

High energy fractures of the distal femur

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Abstract

Introduction: High-energy fractures that involve the joint surface of the distal femur are challenging injuries. Less invasive stabilization system (LISS) has been the preferred treatment for these fractures. However few studies has investigated young patients suffering from high-energy trauma with complex articular fractures, AO 33C.

Method: Ten patients with 11 AO 33C fractures, between the age of 18 and 65 years, where identified from a local database at OUS Ullevål. They where clinically, radiologically and functionally evaluated.

Results: The mean age was 42 (32-61) years old. The follow up time was 8-47 months. All fractures were caused by high-energy trauma and treated with the LISS plate. Seven knees underwent secondary surgery, 6 within the follow-up time. Reoperations were due to: Two mal-union, two delayed/non-union, one implant failure and one implant removal due to pain. Clinically they showed an average flexion arc of 95 degrees, limp shortening ranging from 5 to 30 mm and the mean performance on the 6-minute walk test was 414m. Radiologically 6 knees had osteoarthritis, scored with Kellgren–Lawrence grade 2 or worse, no patients show loss of reduction. Functionally only 2 patients were back to work, SF-36 showed a marked reduction in all subscales, most prominently in Role-physical and Physical function. In the KOOS questionnaire our patient group reports considerable difficulties in all five subscales. According to the Schatzker-Lambert classification six of the eleven knees were a failure, three were fair, two were good and none were excellent.

Discussion/conclusion: In our material there was a high incidence of reoperations due to delayed/non-union and mal-union. Health-related quality of life was significantly reduced. The number of patients in this study was small, but all had sustained high-energy injuries and underwent a thorough clinical and radiological examination, in addition to answering validated questionnaires addressing functional outcome and quality of life.

The literature has shown a tendency towards fewer complications like mal/non-union, infections and implant-failure using the LISS-plate. However the evidence base is weak. Our study shows a poorer outcome in this patient group with a higher-incidence of delayed/non-union, mal-unions, a poorer functional outcome and significant self-reported problems. This suggests that the use of LISS in this setting might not give as good results as used on the less “complicated” fractures.

High energy fractures of the distal femur

Introduction

High-energy fractures that involve the joint surface of the distal femur are challenging injuries. During the last two decades minimal invasive surgical techniques, such as the Less invasive stabilization system (LISS), has been introduced as a treatment for distal femur fractures.¹⁻⁷ Smith et. al. showed that there is still a high incidence of loss of reduction, delayed/non-union and implant failure using the LISS. The review also suggests that there is limited evidence supporting the LISS, and data regarding quality of life is poorly assessed.⁷

Field Code Changed

Field Code Changed

Distal femur fractures has two peaks in age-distribution, one represented by younger patients suffering from high-energy trauma, the other represented by older osteoporotic patients^{18 9}. Several studies have addressed the treatment of distal femoral fractures; most of these studies have included heterogeneous patient cohorts, but suggest that the supracondylar-intraarticular fractures (type 33C) are associated with a poorer outcome.^{3 8-13} In this study we wanted to investigate the clinical and radiographic outcome in a case series of 10 patients with high-energy fractures AO/OTA type 33C.¹⁴

Field Code Changed

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Method

A local database at Oslo University Hospital, Ullevål was reviewed for all distal femur fractures classified as AO/OOA 33. We reviewed radiographs of all type 33 fractures to identify the supracondylar-intraarticular fractures (type C). The database records all fractures treated at our institution since November 2003. To allow a minimum follow-up of 6 months we did not include patients treated after December -07. We included patients between 18 and 65 years of age. We identified 32 patients with 33C fractures (figure 1). Three of these were deceased, 6 were amputated, 1 was the same person registered twice, and 2 had a wrong personal identification number. Five of the amputations were performed in the early phase, within one week of the injury. The last one was treated with a Locking Compression Plate for an open fracture, and was amputated due to secondary infection after 29 days. 20 patients were invited to the study, 14 responded positive. 4 of these patients were not eligible to follow-up; three due to other injuries,, one was to fit and did not want to participate. The result of this selection was 10 patients with 11 type 33C fractures.

