Functional outcome after retrograde femoral intramedullary nailing was investigated in 35 patients older than 60 years (mean, 86 years) with 36 fractures, comprising 15 (41.7%) shaft and 21 (58.3%) distal fractures; overall, 7 (19.4%) periprosthetic fractures occurred. Twenty-two (62.9%) of 35 patients were evaluated at a mean 16.5-month follow-up with the Lyshom-Gillquist score and the SF-8 questionnaire. Primary union rate was 97.8%, with no significant differences in duration of surgery, bone healing, mobilization, and weight bearing among different fracture types; periprosthetic fractures revealed a significantly delayed mobilization ($P < .03$). Complications occurred significantly more often among distal femoral fractures ($P < .009$), including all revision surgeries. The most frequently encountered complication was loosening of distal locking bolts ($n = 3$). Lysholm score results were mainly influenced by age-related entities and revealed fair results in all fractures (mean in the femoral shaft fracture group, 78.1 vs mean in the distal femoral fracture group, 74.9; $P = .69$), except in the periprosthetic subgroup, which had good results (mean, 84.8; $P = .23$). This group also had increased physical parameters according to SF-8 score ($P = .026$). No correlation existed between SF-8 physical parameters and patient age or surgery delay, whereas a negative correlation existed between patient age and SF-8 mental parameters ($P = .012$). Retrograde femoral intramedullary nailing is commonly used in elderly patients due to reliable bone healing, minimal soft tissue damage, and immediate full weight bearing. It also offers a valid alternative to antegrade nailing in femoral shaft fractures.

Dr Neubauer and Mr Leitner are from the Department of Trauma Surgery, Landesklinikum Waldviertel Horn, Horn, Drs Krawany and Wagner are from the Department of Trauma Surgery, Wilhelminenspital der Stadt Wien, Vienna, Dr Karl Bauer is from Trauma Hospital Salzburg, Salzburg, and Dr Plecko is from Trauma Hospital Graz, Graz, Austria, and the Department of Trauma Surgery, University Hospital Zurich, Zurich, Switzerland.

Drs Neubauer, Krawany, Karl Bauer, Wagner, and Plecko and Mr Leitner have no relevant financial relationships to disclose.

Correspondence should be addressed to: Thomas Neubauer, MD, Department of Trauma Surgery, Landesklinikum Waldviertel Horn, Spitalgasse 10 A-3850 Horn, Switzerland (thneubauer@aon.at). doi: 10.3928/01477447-20120525-24

Figure: Preoperative anteroposterior (left) and lateral (right) radiographs of a 66-year-old man who sustained an AO 33-C2 fracture in a fall from a height (A). Postoperative anteroposterior (left) and lateral (right) radiographs showing that the fracture lines extending into the joint were fixed by a percutaneous lag screw (asterisk) prior to nail insertion (B).
Retrograde intramedullary nailing is a well-accepted stabilization technique for fractures of the diaphyseal and supracondylar areas of the femur. As with other minimally invasive techniques, the preservation of local vascularity and soft tissues helps improve results and reduce high complication rates of open reduction and internal fixation (ORIF) procedures in the distal femur. Minimal tissue dissection and stable fixation make the implant a popular choice in the elderly because prolonged immobilization is avoided and the risk of fatal complications is reduced. Retrograde intramedullary nailing represents a valuable alternative to antegrade femoral nailing when in situ implants or pathologies of the proximal femur interfere with an antegrade technique.

However, although up to 85% of all supracondylar femoral fractures occur in the elderly, reports of outcome and functional results of retrograde intramedullary nailing in this age group are infrequently found in the literature. The purpose of this study was to investigate the functional outcome of femoral retrograde intramedullary nailing in patients older than 60 years with distal femoral and femoral shaft fractures, which to the authors’ knowledge has not yet been published in a clinical investigation.

**Materials and Methods**

Between 2000 and 2008, thirty-five patients (36 femoral fractures) older than 60 years underwent stabilization with retrograde intramedullary nailing. Mean patient age was 81.3 years (range, 60-103 years). Twenty-seven (77.8%) patients were women and 8 (22.2%) were men. All fractures were treated in 2 urban trauma centers and represented acute injuries (n=31), nonunited fractures fixed with a prior osteosynthesis method (n=3), and pathologic fractures (n=2). Fractures were classified according to the AO classification system as 33 (distal metaphyseal area) (n=21; 58.3%) and 32 (femoral shaft) (n=15; 41.7%). The right side was affected in 17 (47.2%) fractures and the left side in 19 (52.8%). Simple fracture types were predominantly found in the supracondylar area (A1, n=5; A2, n=7; A3, n=3; C1, n=1; C2, n=4; pathologic, n=1) and in shaft fractures (A1, n=6; A2, n=1; A3, n=2; B1, n=5; pathologic, n=1).

