Retrograde Intramedullary Nailing in Supracondylar Femoral Fractures – The Töölö Hospital Experience

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The Distal Femoral Nail (DFN, Stratec Medical, Oberdorf /BL, Switzerland) has been used in our clinics now for two years as a treatment for supracondylar and, in some case, diafyseal femoral fractures. We present the results of the 46 consecutive completed supracondylar femoral fracture treatments. Forty operations were performed for fresh fractures, five were reoperations because of non-union and breakage of condylar screw and plate (DCS), and one was a late operation (three weeks after the trauma). Nine of the cases were due to a high energy trauma and the rest due to a low energy trauma, usually falling on the same level. Seven of the fractures were periprostethic (fracture just above the TKA femur component) and four were open fractures. The operations (operative technique, used nail, duration, estimated peroperative blood loss), the outcome (ROM of the knee joint, pain, radiological results, union time), and per- and postoperative complications were studied retrospectively. The mean followup time was 9 months. We had three (6%) superficial wound infections, no (0%) deep wound infections, three (6%) loss of reduction cases, two (4%) breakdown of a distal locking screw without an effect on the final radiological result, no (0%) breakage of the nail nor the spiral blade, and one (2%) lesion of the branch of the arteria profunda femoris occurred during proximal locking. Our results suggests, that DFN is a reliable alternative in supracondylar femur fracture treatment.

Distal femoral fracture poses a considerable therapeutic challenge. Anatomic reduction, stabilization, early weigth bearing and mobilization are the main aims of the fracture management. Operative treatment has become a standardized procedure. Earlier, stabilization has usually been achieved by an osteosynthesis with condylar screws and plates. Antegrade intramedullary nailing is widely used in the treatment of femoral shaft fractures, where as the stabilization of distal femoral fractures with antegrade nailing is often difficult. The reason for difficulties is the incongruence of the distal intramedullary canal and the distal locking with the nail, which leads to dislocation of the fracture.

In the management of closed displaced supracondylar fractures with blade-plating there has raported an overal complication rate even up to 35 % by Merchan et al. (1). There has been malalignment and pseudoarthrosis, which are proposed to be due to the eccentric lateral location of the plate (2) and less stiffness of the bone stock in the metaphysis (3). Also the iatrogenig soft tissue trauma surrounding the fracture site and devascularization of the periost in placing the extramedullary plate has been suggested to play a role in the development of infection and delayed union (4).

The tehcnique of retrograde intramedullary nailing has been developed to avoid some of the problems associated with condylar plating. The Distal Femoral Nail (DFN, Stratec Medical, Oberdorf /BL, Switzerland) is an unreamed, titanium, solid nail, locked proximally with two screws and distally with one screw and a twisted blade (alternatively with two locking screws). Good results have reported in the management of distal femoral fractures with DFN (5, 6). In cadaveric studies, the Distal Femoral Nail was noted to provide equal or greater stability than the plate, except when large torsional loads are anticipated (7).

Moreover, Ito et al. have showed a beneficial increase in the bone-implant interface surface for improving the acute stiffness and strength of fracture fixation in osteoporotic cancellous bone when using a distal spiral blade (8).
Retrograde intramedullary nailing has been used in our clinics mainly for the treatment of distal femoral fractures, and occasionally for femoral shaft fractures. In this paper we present the early radiological and clinical results of supracondylar femoral fractures treated with DFN.

Patients and methods

Patients. Between December 1999 and June 2001 44 patients with total of 46 displaced fracture of the distal part of femur were treated at our department with a Distal Femoral Nail (DFN, Stratec Medical, Oberdorf /BL, Switzerland). 16 (37.0%) patients were men with an average age of 52.3 years (SD 18, range 20 to 86 years), and 28 (63.0%) women with an average age of 66.5 years (SD 15.9, range 20 to 93 years) (difference of means 14.2, 95% CI 3.9 to 24.5 years). The right femur was the object in 17 (37.0%) and the left one in 29 (63.0%) of the cases. 37 (80.4%) operations were done by a senior orthopaedic registrar (19 surgeons), and 9 (19.6%) by a specialist in orthopaedic surgery (6 surgeons). The average follow-up was 9 months (37 weeks, SD 25, range 12 to 104).