From the patient records we identified mechanism of injury, injury severity score (ISS), open/closed fracture, other injuries to the same extremity, temporary operative treatment, operation date and complications. Two different groups assessed radiographs independently (by JEM and by IB, IØ and GBF). Pre-operative, post-operative and follow-up x-ray pictures were available for all patients. Pre-operative CT pictures was available in 8 patients. Any discrepancy was discussed and revised. To assess arthritis we used the Kellgren-Lawrence scoring system.¹⁵ Union, alignment and congruency were also noted. To identify mal-union we inspected radiographs for varus/valgus deformity, limb length discrepancy and femoral malrotation (measured as a difference in hip-rotation compared to contralateral side). We defined implant failure as screw pullout or plate/screw breakage within the 1st year of plate insertion . If the hardware

failed later than one year after the primary operation we attributed the failure to delayed or non-union.

At follow up all patients were assessed clinically and functionally, and new x-rays were acquired. At the outpatient visit the participants completed the SF-36 and the Knee injury and Osteoarthritis Outcome Score (KOOS)¹⁶. The KOOS questionnaire is a tool to evaluate a patient's opinion about their knee and associated symptoms. KOOS is based on the WOMAC osteoarthritis index with two additional subscales; Sports and Recreation and Quality of Life, to better assess a younger patient group. Answers are rated to a scale where 100 represent no symptoms and 0 represents the worst possible symptoms¹⁷. The patients was also assessed using the Schatzker-Lambert criteria^{8 18}.

The clinical examination was done in cooperation with a physiotherapist. Range of motion, cruciate ligament integrity, varus/valgus stability, limb length, one-leg stance and a 6-minute walk test was registered. The one-leg stance test is a test where the patients try to stand on one leg for as long as they could; 30 seconds maximum. In the 6-minute walk test the patients walk back and forward on a flat surface and along a 30-meter long line, as many times they can in 6 minutes¹⁹. They were allowed to use crutches or similar aiding tools.

Results

Demographics

The demographics, background data and treatment are given in table 1. The mean age in the follow-up group was 42 years old (range 32-61 years). Eight of the patients were working full time before the accident. One patient was between jobs, but had no pre-injury disability. One patient was without a job. The follow-up time was 8-47 months. All fractures were caused by high-energy trauma. One of the patients (patient 9) was initially treated at another hospital. Five of the 11 knees had a Hoffa fracture²⁰.

Treatment

All fractures were treated with the LISS-plate, by surgeons experienced with the LISS technique. Eight knees were initially treated with ex-fix (table 1). All but one of the patients spent more than 4 weeks at rehabilitation centers, the longest stay was 13 months.

Complications

Complications, together with clinical, radiological and functional outcome are summarized in Table 2. Seven patients and seven knees underwent secondary surgery, six within the follow-up time, and in one patient indication for reoperation (non-union) was found at follow-up, and reoperation performed shortly afterward, patient 8. Within follow-up time two of the six reoperations were done for delayed or non-union, two for mal-union, one for implant-failure, and one had the implant removed due to pain. Patient number 5 had a likely external rotation malunion (large increase in external hip rotation compared with the uninjured hip). This patient was not reoperated.

Patient 8 showed clinical and radiological signs of delayed union at follow-up, and was scheduled for revision surgery. Patient 3 had pseudarthrosis and several loose screws in the distal end of the LISS plate. The LISS plate was changed and an additional reconstructive plate on the medial side was implanted. Patient 9 was transferred to a different hospital shortly after the primary surgery, and had multiple surgeries on the affected limb. Two years later he suffered a plate-breakage due to delayed/non-union and was reoperated with an intramedullary nail. Patient 4 had a severe valgus malalignment with a tibial and a femoral component. This was treated with a correcting osteotomy of the tibia. Patient 10 underwent multiple wound revision surgeries due to post-operative infection, and later a rotation deformity was corrected with a femoral osteotomy. Patient 6 had a distal screw pullout and was reoperated due to implant-failure with implant-removal. The fracture was fully healed at the time. Patient 2 underwent implant-removal due to pain.

Clinical results

The participants showed loss of knee extension from 0 to 17 degrees. Maximum flexion varied from 65 to 135 degrees, yielding an average flexion arc of 95 degrees. Rotation in the hip joint was reduced 8 degrees for internal rotation and 3 degrees for external rotation compared to the contralateral side. Patient number 5, had an increase in external rotation of 22 degrees, this was considered a mal-union. Six fractures had limb shortening ranging from 5mm to 30mm. In addition patient 9 had a limb shortening of 50mm, which resulted from a non-union. Patient 3 had a bilateral injury, and is not included in the averages comparing the injured and the contralateral limb. On the Lachman test, three knees had a grade 1 instability, one knee had a grade 3. The mean performance in the 6-minute walk test was a distance of 414 meters.

