

Retrograde Nailing of Femoral Fractures

Retrográdní hřebování u zlomenin femuru

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ABSTRACT

PURPOSE OF THE STUDY

Retrograde nailing represents an established fixation method for fractures of the distal femur and offers in femoral shaft fractures an alternative to the existing technique of antegrade nailing. The aim of this study was to investigate in a retrospective analysis the results of retrograde nailing in distal femoral fractures and selected cases of femoral shaft fractures. Emphasis was posed on long-term functional outcome, especially in daily activities.

MATERIAL

Retrograde femoral nailing was used from 1999 until 2006 in two Level 1 trauma centers for the treatment of distal femoral (AO/ASIF-type 33) and femoral shaft fractures (AO/ASIF – type 32) in 40 patients with 41 fractures. The mean age of patients was 63,7 years (min: 21 / max.: 103) and 70, 7% presented with ipsilateral local pathologies or associated entities. A pre-existing reduced activity level was found in 12 /40 patients (30%) and was equally caused by neurologic conditions and geriatric entities.

METHODS

Indication for retrograde nailing was left in AO/ASIF fracture-type 33 to the individual estimation of the surgeon, while it was restricted in AO /ASIF fracture- type 32 to problematic cases. For fracture fixation the Distal Femoral Nail (28/41 68,3%) of Synthes Int.® and a supracondylar /; retrograde modified sc – UFN (13 /41 31,7%) produced by Synthes® Austria were used. Patients were followed till fracture healing and invited to a functional follow-up using the Lysholm / Gilquist score and the Tegner /Lysholm score.

RESULTS

Osseous healing occurred in shaft fractures in 18,1 weeks on an average compared to 16,5 weeks in supracondylar fractures. Postoperative complications requiring re-intervention were seen in 6/41 (14,6%) fractures. 28/40 patients (70%) were evaluated with a mean follow-up period of 20,4 months using the functional score of Lysholm /Gilquist and the activity score of Tegner/ Lysholm. Both scores were balanced among shaft fractures and distal femoral fractures (Lysholm – mean: 87,7 pts shaft. vs. 80,1 pts. distal Tegner-mean: 5,2 pts. shaft vs. 3,9 pts. distal), while motion showed better results in shaft fractures (arc of motion – mean: 120°) than in distal femoral fractures (arc of motion - mean: 105).

DISCUSSION

Despite a high age of patients (average 63,7 years) and a reduced activity level with many local co-morbidities, retrograde nailing resulted in the majority (95,1%) in reliable osseous healing. Thus, achievement of a painless fracture-site and a stable knee-joint provides early mobilization even in problematic cases. Impairment of functional outcome, mirrored in an over-all Lysholm /Gilquist score of 83,3 pts. and an over-all Tegner /Lysholm score of 4,4 pts. , was mainly related to pre-existing restrictions of the loco-motor system.

CONCLUSION

Retrograde nailing represents a reliable fixation method for extra-articular (33 – A1-3) and simple intra-articular (33 – C1-2) fractures of the supracondylar area. In femoral shaft fractures retrograde inserted nails offer a valuable alternative, especially when the proximal femoral approach is obstructed.

Key words: retrograde nailing, femoral fractures, supracondylar femoral fractures, functional outcome.

INTRODUCTION

Femoral fractures usually require operative treatment to avoid severe local and general adverse sequelae. While in the treatment of femoral shaft fractures intramedullary nailing early became the golden standard, op-

erative strategies in distal femoral fractures refrained to classic plate osteosynthesis (ORIF procedures) for a long period, though it was associated with high complication rates (5, 23, 36). The introduction of so called „biological plating“ – techniques decreased complication rates and the need for bone grafting dramatically,

even when conventional implants were used (4, 16, 38). In recent years two implants were specially designed for the distal femur and specially adapted for minimal invasive procedures with less compromise of local vascularity: the plate/fixator system of LISS-DF (LCP-DF) for extramedullary and retrograde nails for intramedullary fracture stabilization (9, 29, 32). However, the technique of retrograde intramedullary nailing (IMN) is not restricted to the supracondylar area, but also represents an attractive alternative in femoral shaft fractures (12, 13, 28, 35).