Fracture types. Five operations were made because of a nonunion and breakage of a compression screw and plate implant (DCS) and one was a late operation (three weeks after the accident). The rest 40 operations were performed for fresh fractures. Nine of the cases were due to a high energy trauma, four of those patients were multiple injured needing several operations and a long intensive care unit treatment. The rest were due to a low energy trauma, usually falling on the same level. Seven of the fractures were periprostethic (fracture just above the TKA femur component). According to AO-ASIF (Arbeitsgemeinschaft für Osteosynthesefragen - Association for the Study of Internal Fixation) classification, there were 37 (80.4%) AO-type A (extra-articular) and 9 (19.6%) AO-type C (intra-articular) supracondylar femoral fractures (Table 1.). AO-type B fractures were not treated with this method at our department.

Table 1. Characteristics of patients, operation technique and -data in 44 patients with 46 distal femoral fractures, with respect to AO - ASIF type of the fracture.

	A (n:37) mean; SD	C (n:9) mean; SD	Difference of means	95% confidence interval
Patient age (years)	*63.9 6.0*	*50.2 21.7*	*13.7*	*0.8, 26.6**
Operation time (minutes)	*147 49*	*169 44*	*-22*	*-58; 14*
Blood loss (ml)	*1063 818*	*981 773*	*82*	*-525; 689*
Union time (weeks)	*17.6 10.2*	*17.0 7.0*	*0.6*	*-6.7; 7.9*
Weight restriction (weeks)	*8.1 2.4*	*7.3 1.5*	*0.8*	*-0.9; 2.5*

	A (n:37) n(%)	C (n:9) n(%)	Odds Ratio	95% confidence interval
Male patients	*14 (41.2)*	*3 (33.3)*	*1.2*	*0.3, 5.7*
Transligamentar approach	*12 (32.4)*	*2 (22.2)*	*1.7*	*0.3; 9.3*
Open reduction	*29 (78.4)*	*9 (100)*	*N/A*	*N/A*

* = statistically significant correlation

Four of the fractures were open (all because of a high energy trauma), and they were classified by Gustilo-Anderson (three grade II, one grade III A) (9, 10).

Operative technique. Normally the patients were operated in supine position under a spinal anesthesia, where as the multiple injured patients were under a general anesthesia. An image intensifier was used peroperatively. The operations were made either through a transligamentar or parapatellar approach, an additional lateral opening of the fracture site was made in some cases. The most used lentgh of the nail was 300 mm (17 cases) and the diameter 10 mm (22 cases). The distal locking performed with a spiral blade and one locking screw in all but eight cases (two distal locking screws and no spiral blade) and the proximal locking with two screws in all but seven cases (one proximal locking screw) placed either in antero-posterior or latero-medial manner (26 and 20, respectively). A bone grafting was performed in seven cases (six autogenous and one allogenous bone

grafting), four of those cases were reoperations due to problems with earlier condylar screw and condylar plating. The duration of an operation was considered to be the period between the first cut and the last closing skin suture, where as the volume of peroperative bleeding was an estimate made by an operating surgeon and an anesthesiologist.

Aftertreatment. The patients were followed up postoperatively mainly in our clinics by different surgeons (12 patients were followed up in their local hospitals). The first control visit at the policlinics was normally six weeks postoperatively, after that every four to six weeks until the fracture was consolidated. At every visit a native roentgenogram was taken.

Radiological analysis. All the documents and roentgenograms were studied by one author (LH). As the roentgenological criterias for consolidation were considered a callus formation on ¾ cortexes and a fading away of the fracture lines seen on antero-posterior and latero-medial native roentgenograms.