Depending on the institution, 2 types of retrograde nails were used for fracture stabilization: the Distal Femoral Nail (DFN) (Synthes Austria, Salzburg, Austria) (n=17; 47.2%) and the Supracondylar Unreamed Femoral Nail (sc-UFN) (Synthes Austria, Salzburg, Austria) (n=19; 52.8%), a modification of the conventional unreamed femoral nail for use in the distal femoral area (Figure 1).

**Surgical Technique**

Patients were positioned supine with the leg flexed at 40° to 60° with a bolster supporting the distal femur to facilitate reduction. In distal C-type (AO 33) fractures, stabilization of the articular block was accomplished percutaneously prior to nail insertion (Figure 2). A medial paraligamentous (n=30; 83.3%) or transligamentous (n=5; 13.9%) approach was used to open the knee joint; in 1 patient, no patellar ligament was present after knee exarticulation. The entry point of the nail was determined under fluoroscopic control, and arthroscopic assistance was not used. The distal metaphysis was opened using a cannulated reamer over a guide wire, while diaphyseal reaming was performed only in cases of a narrow medullary canal (n=2; 5.6%) and in 1 (2.8%) case of revision surgery.

Reduction was performed in 28 (77.8%) fractures by ligamentotaxis alone using manual traction (n=24) or a translittibial wire (n=2), a small reduction table (n=1), and an external fixator (n=1). In 8 (22.2%) fractures, direct manipulation at the fracture site was performed, and in 2 (5.6%) fractures, an additional cerclage band was applied. All nails were locked on both ends; at the distal end, 27 (75%) nails were locked by bolts alone and 9 (25%)—more than half of the implanted DFN nails—by an additional spiral blade.

Postoperatively, mobilization and physiotherapy started immediately. Weight bearing was allowed depending on fracture type, estimated quality of osteosynthesis by the surgeon, and pattern of concomitant injuries. Patients were followed up until
fracture healing with regular physical and radiographic evaluations.

In a retrospective evaluation, patients were assessed using the Lysholm score\(^6\) and the SF-8 health questionnaire. If patients were not able to be present for a follow-up examination, local doctors and medical facilities took the information and reported to the authors’ institutions.

Statistical analysis was performed with SPSS version 17.0 software (SPSS, Inc, Chicago, Illinois). Categoral variables (eg, sex) were expressed as frequencies and percentages, and continuous variables (eg, age, procedure duration, and scores) were expressed as mean±SD. Differences between study groups were evaluated using the chi-square test for qualitative variables, and unpaired t test was used for quantitative variables. \(P<.05\) was considered statistically significant.

**RESULTS**

The majority of acute fractures represented isolated injuries in low-energy trauma (34/36; 94.4%), whereas 2 (5.6%) occurred in polytraumatized patients. Twenty-nine (80.6%) fractures were caused by simple falls, 3 (8.3%) by a fall from a height, and 2 (5.6%) by traffic accidents; in 2 (5.6%) pathologic fractures, no trauma was detectable.

Regarding preinjury mobility status, 3 (8.6%) of 35 patients were bedridden and 2 (5.7%) were able to transfer to a chair or wheelchair with assistance. Three (8.6%) patients were able to walk with assistance, 12 (34.2%) were mobile by themselves using a walking aid, and 15 (42.8%) had unlimited mobility. In 22 (61.1%) of 36 limbs, local anomalies were found that contributed to the choice of retrograde intramedullary nailing for fixation. Most of these specific findings represented implants in situ (15/36; 41.7%) in the proximal (9/22) and distal (6/22) femur, along with contractions of the knee joint in 3 cases, deformities of the proximal femur in 2, and status post-knee amputation in 2.

Mean time from injury to surgery was 1.6 days, and mean duration of surgery was 91.5 minutes (Table). Mean start of postoperative mobilization was 1.6 days, and full weight bearing occurred at a mean of 3.3 weeks postoperatively. Fracture healing occurred at a mean of 11.3 weeks postoperatively (Table). No significant differences regarding these parameters were observed between distal femur and femoral shaft fractures. All fractures healed except for 1 (2.8%) septic non-union in the distal femoral fracture group.