We reviewed the results of retrograde femoral nailing technique in two Level 1 trauma departments with special regard to the functional out-come.

MATERIAL AND METHODS

From 01 / 1999 until 01 / 2006 40 patients with 41 fractures of the femur have been treated in our two institutions (Wilhelminenspital Vienna and Trauma Hospital Salzburg) with a retrograde femoral intramedullary nail (IMN). Gender distribution was balanced representing 19 males (47,5 %) and 21 females (52,5 %) with a mean age of 63,7 years (min.: 21 / max.: 103) senior patients (> 60 yrs.) represented 35 % of the collective (14 / 40 patients). Side distribution of the fractures was balanced with 17 / 41 (41,5 %) on the right and 24 / 41 (58,5 %) on the left side.

Most injuries were caused by low energy trauma (n = 26 / 41 63,4 %) in simple falls (n = 23) and sports injuries (n = 3), while high-energy trauma was less observed (n = 12 / 41 31,7 %) resulting from MVA (n = 7) and falls from a height (n = 5). Thus, most fractures represented isolated injuries (32 / 41 78 %), while 9 / 41 (21,9 %) were found in polytrauma and three fractures (3 / 41 7,3 %) were open. According to the AO / ASIF -fracture classification 24 / 41 (61,0 %) belonged to type 33 (distal femur) and 15 / 41 (39,0 %) to type 32 (femoral shaft). Most frequently 33 A-2 (n = 7) and 33 C-2 (n = 7) fractures types were encountered in the

Table 1. Special injury patterns and / or ipsilateral pathologies of the operated limbs, favouring retrograde IMN (n = 29/41 70,7 %)

	Shaft (12/16 75 %)	Distal femur (17/25 68 %)
Neurologic condition (Polio, Cerebral sclerosis, spinal cord injury, paraplegia)	3	3
Contractures without neurol. deficit	–	2
Associated fractures:		
Open patellar fx	1	–
Tibia, "Floating knee"	2	1
Periprosthetic femoral fx	1	2
Implant in situ	3	4
Prosthesis in situ	–	4
Non-union	1	–
Ipsilateral Girdlestone hip	1	–
Ipsilateral healed pelvic fracture	–	1



Fig 1. a: Lateral view of the supracondylar retrograde sc-UFN using conventional locking bolts with 4,9 mm diameter; b: Multiple distal locking options in three different planes.

distal femur, while type 32 B-1 was predominantly seen (n = 6) in shaft fractures. Two fractures (2/41 4,9 %) represented pathologic fractures (primary malignoma: bronchus carcinoma, multiple myeloma) of the femoral shaft and the distal metaphysis, respectively and were not classifiable. In one patient retrograde nailing was used for repair of a non-union of the femoral shaft after unreamed antegrade nailing.

In distal femoral fractures (AO/ASIF type 33) the use of retrograde IMN was free to the estimation of the treating surgeon. In femoral shaft fractures (AO/ASIF type 32) the use was restricted to cases where the fracture line extended into the distal dia- metaphyseal area or where distal nail insertion seemed favorable due to the injury pattern (e.g. floating knee injury) or a problematic proximal approach (e.g. inlying implant) (s. Table 1). Pre-existent or associated pathologies of the same extremity were commonly present with an over-all rate of 29 / 41 (70,7 %) (s. Table 1). Impairment of activity level was found preoperatively in 12 / 40 patients (30 %) and was equally caused by neurologic conditions (n = 6) and geriatric entities (n = 6).

Distal Femoral Nail (DFN) of Synthes International was used in one center for fracture stabilization. It offers two different locking options distally: two conventional locking bolts or a combination of one locking bolt and a spiral blade. The other center used a modification of the conventional UFN adapted for distal femoral insertion: this supracondylar solid nail (sc-UFN, Synthes Austria) provides the dimensions 10 mm and 12 mm using the same locking bolts as the antegrade UFN, but offers additional distal locking options (Fig. 1a+b).