Table 2. Radiological assessment of roengenograms and scoring of the final radiological result after fracture consolidation

Shortening	Varus-Valgus	Ante-Retro	Total scoring
0 −9 mm	0° − 3°	0° − 3°	Exellent
4 points	4 points	4 points	10 − 12 points
10 −19 mm	4° − 7°	4° − 7°	Good
3 points	3 points	3 points	7 − 9 points
0 −29 mm	8° − 12°	8° − 12°	Fair
2 points	2 points	2 points	4 − 6 points
> 30 mm	> 12°	> 12°	Poor
1 points	1 points	1 points	1 − 3 points

The alignment of the distal femur was measured on peroperative, immediate postoperative and on the final follow up roentgenograms (shortening, varus-valgus, antecurva-retrocurva). The measurements were scored and the radiological outcome was assessed as showed in table 2.

Statistical analysis. Descriptive values are presented as means, with standard deviation (SD) and range. When differences of means are compared, they are presented with 95% confidence intervals (CI). Intervals excluding 0 are considered as statistically significant. Odds ratios (OR) between different groups of patients were calculated for the factors evaluated, using logistic regression analysis. 95% confidence intervals were calculated for crude odds ratios, and values excluding one were considered as statistically significant.

Results

The operation time averaged 151 minutes (SD 48, range 80 to 290), and the mean peroperative blood loss 1048 ml (SD 801, range 200 to 3500). The longest operation (290 minutes) with bleeding of 3000 ml was performed for the patient sustaining gradus III A open fracture needing large soft tissue revisions (high energy trauma).

Table 3. Technical factors and postoperative details in 46 operations with open or closed reduction of a distal femoral fracture and fixation with a Distal Femoral Nail.

	Open reduction * (n: 40) mean; SD	Open reduction through an additional lateral incision (n:14) mean; SD	Closed reduction (n:6)
Operation time (minutes)	156; 50	167; 42.3	122; 22
Blood loss (ml)	1081; 801	1140; 615	842; 842
Weight restriction (weeks)	7.8; 2.6	7.6; 2.7	8.0; 2.5
Union time	18.0; 10.2	17.6; 5.8	14.5; 3.8

* Medial parapatellar approach

A transligamentar approach through the patellar tendon was used in 14 (30.4%) cases, and a medial parapatellar approach in 32 cases (69.6%). An open reduction of the fracture was performed in 40 (87%) cases, and an open reduction through an additional lateral approach in 14 cases (30.4%) (Table 3.). Patients were discharged from the hospital in average 8.4 days postoperatively (SD 4.8, range 1 to 25). 33 patients (75%) were transferred to their local hospitals for extensional postoperative rehabilitation, the main reason for that was patients old age. Weight bearing on the operated extremity was restricted to approximately 15 kg:s in average for 7.8 weeks (SD 2.6, range 3 to 12).

One peroperative major iatrogenous damage took place. A lesion of the branch of the arteria profunda femoris occured during proximal locking (performed in latero-medial manner) on 86 years old male,

leading to postoperative swelling of the thigh and hemodynamic instability with cardiac problems. The bleeding was ceased with angiographic embolization carried out.

Table 4. Risk factors for delayed union (= union time more than 16 weeks) in 46 operations with a distal femoral fracture fixed with a Distal Femoral Nail.

	Delayed union			
	YES (n:16) n(%)	NO (n:28) n(%)	Odds ratio	95% CI
Age >60	8 (50)	16 (57.1)	0.8	0.2; 2.6
Male gender	4 (25)	12 (42.9)	0.4	0.1; 1.7
A-type (AO)	13 (81.2)	22 (78.6)	1.2	0.3; 5.6
A1	6 (37.5)	10 (35.7)	1.1	0.3; 3.9
A2	5 (31.2)	6 (21.4)	1.7	0.4; 6.7
A3	2 (12.5)	6 (21.4)	0.5	0.1; 3.0
C-type (AO)	3 (18.8)	6 (21.4)	0.9	0.2; 4.0
Open reduction	15 (93.8)	23 (82.1)	3.3	0.3; 30.7
Additional lateral incision	6 (37.5)	7 (25)	1.8	0.5; 6.8
Parapatellar approach	12 (75)	19 (67.9)	1.4	0.4; 5.7
Open reduction secured with Dall-Miles	6 (37.5)	6 (21.4)	2.2	0.6; 8.6