A subgroup of periprosthetic fractures \((n=7)\) revealed showed no significant differences, except for a significantly later onset of mobilization \((P=.03)\) (Table).

Overall complication rate was 30.5% \((11/36)\). Five (13.9%) surgical complications required intervention. The most common complication was loosening of distal locking bolts \((n=3)\), and periprosthetic fracture after 15 months, septic non-union, subcutaneous bleeding, and revascularation of >5° were observed in 1 patient each. Other complications included cardiac problems \((n=3)\) and septic multiple organ failure not related to retrograde intramedul-

lar nailing \((n=1)\). Complications occurred more frequently in the distal femoral fracture group \((10/21 vs 1/15; P=.009)\), which included most of the revisions \((n=4)\) and pathologic fractures \((n=5)\). However, patients with and without complications revealed no significantly differences in duration of surgical procedure \((P=.21)\).

Twenty-two (62.8%) of 35 patients had a mean follow-up of 16.5 months (mean of distal femoral fracture group, 13.7 months; mean of femoral shaft fracture group, 20.5 months; \(P=.27)\) and were investigated using the Lysholm score and SF-8 questionnaire. In 3 patients who lived in a nursing facility, a short observation period of 3 months was accepted. Radiographic follow-up was limited to 13 (39.1%) patients because 2 lived abroad, 2 refused radiographs, and 5 lived in a nursing facility and were investigated there.

In the examined patient group, mobility status remained at the same level in 18 (81.8%) patients, got worse in 3 (13.6%), and increased in 1 (4.5%). Mean Lysholm score was 76.2 points and revealed no significant differences among different fracture types (78.1 in the femoral shaft fracture group vs 74.9 in the distal femoral fracture group; \(P=.69)\). Periprosthetic fractures accomplished relatively good results (mean, 84.8 points), but with no significant difference between other patients \((P=.23)\). Altogether, Lysholm score was good in 8 (36.4%) patients, fair in 11 (50.0%), and poor in 3 (13.6%). The latter were related to multiple joint contractures after poliomyelitis, deficits after septic nonunion, and complications after revision surgery following failed Less Invasive Stabilization System fixation, respectively. In the majority of patients, the encountered functional deficits in Lysholm score were associated with limping or difficulty with weight bearing, stair climbing, or squatting in 13 (59.1%) patients and was related to the general status of their locomotor system (Figure 3).

However, most patients \((n=17; 77.3\%)\) had a stable and painless knee with no swelling, and 3 (13.6%) patients reported some type of locking of the joint.

No significant differences among fracture groups were observed in the physical component \((38.5 \text{ vs} 40.5; P=.7)\) and the mental component \((42.3 \text{ vs} 46.3; P=.49)\) of the SF-8 score. In the periprosthetic fracture group, a significant increase in SF-8 physical component existed \((49.5 \text{ vs} 39.3; P=.026)\). No correlation was found between age and time from injury to surgery or age and physical component score. However, a significant negative correlation existed between age and mental component score (Pearson correlation coefficient: \(-0.523; P=.012\)), indicating a decrease of mental component score with age.

**DISCUSSION**

In elderly patients, fractures of the femoral supracondylar region are pre-
dominantly caused by low-energy trauma. Although associated injuries and considerable soft tissue damage are infrequently found in this age group, these fractures are difficult to treat due to bad bone stock and impaired vascularity. Conservative treatment is at risk for worse functional outcome (up to 3 times higher than in surgical treatment) and even fatal complications; therefore, it is indicated in undisplaced fractures and patients with high perioperative risks due to comorbidities. However, ORIF procedures are associated with high rates of severe complications, especially infections and nonunions, and, subsequently, a significant decrease of function in this specific age group. The introduction of minimal invasive and soft tissue–preserving techniques, such as retrograde nailing or minimally invasive plate osteosynthesis techniques, helped reduce the high complication rates of ORIF procedures. From a biomechanical point of view, retrograde intramedullary nailing represents a reliable and stable fixation method providing results comparable with plate systems regarding construct stability. However, some authors report biomechanical advantages of retrograde intramedullary nailing in certain indications that affect predominantly elderly patients with periprosthetic fractures around knee prostheses. Others report the superior axial stability of intramedullary devices in osteoporotic bone of ambulatory patients. Clinical outcome results of retrograde intramedullary nailing in the treatment of distal femoral fractures are similar to minimal invasive plating, but in minimally invasive plate osteosynthesis, special complications may arise due to the atrophic tissues of a senior population, such as implant loosening in osteoporotic bone and alteration of metaphyseal soft tissues by the bulky implant. Frankhauser et al reported irritation of the iliotibial tract by the implant as the main cause for implant removal in 23.4% of cases. Therefore, the current authors consider the described intramedullary stability of retrograde intra-