Radiological results

Radiographs at follow-up showed a minimal tendency to valgus deformity. The follow-up pictures showed an average anatomic lateral distal femoral angle (aLDFA) of 9 degrees, range 2-14 degrees. Post-operative average aLDFA was 8 degrees, ranging from 3-14 degrees. 6 knees had osteoarthritis, Kellgren-Lawrence grade 2 or worse. Patient number 6 had a Kellgren-Lawrence grade 2 pre-operatively. At the follow-up all fractures but one (patient 10) showed satisfactory alignment, there was no loss of reduction. One patient (patient 9) had an incongruent distal femoral joint surface.

Evaluation of health related quality of life and functional outcome

At follow-up only two patients were back to work. SF-36 showed a marked reduction in all subscales, most prominently in Role physical and Physical function (table 2). Among the mental subscales Social function was most reduced. In the KOOS questionnaire our patient group reports considerable difficulties in all five subscales compared to the normal population.

Scahtzker-Lambert

According to the Schatzker-Lambert classification six of the eleven knees were a failure, three were fair and two were good.

Discussion

A high-energy fracture in the distal femur is a serious injury. In our material there was a high incidence of reoperations due to delayed/non-union and mal-union. Health-related quality of life was significantly reduced. In the KOOS questionnaire it is worth noticing the poor outcome in the sport/rec and QOL subscales, which are supposed to give a better picture of knee function in a younger age group. Eight of the ten patients had not returned to work. According to the Schatzker criteria we had only two good and no excellent outcomes.

Strengths and weaknesses

The number of patients in this study was small, but all had sustained high-energy injuries. The follow-up time was short to medium. The study is strengthened by the fact that the participants attended a dedicated clinical and radiological examination at follow-up, in addition to answering validated questionnaires addressing knee function and health-related quality of life.

Previous studies of distal femoral fractures often included osteoporotic patients with low-energy trauma, but two papers have addressed high-energy injuries exclusively. Hutson et al published in 2000 a study on 16 patients who had sustained high-energy, severely comminuted fractures of the distal femur (33 C3) in a young patient group.¹⁰ All patients were treated with open reduction and internal fixation of the condylar joint surface, and tensioned wire circular external stabilisation of the metaphyseal fracture component. In 2004 Weight et. al did a retrospective analysis on distal femur fractures in a trauma setting.¹³ All fractures were treated with the LISS plate. The study included 22 high-energy fractures, 15 of these were C fractures.

Complications

In the Weight study all fractures healed without secondary surgery, there were no cases of failed fixation, implant failure or infection. They found no varus/valgus deformity. However there were three cases of mal-union, and three patients had implant removed due to pain. In comparison there was in our study three delayed/non-union that required secondary surgery, three patients had mal-union (one of these with post-operative infection), one implant-failure and one implant removal due to pain.

ROM:

Hutson reported an average range of motion of 0-90 degrees, and 8 of 16 knees had less than 90 degrees flexion. Weight found an average knee range of motion of 5 - 114 degrees. In our material the average ROM after internal plate osteosynthesis was 2-97 degrees, and 5 of 11 knees had less than 90 degrees of flexion.

Summary Weight-Hutson

Although small patient cohorts and different study design give limitations in comparison with Hutson and Weight, we show a slightly better result in ROM than the external fixation, and a slightly higher incidence of delayed/non-union and mal-union than Weight reports with the LISS. We chose these studies for comparison because of the similar inclusion criteria.

Loss of reduction

As commented by Smith et.al, loss of reduction has been a problem in treatment of distal femur fractures. None of our patients experienced loss of reduction. Three patients had mal-union, but at least two of these was also present postoperative and was not caused by loss of reduction. Patient 5 had a rotation mal-union, which weren't tested until the follow up. The main challenge in our patient cohort is not unstable fixation but delayed union causing implant breakage and reoperations.

Schatzker-Lambert criteria

The Schatzker-Lambert criteria have been used as a measurement for clinical outcome.^{8 21 22} We therefore include our results with Schatzker assessments, although this only partially shows physical outcome and no mental outcome after operation. Schatzker et. al. in 1974 and Schatzker and Lambert in 1979 showed respectively 18 of 24 and 12 of 17 of distal femoral fractures that received operative treatment (according to the principles of rigid fixation) were considered good or excellent. Two other studies use the Schatzker-Lambert criteria^{21 22}. With patients similar to ours (high-energy fractures in younger patients) Kayali et.al. studies 12 33C fractures, reporting 1 excellent, 6 good, 3 fair and one failure. Syed et.al studies five comparable fractures reporting 1 excellent, 2 fair and 2 failures. In our study we found 2 good, 3 fair and 6 failures. Nearly all our patients reported significant pain and 5 of 11 shows a knee flexion less than 90 degrees, yielding poorer results.

