

Background: Acrylic total hip replacement (THR) is associated with perioperative cardiorespiratory depression and a high frequency of postoperative DVT. Intrapulmonary vascular activation of coagulation seems to play an important role in this pathophysiological process (1,2).

Aim: To investigate the fibrinolytic, antifibrinolytic and acute phase response in relation to coagulation activation in central and systemic blood during and after THR in order to better understand the pathophysiological process leading to these clinical events.

Materials and methods: 5 patients with coxarthrosis. Synchronous blood samples were withdrawn from mixed venous (MVB) and arterial blood (AB) during the operation and on the first postoperative day (PD). Further samples on the third and sixth PD were for practical reasons only withdrawn from AB. The samples were analysed on prothrombin fragment 1+2 (F1+2), tissue plasminogen activator antigen (t-PA), plasminogen activator inhibitor 1 activity (PAI-1), D-dimer (D-D) and interleukin 6 (IL-6).

Results: In AB F1+2 rised rapidly with significantly higher values in AB than in MVB during bone preparation and acetabular implantation, whereafter it declined until a second rise occurred on the sixth PD. t-PA dropped significantly in AB compared to the higher values in MVB during the initial phase of operation. At the end of operation t-PA increased, followed by a gradual decrease from the first PD. A substantial rise in PAI-1 occurred from the end of operation until the first PD, whereafter it dropped to almost preoperative levels on the third PD, and rose for a second time on the sixth day. During the first phase of operation higher values were consistently found in AB compared to MVB. IL-6 followed a pattern almost identical to PAI-1, however, always with higher values in MVB compared to AB. D-D rose continuously until one hour after operation, with almost equal values in AB and MVB, whereafter it declined.

Conclusion: During and after operation a sequential activation of coagulation, fibrinolysis and antifibrinolysis occurred. In sum these processes seemed unbalanced towards a thrombotic state during operation and at the end of the first postoperative week, and was intimately linked to preinflammatory mediation. This study also confirms our earlier findings of the lung as a key organ in promoting hemostatic proteolytic activation in response to orthopaedic surgery.

References

- 1) Dahl, O E, Molnar, I, Vinje, A et al. Thromb Res 50, 875-884, 1988
- 2) Dahl, O E, Johnsen H, Kierulf, P et al. Acta Anaesthesiol Scand 36, 331-335, 1992

Fractures

Internal fixation of subcapital fractures of humerus with the AO/ASIF semitubular plate ad modum Weber

Knut Strømsøe and Bjarne Grøgaard

Ullevaal Hospital, Oslo

Introduction: In displaced 3–4 part fractures of the proximal humerus, closed reduction is often impossible. Weber modified the AO/ASIF semitubular plate for these fractures.

Patients and methods: Since 1988, 9 women and 4 men, age 67 (17–86) years were operated on. In 3 fractures the head had dislocated from the glenoid, 6 had a 3- and 4 a 4-part fracture. 2 patients were reoperated after failure of another fixation method. The deltopectoral approach was used and the plate modified to fit into the head. The greater tuberosity was included in the fixation. A detached lesser tuberosity was fixed with screw or cerclage. Postoperatively, the arm was immobilized in a Gilchrist bandage for 7–14 days. Median follow-up was 28 (2–48) months.

Results: In one case, the main indication was a ruptured axillary artery; the result of reconstruction and internal fixation was good. 2 wounds infected; one patient developed an painful non-union. Both infections healed after metal removal. One avascular necrosis resulted in reduced motion and moderate pain with a satisfactory result. The functional and subjective result in 11 patients was good in spite of reduced motion. The implant has been removed in 6 patients.

Conclusion: The semitubular plate modified by Weber is a good fixation alternative in displaced 3- and 4-part fractures and fracture-dislocations of the proximal humerus.

Reference: Brunner C G F, Weber B G. Besondere Osteosynthesetechniken, Springer Verlag, Berlin 1981: 158–9

Fractures of the proximal humerus Epidemiology and results of treatment

I Rossvoll¹, T Ø Rundén¹, S Svenningsen¹, H Russwurm¹, I Lereim² and A Sollié²

¹Department of Orthopedics and ²Emergency Clinic, Regionsykehuset, Trondheim, Norway

Introduction: The aim of this paper was to study the epidemiological characteristics and the results of treatment of proximal humeral fractures.

Patients and methods: All patients with proximal humeral fractures in a defined population (180,482 persons) were registered prospectively in 1989. Neer's classification (I–VI) and score system were used. Minimally displaced fractures (<11 mm dislocation, <45° angulation) were immobilized (2 weeks) in a sling and early exercises were started. Displaced fractures were treated with closed reduction, osteosynthesis or hemiprostheses according to a protocol. Minimally displaced fractures were followed 6 months and displaced fractures 12 months after injury.

Results: 172 fractures were registered, yearly incidence was 125/100,000 for women and 64 for men. For the age group 60 years or older, the yearly incidence was 358/100,000 for women and 127 for men. Moderate trauma (fall at same level) caused the fracture in 85% of patients 50 years of age or older. There were 112(65%) "minimally displaced" fractures, 40(23%) 2-fragment (Neer; III=34 VI=6), 13(8%) 3-fragment (Neer; IV+V=12 VI=1) and 7(4%) 4-fragment (Neer; IV+V=5 VI=2). Closed reduction was performed in 36, osteosynthesis in 9 and hemiprostheses in 6 fractures. Of patients 18 year of age or younger 24 completed the study, all had an excellent result. Of 142 patients 19 years of age or older 113 (80%) completed the study and the results for these were:

Fracture	Neer	Excellent/ Satisfact.	Unsatis.	Poor
Minimally displ	I	59	8	2
Displaced				
2-fragment	III	17	2	2
	VI	5	-	1
3-fragment	IV+V	3	-	6
	VI	1	-	-
4-fragment	IV+V	-	3	2
	VI	-	2	-
Total		85 (75%)	16 (14%)	12 (11%)

Conclusions: Proximal humeral fractures have epidemiological characteristics typical for fractures associated with osteoporosis. Most patients (84%) with minimally displaced fractures and displaced 2-fragment fractures obtained an excellent/satisfactory result. Of 17 patients with 3- or 4- fragment fractures 13 (76%) had an unsatisfactory/poor result, but only 3 had marked pain.