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Total (N=36)</th>
<th>Distal Femoral Fracture (n=21)</th>
<th>Femoral Shaft Fracture (n=15)</th>
<th>P</th>
<th>Periprosthetic Fracture (n=7)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient age, y</td>
<td>81.3 ±11.5</td>
<td>80.3 ±11.9 (64–102)</td>
<td>82.9 ±11.4 (60–103)</td>
<td>.516</td>
<td>81.0 ±11.5 (64–97)</td>
<td>.924</td>
</tr>
<tr>
<td>Time from injury to surgery, d</td>
<td>1.6 ±2.3</td>
<td>1.53 ±1.7 (0–11)</td>
<td>1.71 ±3.0 (0–5)</td>
<td>.832</td>
<td>1.29 ±1.7 (0–5)</td>
<td>.682</td>
</tr>
<tr>
<td>Duration of surgery, min</td>
<td>91.5 ±31.9</td>
<td>89.1 ±29.4 (26–143)</td>
<td>94.9 ±35.8 (48–195)</td>
<td>.592</td>
<td>85.2 ±16.6 (65–115)</td>
<td>.573</td>
</tr>
<tr>
<td>Start of postop mobilization, d</td>
<td>1.6 ±1.0</td>
<td>1.45 ±0.8 (0–2)</td>
<td>1.87 ±1.1 (0–5)</td>
<td>.22</td>
<td>2.0 ±0.0 (0–5)</td>
<td>.03</td>
</tr>
<tr>
<td>Time to full weight bearing, wk</td>
<td>3.3 ±3.2</td>
<td>4.0 ±3.8 (0–12)</td>
<td>2.3 ±2.0 (0–6)</td>
<td>.09</td>
<td>3.4 ±2.0 (1–6)</td>
<td>.88</td>
</tr>
<tr>
<td>Time to osseous healing, wk</td>
<td>11.3 ±1.8</td>
<td>10.7 ±1.2 (9–12)</td>
<td>11.7 ±2.1 (9–16)</td>
<td>.285</td>
<td>11.8 ±1.3 (10–14)</td>
<td>.393</td>
</tr>
<tr>
<td>Follow-up, mo</td>
<td>16.5 ±13.9</td>
<td>13.7 ±7.9 (3–28)</td>
<td>20.5 ±19.5 (3–54)</td>
<td>.27</td>
<td>15.7 ±21.6 (3–54)</td>
<td>.89</td>
</tr>
<tr>
<td>Lysholm score</td>
<td>76.2 ±17.9</td>
<td>74.9 ±21.2 (15–93)</td>
<td>78.1 ±12.8 (50–93)</td>
<td>.692</td>
<td>84.8 ±7.4 (75–93)</td>
<td>.232</td>
</tr>
<tr>
<td>ROM, deg</td>
<td>102 ±14.7</td>
<td>96.7 ±13.7 (80–120)</td>
<td>110 ±14.1 (90–120)</td>
<td>.174</td>
<td>105 ±12.9 (90–120)</td>
<td>.629</td>
</tr>
<tr>
<td>SF-8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical</td>
<td>39.3 ±11.8</td>
<td>38.5 ±13.2 (17.3–57.3)</td>
<td>40.5 ±10.2 (27.9–54.1)</td>
<td>.7</td>
<td>49.4 ±6.3 (39.2–54.1)</td>
<td>.026</td>
</tr>
<tr>
<td>Mental</td>
<td>43.9 ±12.9</td>
<td>42.3 ±13.2 (24.9–61.7)</td>
<td>46.3 ±12.7 (24.9–59.1)</td>
<td>.49</td>
<td>48.3 ±13.3 (26.3–60.4)</td>
<td>.401</td>
</tr>
</tbody>
</table>

Abbreviations: postop, postoperative; ROM, range of motion.
*One case of septic nonunion required final revision surgery.
Figure 4: Graphs showing Lysholm scores for limp (A), support (B), stair climbing (C), squatting (D), pain (E), instability (F), swelling (G), and locking (H) in 22 patients at a mean 16.5-month follow-up. Abbreviation: pts, points.
nonambulatory patients,\textsuperscript{19} pathologic fractures,\textsuperscript{20} or elderly patients,\textsuperscript{14,18,21-23} early mobilization and reliable osseous healing can be achieved.