The mean union time of the fracture was 18 weeks (SD 10, range 8 to 68). The patient with the longest union time was a 78 years old female with A 1 fracture suffering pain at weigth bearing until 68 weeks postoperatively. A roentgenogram taken at that moment revealed a breakdown of one the distal locking screw with a sligth compression of the fracture site, that ”spontaneus” dynamization of the nail led to the union of the fracture. 3 patients had loss of reduction and one had non-union of the fracture. The patient with the non-union was a 86 years old female with an earlier paraparesis and very osteoporotic bone, who sustained a C 1 fracture which was diagnosed 3 weeks after the initial trauma. Loss of reduction and a pseudoarthrosis was noted at 12 weeks postoperatively, leading to removal of the DFN implant, no further operations were considered in that case. 4 patients had a re-operation of the fracture during follow-up. Delayed union (over 16 weeks) was observed in 16 cases (34.8%). An analysis of factors correlating with delayed union are presented in table 4.

The mean score at latest follow-up was 11.0 (SD 1.6, range 3 to 12). The most significant independent factor predisposing high score (11 or 12) at latest follow-up was age under 60 years (Table 5.). Male gender and approach were factors which were weakly positively associated to a high score, whereas the means of reduction (open or closed) did not correlate significantly to the outcome. Anterior knee pain was observed in 10 patients (21.7%). There was no correlation between the frequency of anterior knee pain and the use of approach (odds ratio 1.7, 95% confidence interval 0.3 to 9.8 between transligamentar and parapatellar approach), the AO-ASIF type of the fracture (OR 2.9, 95% CI 0.6 to 14.5 between type A and C), or the type of reduction (OR 0.5, 95% CI 0.1 to 3.6 between open and closed reduction).

Table 5. An analysis of factors associated with the final radiological result.

	Points			
	<11 (n:11)n (%)	= > 11 (n:33) n(%)	Odds ratio	95% CI
Age >60	10 (90.9)	14 (42.2)	13.6	1.6; 119*
Male gender	1 (9.1)	15 (45.5)	0.1	0.0; 1.0
A-type (AO)	9 (81.8)	26 (78.8)	1.2	0.2; 6.9
Open reduction	9 (81.8)	30 (90.9)	0.4	0.1; 3.1
Additional lateral incision	2 (18.2)	11 (33.3)	0.4	0.1; 2.4
Transligament ar approach	1 (9.1)	12 (36.4)	0.2	0.0; 1.5
Open reduction secured with Dall-Miles	1 (9.1)	11 (33.3)	0.2	0.0; 1.8

* = statistically significant correlation

We had three loss of reduction cases out of 46 (6%) leading to two reoperations (4%) and one non-union (2%) followed by an implant removal at 12th postoperative week. Two out of three loss of reductions appeared on patients with distal AO-ASIF type-A fractures in very osteoporotic bone, and one with patient having co-operation problems due to his alcohol abuse leading to early weight bearing and compression of the fracture due to migration of the locking screws, no implant failure was noted in that

case. In two cases (4%) the breakdown of a distal locking screw was noted, but neither of them led to malposition, only to compression of the fracture. No breakage of the nail itself nor the spiral blade was noted. One patient (93 year old female) died on 17th postoperative day because of cardial dysfynction leading to a untreatable decompensation.

Discussion

The retrograde intramedullary nail is inserted via transarticular approach and thus there is a great consern of the knee joint, especially when there is an extra-articular (AO-ASIF type A) fracture with no intra-articular trauma manifestation. A through lavage of the knee joint has to be done before closure in order to clean off all the bone chips orginating from the opening procedure of medullary canal. The main conserns are the risks of iatrogenous septic arthritis and postoperative knee pain, and possible "post traumatic" changes in the knee joint due to transarticular nail insertion.