Humeral shaft fractures treated with interlocking nailing

Grete Sofie Hortemo¹, Anders O Mølster¹ and Markus Hordvik²

¹Department of Orthopedics and traumatology and

²Department of Radiology, Haukeland University Hospital, Bergen, Norway

The standard treatment of diaphyseal humeral fractures is non-operative. In some selected cases operative treatment may be indicated.

15 patients were treated with Seidel's interlocking nail system. 9 patients were operated within 12 days and the indications were; pathologic fracture in 4 patients, radial nerve paralysis in 2 patients, multitrauma in one patient, redislocation of reduced fracture in one patient and mental retardation in one patient. In 6 patients the indication for operative therapy was pseudarthrosis, all treated more than 3 months after injury.

9 fractures were located in the middle third of humerus, 5 in the proximal third and one in the distal third of humerus. There were 14 oblique fractures and one transverse.

There were 4 per- and postoperative complications; paralysis of the radial nerve in 2 patients, one hematoma and one skin infection. Both nerve lesions occurred in patients with pseudarthrosis and dislocation, operated by closed nailing without nerve exploration.

11 patients were evaluated 3-14 months after surgery. 7 fractures were healed while 4 revealed non-union, with clinical and radiographic distal loosening of locking resulting in rotatory instability. Only 2 patients had normal shoulder mobility, and 5 patients had normal elbow mobility. 4 patients complained of painful shoulder function, and 3 patients complained of painful elbow.

The patients with preoperative radial nerve paralysis were restituted, while one of the patients with iatrogenic nerve injury was found still paralytic. The other patient had neurophysiologic signs of incomplete lesion shortly after operation while still clinically paralytic, but did not come for follow-up.

Conclusion: Seidel's interlocking nail did not solve all problems in this selected material. The low rate of satisfactory results may in part be explained by the selection of patients or operative errors. However, we feel that the insertion site may be the cause of impingement syndrome even with the nail inserted well below the bone surface, and the distal locking mechanism may be too weak.

Operative treatment of acetabular fractures Preliminary experiences

Anders Mølster and Per Helland

Department of Orthopaedics and Traumatology, Haukeland University Hospital, Bergen, Norway

Since January 1988, 18 patients have been operated, 15 males and 3 females, aged 32 (22-80) years. 7 fractures were classified as "both column", one was unclassified with open crush fracture of the entire left pelvis and a complex fracture of the sacrum. 6 were posterior wall fractures, one transverse, one posterior wall with hemitransverse fracture line and one hemitransverse with fragment in acetabulum after reduction of luxation. 4 patients were operated with ileo-inguinal incision (Letournel) alone, 3 with combined ileo-inguinal and posterior (Kocher-Langenbeck), 10 with posterior incision alone, and one with tri-radiate incision (Mears). Duration of operation was 4-7 hours (median 4.5) with ileo-inguinal incision, 6-8 hours (median 7.5) with combined incision, 1.5-4 hours with posterior incision, and 3.5 hours with tri-radiate incision. Peroperative blood loss was estimated to be 1150-4500 mL (median 1600) with ileo-inguinal incision, 2300-6500 mL (median 2500) (the last patient operated 2 days after injury by a surgeon less experienced in the anterior incision) with combined incision, 400-2800 mL (median 500) with posterior incision, and 800 with tri-radiate incision.

Early complications were one DVT, one infection (in the patient with longest duration of operation and greatest blood loss. Subsided after removal of plate located on the iliac crest). One patient with head injury developed a cerebral infarction, and one multitraumatized patient died after transmission to

another hospital, probably of pulmonary embolus.

Results: All fractures were considered stable after operation, and no secondary dislocation was seen. All posterior and the transverse fractures were considered anatomically reconstructed, while only 2 of the more complex fractures had a perfect reduction. Only 2 had more than 2 mm intraarticular steps estimated on postoperative standard radiographs. All patients moved the hip joint in bed from the first day postoperatively, and were mobilized on the 2-19 day (median 8 day). After 2 months - 4 years 8 months (median 20 months), one patient has developed arthrosis and received hip prosthesis (patient with only fragment removal without osteosynthesis of hemitransverse fracture). The rest have not developed radiographic signs of arthrosis with loss of cartilage.

Conclusion: Operative treatment of acetabular fractures gives stability and permits early ambulation. Combined anterior and posterior incisions can be made with acceptable risk for complications. Acceptable reduction may be achieved in most cases, even if perfect reduction may be difficult to achieve in the most complex fractures. The treatment of these difficult and relatively rare fractures should be centralized.

Femoral neck fractures A retrospective study of 1197 patients

Lars B Engesaeter¹, Per Torgeir Nilsen¹
and Lodve Stangeland²

¹Orthopedic and ²Surgical Department, Haukeland University Hospital, Bergen, Norway

Introduction: The files of 2018 patients with fractures in the upper end of the femur, treated in the period 1977 to 1985, were reviewed. 60% of these fractures were located to the femoral neck (1197 fractures). The median age for these patients was 78 (16-101) years. 80% were females.