Conclusion

After introduction of the LISS, this has been widely used in the treatment of distal femur fractures. The literature has shown a tendency towards fewer complications like mal/non-union, infections and implant-failure. However the evidence-base is weak and few studies look at the younger patient group with type 33 C fractures due to high-energy trauma. Our study shows a poor outcome in this patient group; with a high incidence of delayed/non-union and mal-union, together with a poor functional outcome and significant self-reported problems. This suggests that the use of LISS in this setting might not give as good results as used on the less "complicated" fractures. However, these patients are often multi-traumatized with severe soft tissue damage and multiple other injuries. Due to the trauma-mechanism, to expect good to excellent results in all these cases might not be achievable regardless of the implant of choice. As encouraged by Smith et. al., hopefully this can contribute to more definite knowledge about these fractures and their treatment.

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Figure 1

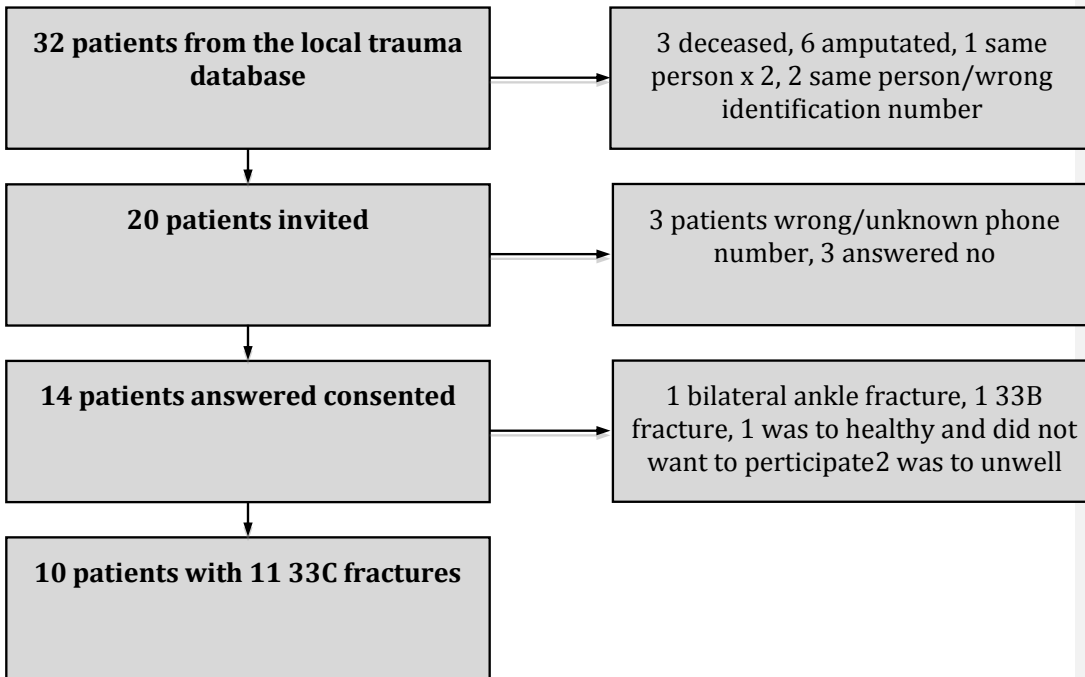
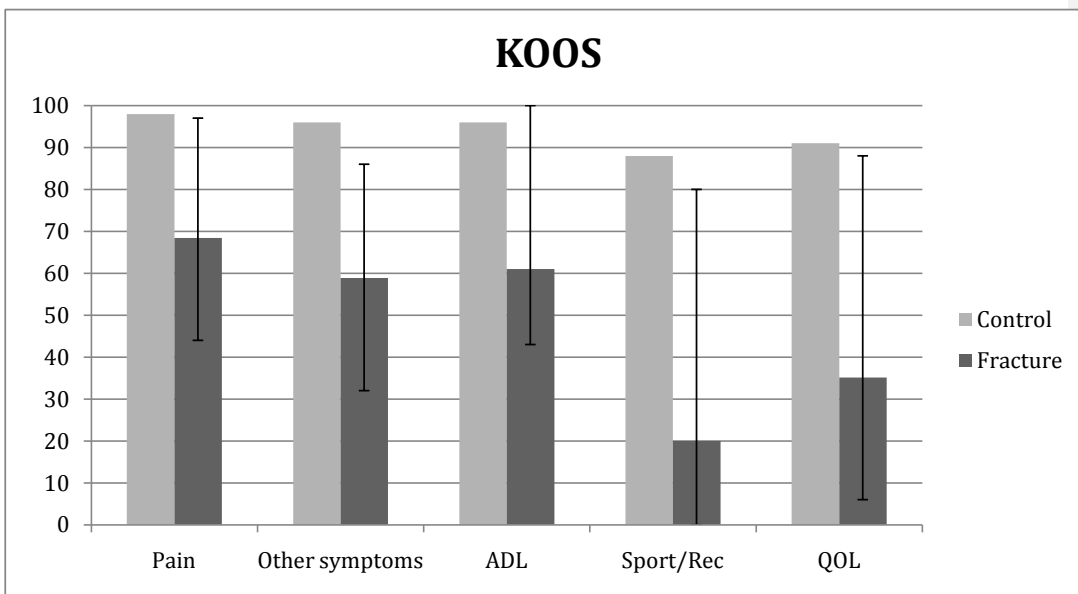