In the current series, only 1 case of nonunion following a septic complication was observed in a patient with extreme obesity, diabetes mellitus, and marked artherosclerosis. Janzing et al\textsuperscript{23} reported predominantly good and excellent results (88.9\%) and no failures in Neer score in patients older than 65 years treated with a Green Seligson Henry nail. Christodoulou et al\textsuperscript{14} used the Schatzker and Lambert criteria and reported 51\% excellent, 9\% fair, and 9\% poor results after 28 months. The high percentage of fair results in the current series seems to be influenced by the high average age of the patients and the use of a strict knee rating system in which less favorable results are inherent in advanced age. Thus, the majority of the current patients’ score deficits were related to limitations of motion associated with limping, squatting, or stair climbing. However, a minority of patients reported pain, instability of the knee joint, and swelling. Only 3 follow-up patients reported decreased mobility compared with preoperative status. Similarly, El-Kawy et al\textsuperscript{22} reported no alteration of patient satisfaction even in the presence of problems, citing a 39.2\% rate of malalignment but only 10\% of patients reporting complaints.

Although Gynning and Hansen\textsuperscript{17} reported backing out of the distal locking bolts as the most common complication (5/30) and reported 2 broken nails, all patients regained flexion of at least 90\° with no tenderness at the fracture site. Loosening of distal bolts in osteoporotic bone is a major problem and is subject to various attempts to improve the purchase of the distal screws/bolts.\textsuperscript{24} In the current series, this was the most frequent single surgical complication. Singh et al\textsuperscript{25} reported that 10 of 26 distal screws of T2 nails disengaged within 10 weeks in patients aged an average of 78 years. Janzig et al\textsuperscript{23} reported loosening in 5 of 26 patients and fixed the distal screws with bone cement due to poor intraoperative purchase in 4 patients.

In femoral shaft fractures (AO 33), retrograde intramedullary nailing is an established alternative to antegrade nailing with comparable results.\textsuperscript{14} Almost half of the current patients presented with shaft fractures and revealed local conditions that prevented antegrade nailing in the majority of cases. Over the past few decades, implants in situ became a major issue in preoperative planning due to longer patient lifetimes, an increasing number of joint replacements due to severe osteoarthritis, and an increasing number of femoral fracture stabilization. Thus, Kumar et al\textsuperscript{18} reported local implants in the femur in 25\% of cases, Gynning and Hansen\textsuperscript{17} in 33\% of cases, and the current study in 41.7\% of cases. However, the presence of knee arthroplasty does not absolutely prevent retrograde intramedullary nailing because, depending on the design of the prosthesis, the nail can pass the femoral component (Figure 4).

The current study had some limitations due to its retrograde design, the relatively small number of patients with follow-up, and the limited observation period of this age group. However, without influence due to fracture type and type of nail used, early mobilization, reliable fracture healing, and a tolerable complication rate were observed with retrograde nailing. Functional deficits were mainly based on mobility limitations related to age. Thus, further studies are required to evaluate the long-term functional outcomes of retrograde intramedullary nailing compared with minimal invasive plating to establish treatment strategies acceptable for use in an impaired locomotor system.

**CONCLUSION**

Retrograde intramedullary nailing is a reliable fixation method for extra-articular and simple intra-articular fractures of the supracondylar area of the femur and is an alternative to antegrade intramedullary nailing in femoral shaft fractures in elderly patients.

---

**Figure 4:** Preoperative anteroposterior (left) and lateral (right) radiographs of a 79-year-old woman who sustained a comminuted fracture AO 33-A3) above a total knee arthroplasty in a simple fall. The implant design was adequate, and no signs of implant loosening were observed (A). Postoperative anteroposterior (left) and lateral (right) radiographs after fracture stabilization with retrograde intramedullary nailing (B).
ly patients. Stable fracture fixation and minimal soft tissue damage provide early mobilization, which helps to prevent fatal complications and make the implant suitable for this age group. Among distal femur fractures and femoral shaft fractures, no differences in functional outcome were observed, and deficits were predominantly related to the increased age of the patients and concomitant limitations of the locomotor system.

REFERENCES
3. Ricci WM, Bellabarba C, Evanoff B, Hersco...