98% of these fractures were treated by 2 von Bahr-screws (342 fractures), hip compression screw (HCS) (440 fractures) or hemiprosthesis (396 fractures). The following median values were found for these 3 groups:

	Age (years)	Op time (min)	Blood loss (ml)	Hosp stay (days)	Infection (%)
1. von Bahr	78	35	0	7	1.5
2. HCS	71	65	150	9	5.9
3. Prosthesis	81	85	300	12	4.3
1 vs 2	*	*	*	*	*
1 vs 3	*	*	*	*	*
2 vs 3	*	*	*	*	*

*p < 0.005

The frequency of reoperations for the 3 groups and the main reasons for reoperations, are given in the following table:

	Re-oper (%)	Re-disloc (%)	Avasc necros (%)	Discomf of imp (%)	Infection (%)
1. von Bahr	17	4.1	3.2	8.8	0.3
2. HCS	32	5.5	12.1*	11.2	3.4
3. Prosthesis	8	—	—	1.3	2.0
1 vs 2			*		*
1 vs 3	*			*	
2 vs 3	*			*	

* $p < 0.005$

Conclusion: In this retrospective non-randomized study for femoral neck fractures, 2 von Bahr screws were found to give shorter operating time, less perioperative bleeding, less infection and no more reoperations than a hip compression screw.

Displaced femoral neck fracture treated with HCS or Olmed screws—225 randomized patients followed for 3 years

Jan G Benterud and Antti Alho

Ullevaal Hospital, University of Oslo, Oslo, Norway

Patients and methods: During 1987–89, 225 patients with displaced femoral neck fracture were randomized and internally fixed. 22 patients died within 12 weeks without reoperation. 97 patients operated with HCS (Richards) and cancellous screw and 106 patients with 2 parallel Olmed screws were followed for 39 (2–51) months. There were 161 women and 42 men, age 81 (63–97) years, 51 of them died during follow-up. Early healing disturbances were: redisplacement (48), backing of screws (16), and other (9). Failures at follow-up >3 months were: non-union (35), segmental collapse (16), and other (11) (n.s. between the fixation groups).

Results:

	Healing disturb. within 3 mo	Reoperated within 3 mo	Failures (total)	Reop. (total)
HCS	36 (37%)	20 (21%)	47 (49%)	40 (41%)
Olmed	37 (35%)	11 (10%)	48 (45%)	34 (32%)

Reoperations related to early healing disturbances

	Early disturbance	No early dist.
HCS	28/36 (6 early deaths unoperated)	12/61
Olmed	23/37 (8 early deaths unoperated)	11/69

Odds ratios of failure in a logistic regression analysis were: 3.1 for imperfect reduction and 6.6 for operation with HCS outside office hours.

Conclusion: Early healing disturbance is a reliable sign of failure. Poor reduction is unacceptable. The 2 fixation methods used gave similar results. It is most favorable to operate during day-time working hours.

Conservative treatment of impacted femoral neck fracture

Kjetil Hvaal, Bjarne Grøgaard, Olav Røise and Antti Alho

Ullevaal Hospital, Oslo, Norway

Poor selection of patients with impacted subcapital femoral fracture may explain the previous poor results. Using strict criteria of impaction, Raaymakers (1988, ISBN 90-9002160-4) reported union in 86% of patients.

Patients and methods: The criteria of impaction were: no displacement in calcar, valgus 0°–30°, retroversion 0°–30°, ability to flex the hip and knee unsupported. During January 91 – August 92, 30 women and 6 men, age 56–92 years, filled these criteria. Their valgus angle was median 8° (0°–30°) and retroversion 6° (0°–26°). They were mobilized on walker or crutches the day after the injury and instructed partial weight bearing, 15–20 kg. Radiographs were taken every other week until 6 weeks and whenever the patient had pain. The follow-up period was one to 20 months. Patients with secondary displacement were treated with Charnley-Hastings bipolar hemi-endoprosthesis.

Results: 13 of the first 25 fractures became unstable and were reoperated at median 12 (1–20) months. One of the most recent 11 fractures failed at median 6 (2–8) months ($p = 0.015$, Fisher test).

Discussion: Our series indicates a learning curve in the conservative management of impacted femoral neck fractures. Strict criteria of impaction have to be used in the selection and the care has to be well controlled. With these prerequisites, conservative management is cost-beneficial and saves a number of patients from operation.

Geographical differences in hip fracture incidence in Norway

Trine S Kaastad, Jan A Falch, Geir Bøhler, Trond Espeland and Ole-Johan Sundsvold

Internal Medicine, Aker Hospital, University of Oslo, Surgical Department, Central Hospital of Sogn og Fjordane and Lærdal Hospital, Norway

Introduction: We have reported the increasing incidence of fractures in the proximal end of femur in Oslo and the age- and sex-specific differences within the city. There are differences between urban and rural populations, and among Nordic cities. We wanted a closer look at the great differences found in 1978/79 by Falch et al between Oslo and Sogn og Fjordane, a mainly rural county on the western coast of Norway.

Material: In 1988 and 1989 we registered all new fractures in the proximal femur in Oslo and Sogn og Fjordane.

Results: In Oslo we found 2790 fractures (79% women), 58% cervical. Exponential increase in age-specific incidence in both sexes. Except for women between 50 and 59 the incidence had increased for all groups above 50 years. In Sogn og Fjordane 385 fractures were reported (69% women), 64% cervical. Again exponential increase, but the observed incidence

was only 65% of the expected when we projected one year age groups in Oslo on the corresponding Sogn og Fjordane population.

Conclusion: Sex- and age-specific hip fracture incidence is still increasing in Norway, and the geographical differences in incidence are great. This knowledge helps us design further studies to disclose causes of the hip fracture epidemic.