Figure 2



The bars in the fracture columns show minimum and maximum score.

Table 1 Background-data and treatment

Patient nr	Age	Sex	Fracture type	Mechanism of injury	ISS	Open/Closed	Ipsilateral injury	Hoffa fracture	Time to primary operation	Ex-fix	CPM	Time at rehabilitation centre
1	34	M	C1	Fall from 4 m	9	Closed		No	<24 h	No	No?	1.5 months
2	37	F	C2	Car	18	Open 3A	Tibia plateau fracture, Calcaneal fracture	Yes	16 days	Yes	Yes	4 months
3 right	61	F	C2	Car	34	Open 3A		No	5 days	Yes	Yes	6 months
3 left			C3			Open 3A		Yes	5 days	No	Yes	6 months
4	60	M	C2	Car	25	Closed	Proximal tibia fracture	No	2 days	Yes	No?	4.5 months
5	41	F	C3	Car	10	Open 3A		Yes	6 days	Yes	Yes	2 months
6	48	M	C2	Car	17	Closed		No	2 days	No	No?	None
7	32	M	C2	MC	9	Open 3A	Lisfranc fracture dislocation	No	15 days	Yes	No?	1 month
8	32	F	C3	Car	22	Open 3A		Yes	10 days	Yes	Yes	In rehabilitation at follow up
9	47	M	C3	MC	9	Open 3A	Fracture of the tibia	Yes	14 days	Yes	Yes	1 month
10	32	F	C2	Parachute	9	Open 3A		No	5 days	Yes	Yes	13 months

CPM: Continuous passive motion

Table 2 Complications, reoperations and outcome

Patient nr	Follow up time (months)	Complication	Reoperation	Time from initial surgery to reoperation (months)	ROM	Loss of limb length (mm)	Kellgren-Lawrence	6-min walk test (m)	One leg stance (injured/non-injured, sec)	SF-36 Role physical (ref 78)	SF-36 Physical function (ref 87)	Schatzker-Lambert
1	12				0-78	0	1	240	0/30	0	83	Failure
2	32	Pain do to implant	Metal removal	22	0-95	5	3	135	0/30	0	60	Fair
3 left	43				0-82	0	3	148	10/0	100	83	Failure
3 right	43	Delayed/non-union	Removal of old LISS, new inserted. Reconstruction plate medial side. Bone graft.	29	10-73	0	1	148	10/0	100	83	Failure
4	43	Mal-union	Correcting osteotomy ipsilateral tibia	11	0-135	20	3	507	30/30	50	73	Good
5	45				0-120	5	2	602	30/30	0	53	Good
6	10	Screw penetration to joint	Metal removal, screws only	4	17-110	10	3	634	0/30	0	50	Failure
7	12				0-129	10	0	613	30/30	0	50	Fair
8	8	Delayed/non-union			0-105	0	0	255	0/17	0	53	Fair
9	47	Delayed/non-union	Metal removal, insertion of intramedullary nail.	no data	0-65	50	4	360	0/30	25	50	Failure
10	25	Mal-union/infection	Wound revision. Osteotomy.	22	0-72	5	1	648	30/30	0	43	Failure