In earlier series of supracondylar femoral fractures treated with retrograde intramedullary nailing, there are reports of infection rates 0% to 3% and loss of reduction or implant failure in 0% to 6% of cases (6, 11). There are no reports of long term knee joint effects after retrograde nailing done transarticulary. Moed et al. (12) reported of no infections and only minimal complaints of knee pain associated with retrograde intramedullary nailing of fractures of the femoral shaft. In cadaveric studies Morgan et al. (13) showed that the placement of a retrograde femoral intramedullary nail is critical, but a proper placement should not significantly influence the biomechanics of the patellofemoral joint. In this study, we had no deep infections but three superficial infections leading to total infection rate of 6%. These rates are comparable to earlier reported series.

In two cases (4%) the breakdown of a distal locking screw was noted, but neither of them led to malposition, only to compression of the fracture. No breakage of the nail itself nor the spiral blade was noted. That is an advantage compared to condylar plating in cases of delayed union, as the plate has a tendency to bend and finally break down in such a cases. The very distal periprostethic fractures (fracture just above the TKA femur component) are sometimes very diffucult or even impossible to treat with DFN, because of the comminution of the condylar cortexes at the level of the distal locking. Our experience is, that one should choose an alternative method for fracture fixation in such cases.

In this series, we had one lesion of the branch of the arteria profunda femoris occuring on proximal locking performed in latero-medial manner, it was treated with angiographic embolization. An arterial lesion during proximal locking can arise by two different mechanisms; by an avulsion which may occur several centimeters away from the drilling and is presumably caused by a muscle fibre entangling around the drill bit, and by a direct lesion (14, 15). One should thus take care not to penetrate the medial soft-tissue when locking distal femoral nails proximally. Particular precaution should also be taken, when drilling is performed with a blunted drill bit, which often causes an inappropriate use of force.

In this study we had a mean follow up of 9 months. The main reason for such a short time was the high age of our patients, who either already before the fracture were permanently hospitalized due to poor overall condition or were not in condition to manage at home after the fracture and the operation. Those patients were followed until the fracture healed, but were asked for no more visits after that. That might have had an influence on the results of postoperative knee pains, mainly anterior knee pain and mobilization pain, and range of movements (ROM). The younger patients are normally followed up at least 12 months when the decision of possible implant removal is done. The assesment of the fracture consolidation and union time was made by roentgenograms taken normally every four to six weeks. It is possible that union times recorded are more probably longer than shorter comparing to ones assested by more often taken roentgenograms.

The main advantages of DFN are the greater stability than provided by condylar plating, exept when large torsional loads are anticipated (7) and the benefits of increasing the bone-implant interface surface for improving the acute stiffness and strength of fracture fixation in osteoporotic cancellous

bone (8). The avoidance of opening of the supracondylar fracture site in order to limit devascularization and further appearance of pseudoarthroses and infections is also possible with DFN. In our series, an open reduction of the fracture was performed even in 40 (87%) cases, and an open reduction through an additional lateral approach in 14 (30.4%) cases. An open reduction of the fracture did not offer any advantages in fracture healing, when compared to closed reduction. On the contrary, open reduction of the fracture was associated with factors, which may be considered as disadvantageous in fracture treatment, such as increased blood loss and operation time. Although open reduction of the fracture cannot always be avoided due to gross displacement of the fracture, we recommend that closed reduction should be considered as the primary means, whenever possible. Closed reduction is, however, often impossible in most comminuted cases and in AO-ASIF type-C intercondylar fractures. In our series, the mean union time of the fracture was 18 weeks. We considered union time to be normal up to 16 weeks, after that it was considered delayed. The rate of delayed unions was fairly high (35%), but one confusing factor for that are those four to six weeks intervals between radiographs during the follow up as mentioned above.

We conclude, that Distal Femoral Nail (DFN) is an reliable alternative in supracondylar femur fracture treatment. Careful preoperative planning should be done when dealing with very distal periprostethic fractures, because of the comminution of the condylar cortexes at the level of the distal locking. There are not knowledge about the long-term effect of retrograde nailing on the knee joint, thus the decision to treat young patients with DFN has to be done with great precaution. Further studies with longer follow ups are to be done about the long-term knee effects.

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