Modified Grosse-Kempff locked nail in combined diaphyseal, trochanteric and pathological trochanteric fractures

Arne Kristian Aune, Bjarne Grøgaard, Knut Strømsøe, Antti Alho and Arne Ekeland

Ullevaal Hospital, University of Oslo, Oslo, Norway

Patients and methods: The cylindric part of a slotted Grosse-Kempff nail was manufactured to fit two 7-mm Ullevaal hip screws to be introduced in the femoral neck/head. 11 women and 6 men, age 25–92 years were followed for median 46 (2–80) months. 4 multiply injured patients were operated as emergencies for trochanteric-diaphyseal fractures; one died from MOF, 3 healed uneventfully. 3 pathologic trochanteric fractures had considerable bone loss; in one with distal locking, the nail broke, the course has been uneventful after refixation without distal locking. 8 patients had fractures distally to a previous trochanteric-subtrochanteric fracture treated with 7 Gamma nails and one Richards CHS. These fractures were still ununited and the reoperation was done with the modified Grosse-Kempff nail with static locking. 7 fractures healed uneventfully, one patient died from unrelated cause before union.

Discussion: The Grosse-Kempff slotted nail was modified to be used in severe trochanteric-subtrochanteric fractures and in combinations of trochanteric and shaft fractures. The primary results have been satisfactory.

Distal femoral fractures treated with AO condylar plate

Antti Alho, Kjetil Hvaal, Knut Strømsøe

Ullevaal Hospital, University of Oslo, Oslo, Norway

We have used the AO condylar plate as the main treatment of distal femoral fractures independent of age, and made a retrospective analysis of our results.

Material and methods: During 1983–1990, we treated 44 distal femoral fractures in 33 women and 11 men, median age 78 (22–92) years. According to AO, 34 fractures were Type A 1–3 and 10 Type C 1–3. 3 patients had multiple injuries. 8 patients, all over 80 years of age, had a previous osteosynthesis in the same proximal femur and 4 patients had an ipsilateral hip prosthesis. The follow-up time was median 4 (1–7) years.

Results: One technical failure resulted in reoperation with a new condylar plate in a 75-year old female. 4 femoral fractures occurred proximal to the plate, 3 of them had a previous proximal internal fixation. One was treated with a new, longer condylar plate and 3 with brace. All 4 secondary fractures occurred among 17 patients older than 80 years and none in younger patients ($p=0.017$, Fisher test).

Discussion: Distal femoral fractures in the elderly may pose a special fixation problem. The proximal end of the plate creates a stress rise in the shaft. This effect is accentuated in connection with a proximal blade or screw plate osteosynthesis. The stress riser effect may be reduced by overlapping of the plates, the distal plate being ventral to the proximal one. We had less problems in a series of locked intramedullary nailing of distal shaft fractures in the elderly (Strømsøe et al. Acta Orthop Scand 1990;61:512).

Operative treatment of comminuted fractures of the calcaneus

Espen Mørk, Knut Strømsøe and Antti Alho

Ullevaal Hospital, University of Oslo, Oslo, Norway

The treatment of calcaneal fractures is still controversial. The goals of operative treatment have been to restore Böhler's tuber-joint angle and subtalar joint. Recently, favorable results have been reported (Regazzoni 1988, Melcher et al. 1991).

Patients and methods: During 1987–1991, 20 fractures of the calcaneus in 17 patients were operated. The preoperative studies: radiographs in lateral, AP, and Brodén's projection followed by CT scan. The indications for operation were: incongruity of the posterolateral articular facet, shortening and broadening of the calcaneus, and Böhler's angle $<5^\circ$. The operation was performed within 10 days through a lateral approach with reconstruction of the joint, temporary pin fixation, final fixation with AO Cervical Spine Plate, and autologous cancellous bone grafting. Partial weight bearing was allowed after 6 weeks and full weight bearing after 12 weeks. In bilateral fractures, the Allgöwer braces were used.

Results: All except one fracture healed in the position obtained at operation; the later patient needed a triple arthrodesis 10 months postoperatively. There were 4 wound infections that healed. According to our evaluation scale, rating pain, daily function, and motion, 10 results were excellent, 6 good, 3 fair, and one poor.

Discussion: Our preliminary results of operative management of calcaneal fractures are satisfactory. The follow-up period is still short. The operation is preferably performed after the soft tissues have recovered, 7–10 days post-injury. Comparative studies with conservative treated fractures are still needed.

Tarsometatarsal fractures and dislocations

Clement S Trovik¹, Markus Hordvik² and Anders O Mølster¹

¹Department of Orthopedics and ²Department of Radiology, Haukeland Hospital, Bergen, Norway

Injuries to Lisfranc's joint are rare and as many as 20% are not diagnosed at the first examination. In those diagnosed, primary treatment is often not optimal. This results in a less than satisfactory outcome in many series. The importance of accurate reposition is stressed in the literature. On the issue of fixation, however, there are different views. There are some indications that screw-fixation is better than traditional fixation with Steinmann-pins.

We have mainly used pin-fixation and wanted to evaluate our results. 12 patients, which were those treated at our department in the period 1980 to 1991, were examined. We used a score-system similar to that utilized by other investigators to evaluate clinical and radiographic data.

In 9 patients the reposition was maintained with unthreaded Steinmann-pins, in 2 patients with plaster-cast only. In one patient the injury was overlooked primarily and the patient was without treatment for 4 months. Reposition at this time was followed by continuous pain at activity.

Conclusion: There were no signs of redislocation after fixation with unthreaded Steinmann-pins. When the joints were repositioned accurately, there were minimal sequelae.

od described by Kessel, which involves removal of the anterior acromion including the acromial surface of the acromio-clavicular joint. The other half of the patients had an acromioplasty as described Neer.

Results: The clinical results are classified according to the UCLA-score (Ellmann 1986):

		Satisfactory		
		Excellent	Good	Poor
Acromioplasty a m Kessel	(n=49)	19	12	18
Acromioplasty a m Neer	(n=49)	13	16	20
Total	(n=98)	32	28	38

66% of the patients were satisfied with the result of the operation. Statistically, we found no difference between the clinical results of the 2 operative methods. Nor could we find a correlation between the results and duration of symptoms or age at operation. Intraoperatively, 9 partial and 8 full thickness cuff tears were detected, reconstruction was performed in 7 and 4 cases, respectively. The clinical result was satisfactory for 8/9 with partial cuff tear and for 2/8 with full thickness tear.