Intraoperatively patients were positioned supine on an operation table with the leg flexed at 40°– 60° and the distal femur supported by a pillow to facilitate reduction of the distal fragment. For nail insertion a medial

paraligamenteous (31 / 41 75,6 %) or transligamenteous (10 / 41 24,4 %) incision was used. The distal fragment was opened under direct vision and fluoroscopic control at the entry point by the use of an guide wire and a cannulated reamer. The femoral shaft was only reamed in very narrow medullary space (2 / 41 4,9 %) and in corrective osteotomy (1 / 41 2,4 %). Postoperative mobilization / physiotherapy started immediately and weight bearing was adapted to the fracture type, co-morbidities, the estimated quality of osteosynthesis and bone stock. Patients were followed with regular clinic and radiographic evaluation till fracture healing. All were invited for a retrospective evaluation with clinical assessment due to the Lysholm / Gilquist (21) score as well as the activity score of Tegner / Lysholm (34) and a radiographic evaluation. If patients were not able to join the follow-up examination local doctors and medical facilities were contacted to substitute and report to our institutions.

RESULTS

In 28 / 41 (68,3%) DFN – nails, we used in 11/28 fractures distally the version of a spiral blade and one locking bolt, and in 17/28 fractures the combination of two conventional locking bolts. All other fractures (13 / 41 31,7 %) were stabilized with the retrograde sc-UFN. The average time-lapse between injury and surgery lasted 1,5 days in 38 acute fracture fixations (min: 0 / max.: 11). Reduction of the fracture was in most cases indirectly accomplished (35 / 41 85,4%) either manually, by traction or external fixation. In 6 / 41 (14,63%) cases open reduction of the fracture was performed (1 non-union revision, 2 AO/ASIF 33- C-fractures, 3 fractures indirectly non reducible).

Mean operation time lasted 86,2 min (min.: 26 min. / max.: 219 min.) and was found slightly longer in femoral shaft fractures with 92,1 min. on an average (min.: 48 min. / max.: 195 min.) than in distal fractures with 76,9 min. (min.: 26 min. / max.: 143 min.) three nailings of floating knee injuries were excluded. Postoperative weight bearing was adapted to individual fracture anatomy, estimated quality of stabilization and concomitant injuries. It was started in femoral shaft fractures after 4,2 weeks on an average (min.: 1 – max.: 8) compared to distal fractures after 6,4 weeks (min.: 2 – max.: 12). Osseous healing in acute fractures took slightly longer in shaft fractures with 18,1 weeks (min.: 9 – max.: 62) than in distal fractures with 16,5 weeks (min.: 8 – max.: 78) (s. Table 2). Adequate time for fracture healing was observed in 39 / 41 fractures (95,1 %) in, while delayed / non-union developed in one shaft and one supracondylar fracture, respectively.

Complications were seen in 11 / 41 fractures (26,8 %), but required re-intervention in only 6 / 41 (14,6 %) (s. Table 3). Protrusion of the distal nail end occurred in 4 cases and could be treated conservatively in two asymptomatic patients with only a minimal overriding (1–2 mm). The other two protrusions were associated with implant failure (breaking of locking bolts) due to

Table 2. Data (mean values) of 41 fractures treated with retrograde intramedullary nailing (IMN) in 40 patients

	Femoral shaft fx (n = 16)	Distal femoral fx (n = 25)
Age	63,75	65,64
Injury – op. fixation (days) **	1,75	1,39
Op duration (minutes) *	84,53	79,04
Full weight bearing (wks)	4,2	6,4
Osseous healing (wks) **	18,12 wks	16,5 wks

* : exclusively three „floating knee“- injuries

** : exclusively two pathologic fractures and one corrective osteotomy.

Table 3. Complications* in 40 patients/41 fractures with retrograde intramedullary nailing of the femur. Over all rate: 11/41 fractures (26,8 %) re-intervention rate: 6/41 (14,6 %).