Conclusion: In this retrospective study of clinical results after surgical treatment of impingement syndrome, 62% of the patients obtained a satisfactory result and for 38% the result was classified as poor. We found no difference between the two operative methods.

Upper extremity

Subacromial impingement—clinical results after surgical treatment

A Aamodt, T Bredland, I Rossvoll and L Engebretsen

Department of Orthopedic Surgery, University Hospital of Trondheim, Norway

Introduction: Subacromial impingement is the most common cause for chronic shoulder pain. Mechanical impingement of the rotator cuff between the acromion and the humeral head is leading to inflammatory changes and eventually tears in the cuff. In the early stage the pathological changes are reversible and usually respond to conservative treatment. In the chronic stage of the disease, surgical treatment can be an alternative. The aim of this retrospective study was to document the clinical results after surgical treatment.

Patients and methods: During the period from 1983-1990 106 patients were operated on for subacromial impingement. 98 shoulders (90 patients) have been followed up after a mean period of 4 (1-9) years after the operation. There were 47 women and 43 men, mean age at the time of operation was 48 years. 54 were operated in the right shoulder, 36 in the left and 8 bilaterally. Mean duration of symptoms prior to surgery was 4.4 (0.1-17) years. 49 patients were operated using the meth-

Injuries in the carpus/TFCC secondary to distal radial fractures

Torstein Husby

National Orthopedic Center, University of Oslo, Oslo, Norway

The combination of distal radial fractures with carpal injuries is a topic very little addressed in the orthopaedic literature. At our department 25% of wrist arthroscopies are performed because of sequelae secondary to distal radial fractures. In 1991-1992, 8 patients with radial fracture sequelae had a wrist arthroscopy (5 women, 3 men, age 30 (19-47) years). Time from fracture to referral was 34 (6-156) months. 5 patients had an injury of the triangular fibrocartilage complex (TFCC). 2 of those had peripheral ruptures, treated arthroscopically with percutaneous suturing. After 12 weeks in a brace, all were back to normal function. 3 patients had central lesions of the TFCC, all these were treated with shaving or resecting forceps. All these patients have gained clinical improvement. In 5 patients osteochondral lesions of the radius and/or in the carpus were recorded. All had chondral lesions on the radial side, and in all cases the lesions were resected with a shaver. In addition one patient had a chondral lesion on the capitate and the lunate, one patient had a chondral lesion on the lunate alone.

One patient had a scapho-lunar dissociation, treated conservatively with a brace.

It is emphasized that fractures of the radial or ulnar styloid often are combined with perilunar and triquetral instability. Volar intraarticular radial fractures (reverse Barton fracture) may be combined with lesions to the proximal carpal ligaments with volar dislocations. Distal radial fractures may also be combined with fractures through the scaphoid and/or the capitate. Principally almost all fractures and ligament injuries in the carpus may be combined with distal radial fractures.

Arthroscopy may be a useful tool in the treatment of acute intraarticular radial fractures. Our experience is limited due to the fact that we are mainly dealing with sequelae. It should be possible though to adjust the intraarticular fracture alignment arthroscopically. In addition pinning would be advisable, maybe in combination with an external frame.

Conclusion: Radial fractures may be combined with injuries to the TFCC, osteochondral fractures and in addition cause ligament injuries and instability in the carpus. Instability/dissociation of the scapho-lunate joint is the most common. Radial fractures with suspected carpal lesions should be referred to a hospital where arthroscopy of the wrist/carpus can be performed. Arthroscopic manipulation should be considered in acute intraarticular radial fractures.

Triangular fibrocartilage injuries

Torstein Husby, Kjell Bye, Jan R Haugstvedt and Astor Reigstad

National Orthopedic Center, University of Oslo, Oslo, Norway

The triangular fibrocartilage complex (TFCC) is a discoid meniscus separating the distal head of the ulna from the carpus. It is considered an important anatomical structure, preventing direct contact between the ulna and os triquetrum. Injury to the TFCC is not much addressed in the literature, but the interest is increasing due to the introduction of wrist arthroscopy.

Patients and method: In 1991–1992, 11 patients were treated for injuries of the TFCC (8 women, 3 men, age 31 (16–56) years). Symptoms were pain, clicking, crepitation and reduced grip strength. Time from symptoms started to referral was 17 (6–48 months). 5 patients had TFCC lesions secondary to distal radial fractures, 5 patients fell on outstretched hand and one patient had a direct trauma. 7/11 patients had radial/central lesions of the TFCC. 5 of those had resections with conventional forceps and/or had an arthroscopic shaving. One radial lesion was attempted repaired with suturing, and one was treated with a brace. 4 patients had peripheral/ulnar ruptures of the TFCC and were sutured arthroscopically after debridement of the area. Postoperatively the patients with sutured TFCC lesions had a cast for 12 weeks.

Results: All the central TFCC lesions treated with resection experienced reduction of pain and improved function. Of the 4 sutured peripheral ruptures, 3 patients has gained normal function, one patient has still some pain and is not back in full work. The only sutured radial/central lesion ended up with a distal ulnar resection due to pain. This patient also had a tem-

porary neuropraxia in the dorsal sensory branch of the ulnar nerve. This was the only complication in this material.

Discussion: TFCC lesions in the wrist joint can be treated arthroscopically. Central lesions are best treated with resection/shaving. Patients with peripheral/ulnar tears in the TFCC may be treated with percutaneous suturing using an outside-in technique. Patients with uncertain diagnosis after wrist trauma and discomfort secondary to distal radial fractures should be referred to hospitals where wrist arthroscopy can be performed.

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Pediatric orthopedics

Ultrasonography for measurement of femoral anteversion in children

Terje Terjesen, Svein Anda and Svein Svenningsen

Departments of Orthopedics and Radiology, Trondheim University Hospital, Trondheim, Norway

The aim of this study was to evaluate the reliability of our ultrasound technique for measurement of femoral anteversion (AV) angles in children.

Patients and methods: AV angles were determined by ultrasound and biplanar radiography in 63 children aged 3–11 years. With the patient supine, knees flexed 90°, and the lower legs kept vertical, only one ultrasound scan of the proximal femur was necessary. The anterior tangent of the femoral head and the greater trochanter (head-trochanter tangent) was used as the reference line. The transducer was tilted until the head-trochanter tangent appeared horizontal on the monitor screen. In this position, the angle of tilt of the transducer, which represented the AV angle, was measured with an attached clinometer.

Results: There was a high correlation between the AV angles measured by ultrasound and radiography ($r = 0.71$). However, the AV angles were an average of 5.5° larger by ultrasound than by radiography. Thus, a correction factor of 5° should be subtracted from the angle measured by ultrasound in order to obtain the real AV angle in children. When this was done, the discrepancy between ultrasound and radiography was less than 10° in 94% of the hips.

Conclusion: Because reliable results were obtained by ultrasound and because ionizing radiation is avoided, our ultrasound technique for measurement of femoral AV angles is recommended for routine clinical use in children with rotational disorders of the femur.

Ultrasonographic measurement of femoral anteversion in newborns

Thore Hinderaker¹, Alf Uden^{1,2} and Olav Reikerås¹

¹Department of Orthopedics, University Hospital, Tromsø, Norway and ²Department of Orthopedics, Malmö General Hospital, University of Lund, Lund, Sweden

We have evaluated a direct method for ultrasonographic measurement of the anteversion angle of the femoral neck in newborns. It was measured as the angle between the posterior tangent to the femoral condyles and the centre line through the femoral head and neck, projected on a plane perpendicular to the long axis of the femur. The femoral anteversion, then, was measured in the same way as by computed tomography, which corresponds to the usual definition. By intra-observer test a precision of $0.2^\circ \pm 5.7^\circ$ was found. With this method the femoral anteversion was measured in 30 newborns in vertex presentation, and it was found to be $25^\circ \pm 8^\circ$.

There were no significant differences between right and left side, nor between boys and girls. In the same way the femoral anteversion was measured in breechborns, and it was found to be on average 10° higher than in those born in vertex presentation ($p < 0.0001$).

Grice subtalar arthrodesis A review of 131 operations

Jan Roar Orlin and Cato Hellum

National Center of Orthopaedics, Sophies Minde, University of Oslo, Norway

A retrospective study of subtalar, extraarticular arthrodesis in 83 patients with cerebral palsy (CP) or meningomyelocele (MMC) was carried out.

In the CP-group 68 feet were operated in 42 patients with a mean age of 9.5 years without complications. The results were evaluated after a mean observation period of 4.5 years. All but one transplant healed, and the result was satisfactory in 54, acceptable in 9 and poor in 5 feet.

In the MMC-group of predominantly L4-, L5- and S1-affection, 63 feet were operated in 41 patients with a mean age of 8 years and the results evaluated after a mean observation period of 6.5 years. The transplants healed in 56 feet whilst a pseudarthrosis occurred in 7. The result was satisfactory in 56 feet, acceptable in 3 and poor in 4 feet. One patient sustained necrosis of the talus and a subsequent physeolysis in the distal tibia.

Because Grice arthrodesis may possibly be compromised by ankle valgus, the value of preoperative bracing is discussed.

Conclusion: Grice arthrodesis in this material led to a good functional result in 110/131 feet (84%). The operation may be recommended for children with CP or MMC conditioned valgus deformities.

The Boston brace in treatment of idiopathic scoliosis—what characterizes the scoliotic patients responding to brace treatment?

Johan Emil Lange, Harald Steen and Stig Larsen

State Centre for Orthopaedic Surgery, Sophies Minde, Oslo Med Stat Research, Lillestrøm

Introduction: The scoliosis research has been concerned about the etiology, pathogenesis and the natural history and its influences on the therapeutic methodology. The prediction of the efficiency of the brace treatment is determined by many factors. This study has a longitudinal registration of the parameters that can give a basis for a statistic analysis and a theoretical model for the selection of patients to brace treatment.

Material: 468 patients with juvenile and adolescent scoliosis, 434 girls and 34 boys. They were longitudinally followed from brace start to the last observation after weaning. The magnitude of the scoliosis, the apex vertebra and the number of vertebra in the curve, right and left deviation, apex vertebral rotation, skeletal maturity, were among the parameters that are collected in the primary registration. The age at brace start, menarche age, age at weaning and age at last observations were recorded. The major curve and the secondary curves were longitudinally registered.

Method: The flexibility of the major curve is defined as the difference between the scoliosis curve on standing and in the prone position at brace start. Redressibility is the difference between the scoliosis curve standing and the redressement in the first Boston brace. The development of the major curve half a year in the brace is defined as the difference between the curve standing at brace start and the curve without brace one hour or more after 6 months treatment in the brace. The results after half a year in the braces form the basis for the statistical model on the prognosis of the further brace treatment. We have defined as Responder a patient who gains more than 2 times the standard deviation in the population both in the reduction in per cent, and reduction in degrees compared with the prebrace curves. After this definition the responders have 6° and 20% or more reduction of the primary curve after half a year brace treatment. Nonresponders have no gain in reduction of the primary curve or a negative result and inclassifiable response is defined for those who have results between responders and nonresponders.