Complication(n):	Re- intervention (n):
loosening of locking bolts:	2
breaking of locking bolts with secondary nail protrusion:	2
minimal nail protrusion:	2
postoperative bleeding:	1
malalignment:	1
• Varus /Valgus > 5°:	1
• Ante-/Recurvation > 10°:	1
periprosthetic fracture:	1
delayed / non- union:	2
sepsis / MOF:	1

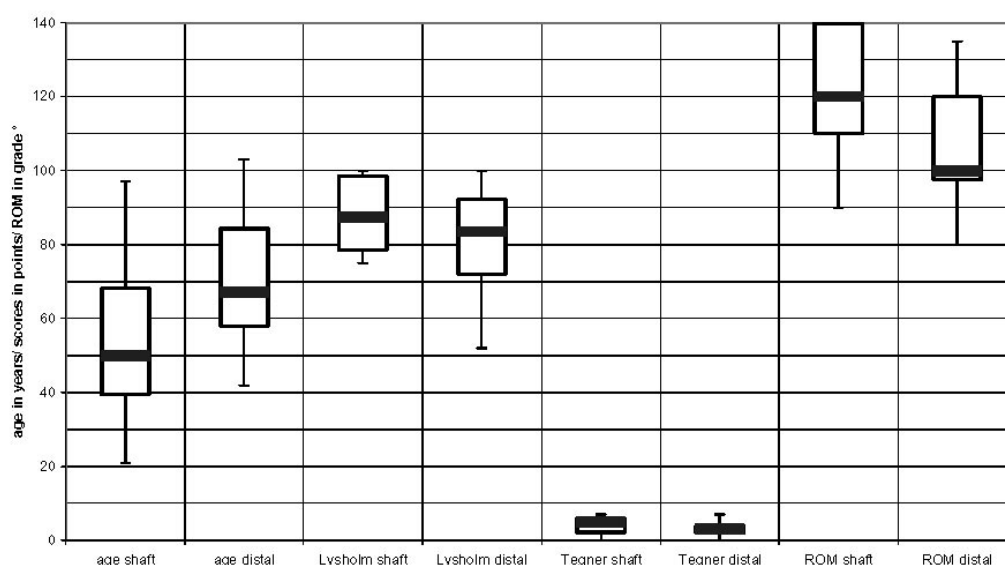
* multiple nominations possible

extreme straining in sports and incorrect surgical technique, respectively. While bony healing could finally be accomplished in one case by revision surgery and changing of the nail the other developed septic non -union, which has not united yet and is still under treatment. Loosening of one distal locking bolt was seen in two patients: one required bolt-removal, while the other stayed asymptomatic. Arthrofibrosis in one knee joint required resection of pannus tissues 3 months after IMN of an open 32 -C fracture. Mal-alignment was seen in two patients, but both were not corrected as deviation was mild and concerned a bedridden patient after spinal trauma and another patient with psychiatric disorder and missing compliance. Bleeding of the s.c. tissues had to be revised on the second postoperative day in one case. One patient died due to septic MOF after polytrauma and one periprosthetic fracture occurred 15 months after IMN and was treated with revision arthroplasty.

28/ 40 patients (70 %) could be invited to a functional evaluation with a mean follow-up time of 20,4 months (min.: 3 – max.: 84). The rest (n = 12/40) did not participate as two patients lived abroad, four had passed away after fracture consolidation, four were bedridden due to pre-existing spinal cord injuries (n = 3) or due to senile marasm (n = 1) and two denied to participate. Examination included x-rays of the affected limb and clinical evaluation of the patients according to the Lysholm / Gilquist -score and the Tegner / Lysholm -score. The follow-up group with distal femoral fractures (n = 18) showed a higher age-level and a shorter fol-

Table 4. Data (mean values) of follow-up examination after retrograde intramedullary nailing (IMN) in 28 patients.