Results: The analysis of this material gave 235 responders, 41 nonresponders and 188 inclassifiable. The longitudinal development of the major curves show significantly better results at last observation for the responders. In the discriminant analysis the following variables contributed to a prognostic evaluation of the continued treatment in the brace: age, flexibility, redressibility, rib hump, number of vertebrae in the curve, single or double curves. Each variable has a coefficient and the discriminant function arranged in a table and a fixed constant was calculated. In this table a patient who had been treated for 6 months with a Boston brace was calculated as a responder or nonresponder with an estimation of 80%. The unclassifiable had 60% chance as responders and 40% chance as nonresponders.

Conclusion: The longitudinal prospective analysis of 468

patients with idiopathic scoliosis has given the basis for a study of the variables influencing the end results. By statistic analysis we have created a model for calculating the prognosis in continued brace treatment. We wish to improve the model and the results are preliminary. The aim is to exclude the groups of patients with scoliosis where the continued brace treatment only confirms the natural history of the scoliosis.

Varia

Osteosarcoma treatment 1986 to 1991

Gunnar Follerås¹, Ingjald Bjerkreim¹ and Gunnar Sæther²

¹State Orthopedic Hospital and ²Norwegian Radium Hospital, Oslo, Norway

Introduction: The experience gathered treating osteosarcoma patients is reviewed.

Patients: 35 patients, 25 men and 15 women were diagnosed and treated according to the protocol of Scandinavian Sarcoma group. Most tumors were localized in the proximal humerus and about the knee. The observation time is mean 35 (5–75) months. 33 tumors were high grade, 2 were low grade. Staging: IB: 1, IIB: 33, IIIB: 1.

2 tumors were removed without reconstruction, 13 patients were amputated and 20 had resection and reconstruction. To reconstruct the extremity, 8 osteoarticular allografts, 9 shaft allografts, and 2 tumor prosthesis were used. One rotation plasty was performed.

Results: 2 infections, one fistula that closed spontaneously, and 2 skin necroses occurred postoperatively. Later, 2 fractures and breakage of implants occurred in 3 patients. Reconstructed patients with movable joints had a mean functional score of 28 (max 35), 4 excellent, 7 good, 0 fair and 1 poor. 12 patients are dead, 3 live NED after removal of lung metastasis, and 20 patients have no detectable disease.

Conclusion: Combined oncologic and surgical removal gives good tumor control. It is rewarding to reconstruct the extremity after resection of the tumor.

Osteoid osteoma—diagnosis and treatment

Asgeir Furnes, Jørgen Vestby, Anders Walløe and Lars Birger Engesæter

Bergen University, Department of Orthopedics and Department of Pathology, Haukeland Hospital, Norway

Patients and methods: The clinical and investigative features of 28 patients treated for osteoid osteoma from 1978–1992, were analysed retrospectively. Median age of the 18 men and 10 women was 14 (2–45) years. The median duration from the

onset of symptoms to diagnosis was 10 months. A dull, aching pain, most noticeable at night and after physical exercises, was the main symptom. ASA and/or other NSAID's relieved the pain in all patients who had tried those drugs. 17 lesions were localized in the cortex, 10 in cancellous bone and none subperiosteally (one unknown). Most of them occurred in femur (8) and tibia (10). The diagnosis was supported by ordinary radiography, CT-scans, scintigraphy and confirmed histologically in 24 of 26 operated cases.

21 were treated with surgical en bloc excision, 4 with curettage and 2 conservatively.

Results: 2 recurrences were reoperated after 5 and 7 months. One tibia fractured 3 months postoperatively after a trauma. After a follow-up period of median 35 (3–167) months, all the operated patients were painfree. One of the 2 conservatively treated patients, still has pain and is now going to be operated.

Conclusion: The differential diagnosis osteoid osteoma should be considered in all cases of chronic skeletal pain, especially in patients less than 25 years. Complete surgical excision of the nidus of the osteoid osteoma is curative and brings immediate and dramatic relief of the symptoms.

Short-time results of 17,958 cemented and uncemented total hip replacements

Leif I Havelin, Birgitte Espehaug, Lars B Engesæter and Stein E Vollset

Bergen University, Department of Orthopedics, Haukeland Hospital and Section for Medical Statistics and Informatics, Bergen, Norway

Patients and methods: In the Norwegian Arthroplasty register, time until revision was studied in 15,679 cemented and 2,279 uncemented primary total hip replacements (THR), observed for 0–4.5 years. The Kaplan-Meier method and the Cox proportional Hazard analyses were used. Differences in failure were tested with the log rank test.

Results: After 4 years the failure rate was 2.7% for the cemented and 7.3% for the uncemented THR ($p < 0.0001$). Analysing the uncemented THR only, no effect of sex and age could be detected. After adjustment for differences in age, sex and diagnosis, Cox analysis gave a 2.55 increased risk ratio of the uncemented THR compared to the cemented.

Conclusion: The uncemented THR used in Norway from September 1987 to December 1991, gave significantly inferior results compared to the cemented.

Scintimetry of total hip arthroplasties

T Iversen, J F Winge, J Sundsfjord and O Reikeraås

University Hospital of Tromsø, Norway

Total hip arthroplasty may induce unphysiological load distribution and, subsequently, proximal femoral bone remodeling.

These factors have been associated with typical mid thigh pain that is commonly observed in patients with uncemented prostheses. From a theoretical point of view, femoral bone remodeling might be visualized by scintimetry.

Patients and methods: The present study includes 30 patients that were investigated with scintimetry with a minimum follow-up of 3 years after total hip arthroplasty. 10 patients were operated on with a standard cemented prosthesis (Exeter), 10 were operated on with an uncemented press fit prosthesis (Biofit) and 10 were operated on with an uncemented hydroxyl apatite coated prosthesis (Landos).

Results: The scintimetric activity was rather normal in the bone along the femoral stem in the patients with the cemented prosthesis and in those with the hydroxyl apatite coated uncemented prosthesis. In the patients with the uncemented press fit prosthesis, the scintimetric activity was rather high at the distal part of the femoral stem, and there was reduced activity at the proximal part. The scintimetric findings corresponded well to the radiographic findings, and the results were also associated with a rather high frequency of mid thigh pain in the patients with the uncemented press fit prosthesis.

Conclusion: This study may indicate that uncemented hydroxyl apatite coated prostheses have a rather even load distribution along the femoral stem as in cases with cemented femoral stems.

Biofix rods in osteochondritis dissecans in knees

A Tegnander, L Engebretsen, K Holen, E Eide and J Gannon

Department of Orthopaedic Surgery, Trondheim University Hospital, Trondheim, Norway

Introduction: Osteochondritis dissecans (OCD) is a commonly seen disorder of the knee. Treatment varies from observation, fixation or removal of the fragment based on the severity of the disease. Fixation of OCD fragments with bone pegs have been used, yet more recently biodegradable polyglycolic acid (PGA) pins have been utilized. A recent report by Fridén and Rydholm (Acta Orthop Scand 1992; 63 (1): 94-97) described complications using this material. The aim of this study was to evaluate the treatment of OCD fragments fixed with Biofix pins (PGA pins) and review a complication associated with their use.

Material and methods: 9 patients (10 knees) with an average age of 19 (12-47) years underwent arthroscopic or open fixation of loose, symptomatic OCD fragments using Biofix bioabsorbable pins. Postoperatively the patients' knees were immobilized in a cast or orthosis for approximately 6 weeks. Routine postoperative examinations were done at 2, 6 and 12 weeks. Weight bearing was advance as tolerated after 4 weeks.

Results: Average follow-up was 6 (3-15) months. Of the 9 patients, 5 had prolonged postoperative courses. In particular 2 patients developed non-specific inflammatory reactions in the involved knee characterized by edema, warmth and painful, limited range of motion. In both cases the serious complications of infection and deep vein thrombosis were ruled out.

One case involved a 47-year old female who was noted to be doing well week 4 postop but developed knee pain, swelling, warmth and limited range of motion by week 7. Her symptoms have persisted at 6 months postop despite a negative work-up. In the second case a 13-year old boy developed the rapid onset of knee pain, swelling and limited range of motion postop day 3. Joint fluid analysis showed no bacteria and cultures were negative, yet he had a greatly elevated PMN count. Lab values showed CRP of 45, ESR of 60 and WBC of 11.4. The patient's symptoms persisted for 3 months, yet by 6 months he was asymptomatic. In both cases the non-specific inflammatory reactions are suspected to be related to the use of the bioabsorbable polyglycolic acid pins.

Conclusion: 2 of 9 patients treated with Biofix (bioabsorbable polyglycolic acid) pins developed non-specific inflammatory reactions at variable times during their postoperative course. In both cases more common causes of inflammatory reactions such as infection were ruled out. We feel that the cause of the reactions in these patients may be due to an incompatibility with the polyglycolic acid pins.

Bone segment transport after resection of pathological processes of long bones

Ingjald Bjerkreim, Gunnar Follerås, Erik Rosenlund and Leif Pål Kristiansen

National Center of Orthopedics, Sophies Minde, University of Oslo, Norway

In 3 patients we have performed transport of a bone segment after resection of a pathological process. All were localized to the tibia, one in the upper part and 2 in the lower part. An Orthofix apparatus with a transport frame was used in 2 cases and Ilizarov instrumentation in one.

The first patient was a 15-year old girl who had a spontaneous fracture because of a Giant cell tumor of the upper tibia. This tumor was first treated by curettage and filled with bone cement. She had a refracture 5 months later. A resection of 4.5 cm was done keeping the upper part of the cement for secure fixation. After distal corticotomy and bone transport, the rest of the cement was removed and the gap filled with autologous and allogenic bone.

The second patient was a 48-year old woman with a solitary metastasis to the lower tibia from a malignant melanoma removed 10 years earlier. In this case 10 cm of the lower tibia with the metastasis was resected. An arthrodesis between fibula and talus was performed and the cartilage of talus removed. After a proximal corticotomy bone transport was started, 1 mm a day. The transported segment had to be adjusted once to meet the talus in correct position.

The third case was a 42-year old man with an infected pseudarthrosis and angulation in the middle third of the tibia. The pseudarthrosis was resected, and the defect filled with collagen sponge containing Gentamycin. After proximal corticotomy bone transport was started using the Ilizarov technique. *Staphylococcus aureus* was cultured from the resected specimen. No major problems occurred in these 3 cases.

Correction of relapsed congenital club foot using the Ilizarov apparatus

Erik Rosenlund¹, John Herzenberg² and Ingjald Bjerkreim¹

¹National Centre of Orthopedics, Sophies Minde, University of Oslo, Norway and ²The James Lawrence Kernan Hospital, Baltimore, USA

Correction of the relapsed club foot by conventional operative procedures often leads to a shortening of the foot. Complications such as skin necrosis, pseudarthrosis, infection or vascular damage are rare, but potential hazards. The Ilizarov apparatus will correct all components of the deformity by simultaneous progressive correction at the ankle, hindfoot and forefoot, without bony resection or arthrodesis.

We describe the first correction of a relapsed club foot in Norway, using the Ilizarov apparatus.

A hinged-distraction apparatus was applied to the foot of a 6-year old girl treated elsewhere with 4 different surgical procedures. The only additional surgery now was a small resection of the plantar fascia. All components of the deformity were corrected over a timespan of 6 weeks. We encountered no problems with pain or pin-track infection. After removal of the apparatus the corrected position was maintained in a plaster cast for an additional 6 weeks.

We conclude that correction of the relapsed club foot with the Ilizarov apparatus is safe and easily controllable.