	Total (n = 28)	Femoral shaft (n = 10)	Distal femoral fx (n = 18)
age (yrs)	64,96	54,6	70,72
follow-up time (mths)	20,69	32,42	14,18
Lysholm score (pts)	83,28	87,7	80,83
Tegner score (pts)	4,4	5,2	3,9
Range of motion (°)	105,5°	120°	105,4°



low-up period than patients with shaft fractures (n = 10) (s. Table 4). Over-all Lysholms – score reached 83,3 points on an average (min.: 52 / max.: 100) with only small differences between shaft fractures (mean: 87,7 min.: 75 / max.: 100) and distal fractures (mean: 80,1 min.: 52 / max.: 100). Similarly, over-all Tegner activity score was 4,4 points on an average (min.: 2 / max.: 7) and showed improved outcome in shaft fractures (mean: 5,2 min.: 2 / max.: 7) than in distal femoral fractures (mean: 3,9 min.: 2 – max.: 7). The mean arc of motion in shaft fractures consisted of 120° on an average (min.: 90° / max.: 140°) which was a distinctly higher than results in distal fractures with 105,4° (min.: 80° / max.: 135°).

Poor functional outcome was most often associated with a reduced range of motion, which was frequently caused by pre-existing disabilities. Thus, only a minority of patients had an unlimited ability of squatting (32,1 %), stair climbing (39,3 %) or full gait capacity (42,8 %). In contrast, the majority of patients reported no (18/28 64,3 %) or almost no pain episodes (5/28, 17,9 %) as well as an unrestricted full weight bearing capacity requiring no support (21/28 75,0 %) or only one cane (5/28, 17,9 %). Furthermore most of the knee joints were reported to be absolutely stable (23/28 82,1 %) and upon clinical examination no evidence of PCL compromise could be found. Radiological changes in follow up examination were not conclusive, as intra-articular changes could not be directly related to nail implantation or the natural course of osteo-arthritis.

DISCUSSION

Operative treatment of distal femoral fractures is frequently problematic, as in young patients and high energy trauma many comminuted areas are found, while in elderly patients a poor bone stock and / or inlying implants are present. Plate osteosynthesis of these injuries by conventional technique (ORIF) adds considerable surgical trauma and impairment of the local vascularity, which is mirrored in high rates of septic complications and primary non-unions (5, 23, 36). The introduction of indirect fracture reduction techniques and soft tissue preserving approaches significantly reduced these complications regardless the use of extra- or intramedullary implants (4, 16, 22). Specially designed implants for the anatomy of the distal femur and minimal invasive techniques are the LISS internal fixator (32) and retrograde femoral nails (9, 12). Both philosophies cover most indications of distal femoral fractures (22, 31, 39) and provide specific biomechanical advantages (2, 40). However, in an individual fracture the selection of implant is influenced by the grade of articular comminution as well as the design of eventually inlying implants and the personal preference of the surgeon. However, patients with a poor bone stock due to severe osteoporosis or pathologic fracture benefit from minimal blood loss and early weight bearing in retrograde IMN (31). *Schmeiser* (30) found in 14 patients with tetra-/paraplegia after spinal cord trauma an average ROM of the operated knees of 108° at dismissal and 100 %

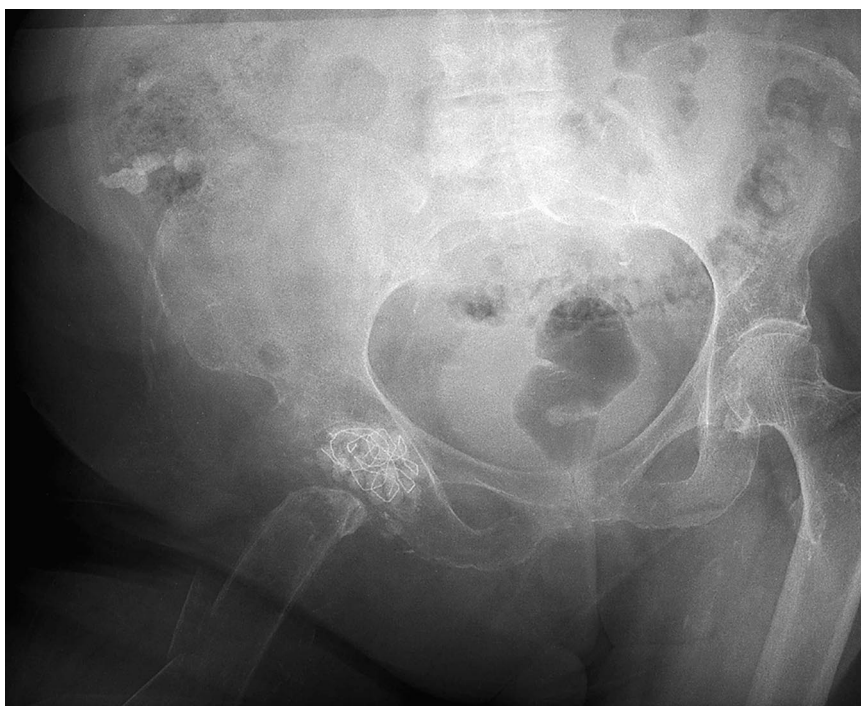


Fig. 2. T.E., f, 98 yrs.: **a:** Girdlestone situation of the right hip after septic complication in total hip arthroplasty 6 years ago. Osteoporotic fracture of the femoral shaft with intra-articular PMMA chains in situ, **b:** Retrograde nailing provided early mobilization and uneventful osseous healing.



a (1)	a (2)
b (1)	b (2)

fractures healing at follow-up examination 11 months on an average after the trauma. Especially the vulnerable and atrophic soft-tissue envelope of the knee area is very well preserved in these patients as the implant is completely submerged beneath the bone surface, while painful soft tissue irritation caused by the prominent implant edges represent a common problem in LISS osteosynthesis with reported hardware removal rates between 3 % (17) and 14 % (37).

Except the distal femur, retrograde IMN offers a reliable alternative in the treatment of femoral shaft fractures, especially when they extend into the distal metaphysis or when problems of the piriform fossa approach exist. The latter problem is frequently encountered in the elderly population, where obstruction of the femoral canal by inly-



Fig 3c ►

Fig. 3. D.T., m, 21 yrs., MCA, polytrauma: **a**): Ipsilateral fractures of the right femur and tibia („floating knee“ – injury) along with complex dislocation/ fractures of the right Lisfranc joint in a motorcycle injury. Femoral component represents an open fracture grade G II° with a dorso-lateral cortical defect; **b**): Both shaft fractures were primarily fixed from one small incision using a retrograde nail for the femoral and an antegrade nail for the tibial fracture; **c**): Though no bone graft was used, uneventful osseous healing; was accomplished image shows status at 20 months postoperatively.



Fig 3c

ing implants / prostheses is reported up to 50 % (10, 18). Furthermore, high rates of ipsilateral femoral pathologies are seen in patients over 55 years (6) we found in our collective 70,7% pre-existing impairment of the loco-motor system or associated ipsilateral local problems. These cases as well as deformities of the proximal femur (severe hip dysplasia, Girdlestone hip,...) represent an ideal indication for retrograde nailing, which offers sometimes the only treatment option (s. Fig. 2). Due to a quicker approach and lesser x-ray exposure retrograde nails may also be preferable in femoral shaft fractures with extreme adipositas, pregnancy or polytrauma. In associated patellar or tibial fractures („floating-knee“ injury) (s. Fig. 3) the retrograde nailing of femoral shaft fractures offers a elegant way to stabilize all fractures from one small incision (14, 20, 27).

Comparing the results of antegrade and retrograde femoral IMN reveals no significant differences in respect to operation time, radiation exposure, technical complications and bone union rates (24, 26, 35). Tigh pains are dominant in antegrade nailing (26, 28, 35) while minor knee pains seem to be slightly dominant and quite common in retrograde nailing (24, 26) with rates between 13 % and 60 % (7, 11, 19). However, development of knee pains (11) seems not to be influenced by trans -or parapatellar approach. Concern has been

issued in the literature about possible intra-articular lesions due to insertion of the nail into the femoral groove, namely the posterior cruciate ligament, and some authors advocate arthroscopic control of the nail's entry point (8). On the other hand, Carmack (3) found that identification of an optimal entry point (in line with the long femoral axis a.p. and lateral) by fluoroscopic control alone resulted in 100 % of portals located within a safe area in relation to the patellofemoral joint and without harm to the PCL. Thus, we consider in daily routine fluoroscopic control of the entry point sufficient as we saw no ligamentous instability related to nail insertion and rarely saw axial malalignment ($n = 2 / 41$; 4,8 %) indicating an incorrect starting point.

The over-all complication rates of LISS and retrograde nailing are comparable (9, 22, 39) and the risk of intra-articular infection after retrograde IMN is low with 0,18 % (25). Complication rate in our collective was quite high with 26,8 %, but the rate of required re-interventions (14,6 %) was lower than reported rates (17%) in the literature (25). We attribute this to a high average age of our patients with many pre-existing locomotor disabilities, favouring minor complications that can be handled conservatively.

Retrograde IMN provides reliable fracture healing (9, 25) and good functional results, even in the elderly age group (1, 6, 7, 10, 15) or in extreme osteoporosis (30). Thus excellent and satisfactory results, according to Neer's classification, are found in 72 % (15) to 85% (6) of geriatric collectives. El Kawy (7) emphasized the benefit of early mobilization provided by IMN without decrease of mobility, though he observed in his collective a high rate (35 %) of postoperative mal-alignment. A survey of the literature found an average mobility of the knee joints operated with retrograde IMN for distal femoral fractures of 104° and for femoral shaft fractures of 127° . The authors (15) attributed the better results in femoral shaft fractures to the fracture location, the younger age of the patients group and the absence of any pre-existent lower extremity pathology. Though we cannot draw clear conclusions from our small collective, our data support that an increased age in our distal femoral fracture group influenced the functional outcome as well as the motion of the knee joint. Most functional deficits were based on a decreased knee joint motion, which mainly resulted from concomittant and pre-existing disabilities. On the other hand the retrograde IMN proofed to be a reliable treatment option in both distal and femoral shaft fractures due to minimal rates of persisting pains and instabilities, thus providing a pre-requisite for early mobilization.

CONCLUSION

To us retrograde nailing represents an established stabilization method in distal femoral fractures without exceeding articular comminution (AO / ASIF classification 33-A1-3, 33-C1-2). In femoral shaft fractures (AO / ASIF classification 32) the retrograde technique offers a reliable alternative to antegrade nailing and may

be in some situations even advantageous, especially in the presence of hip pathologies / implants which are increasingly common in elderly patients. Especially this age group benefits from retrograde IMN by early postoperative mobilization of the patients combined with a minimal compromise of local vascularity and an almost complete submerging of the implant, which reduces soft-tissue irritation and makes the implant feasible even in persons of poor general status.

ZÁVĚR

Retrográdní hřebování je často používanou metodou u zlomenin distálního femuru a u zlomenin diafýzy femuru poskytuje alternativu k technice antegrádního hřebování. Cílem retrospektivní studie bylo zhodnotit výsledky retrográdního hřebování uvedených zlomenin u pacientů vyššího věku. Důraz byl kladen na funkční výsledky, hodnoceny byly denní aktivity pacientů s ohledem na preexistující snížení těchto aktivit.

Hodnocení pomocí Lysholmova-Gilquistova skóre a pomocí Tegnerova-Lysholmova skóre prokázalo srovnatelné výsledky u obou typů zlomenin, ale rozsah pohybu v kolenním kloubu byl lepší po zlomeninách diafýzy než po zlomeninách distálního femuru. Zhoršení funkčních skóre bylo pozorováno zejména u pacientů s preexistujícím omezením lokomočního systému. Retrográdní hřebování autoři považují za spolehlivou fixační metodu pro extraartikulární (33-A1-3) a jednoduché intraartikulární (33-C1-2) zlomeniny suprakondylické oblasti. U diafýzárních zlomenin femuru jsou vhodnou alternativou zejména u pacientů, u kterých není možný proximální přístup.

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