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ORIGINAL PAPER

Chang-Wug Oh · Jong-Keon Oh · Woo-Kie Min · In-Ho Jeon · Hee-Soo Kyung · Hyung-Soo Ahn · Byung-Chul Park · Poong-Taek Kim

Management of ipsilateral femoral and tibial fractures

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Abstract This is a retrospective study of 18 patients who had ipsilateral femoral and tibial fractures. They were treated by the retrograde femoral and antegrade tibial intramedullary nail from a single incision in the knee. The average time for union of femoral shaft fractures was 27.6 (18–40) weeks. One patient required antegrade nailing with a bone graft due to metal failure after using the short nail. Two tibial fractures required bone grafting due to bone loss, with an initial open fracture. The average time for union of tibial fractures was 24.5 (18–30) weeks. Functional results using the Karlstrom–Olerud criteria were excellent in 14, good in three, and acceptable in one. The only acceptable result was in a supra- and inter-condylar femoral fracture, with protrusion of the nail tip into the knee joint, which created moderate limitation of knee motion. Simultaneous retrograde femoral and antegrade tibial nailing with a single incision in the knee can achieve satisfactory results in the management of these types of fracture.

Résumé Etude rétrospective de 18 patients qui avaient une fracture fémorale et tibiale ipsilatérales. Ils ont été traités par enclouage centromédullaire rétrograde fémoral et enclouage antérograde tibial, en utilisant une seule incision sur le genou. Le temps moyen de consolidation des fractures diaphysaires fémorales était de 27,6 (18–40) semaines. Un malade a nécessité un enclouage antérograde avec greffe osseuse à cause de l'échec dû à l'utilisation d'un clou trop court. Deux fractures tibiales ont nécessité une greffe osseuse à cause de la perte de substance dûe à une fracture ouverte initiale. Le temps moyen de consolidation des fractures tibiales était de 24,5 (18–30) semaines. Les résultats fonctionnels, avec les critères de Karlstrom–Olerud étaient excellents dans 14 cas, bon dans trois et médiocre dans un cas. Le seul résultat médiocre était aprés une fracture sus et intercondylienne fémorale, avec issue de l'extrémité du clou dans l'articulation du genou, créant une limitation modéré de la mobilité. L'enclouage simultané rétrograde fémoral et antérograde tibial avec une seule incision sur le genou peut donner des résultats satisfaisants dans la gestion de ces fractures.

This study was conducted at Kyungpook National University Hospital, Daegu, Korea.

C.-W. Oh (✉) · W.-K. Min · I.-H. Jeon · H.-S. Kyung · H.-S. Ahn · B.-C. Park · P.-T. Kim
Department of Orthopedic Surgery,
Kyungpook National University Hospital,
50, Samdok, Chung-gu,
Daegu, 700-721, South Korea
e-mail: cwoh@knu.ac.kr
Tel.: +82-53-4205628
Fax: +82-53-4226605

J.-K. Oh
Department of Orthopedic Surgery,
Ehwa University Hospital (Dong-Dae Moon),
Seoul, South Korea

Introduction

Treatment recommendations have varied for ipsilateral femoral and tibial fractures. Although earlier reports favoured non-operative treatment, poor results, such as non-union or malunion, have been reported with such treatment [8, 18]. Aggressive, early stabilisation of both fractures is important to prevent systemic complications in polytrauma patients, such as a floating-knee injury [3, 8, 10]. This is most commonly achieved via the intramedullary fixation of femur and tibia [18, 19]. Retrograde femoral nailing is beneficial in achieving a quicker and easy stabilisation of the floating-knee injury. The purpose of this study was to describe efficacy and results of ipsilateral femoral and tibial fractures treated by retrograde femoral and antegrade tibial nailing with a single incision in the knee.

Materials and methods

Patients

From 1January 1999 to December 2003, 19 patients with ipsilateral femoral and tibial fractures were treated at Kyungpook National University Hospital. With the excep-

tion of one patient who died after operation, 18 patients were included in this study. Road traffic accidents accounted for all cases.

Surgical procedures

The procedure is performed after adequate resuscitation and stabilisation of the injured patient, especially in patients with a high Injury Severity Score [2] and other associated injuries. The patient is placed on a radiolucent operating table, and the injured extremity is placed on the height-adjustable Mayo-stand table after draping from the iliac wing to the toes.

When considering the order of operation, the grade of the open fracture and the necessity for fasciotomy in a swollen leg are the main factors. Otherwise, the tibial fracture is usually addressed first, as the surgeon's preference. By palpating the subcutaneous anterior border of the tibia after reduction, it is relatively easy to check the rotation of the tibia. However, the "rule of thumb" (such as cortical step sign or diameter different sign) is the only method for checking the rotation of the femur [9].

An incision is made in the mid-line of the palpable patellar tendon. It starts at the inferior pole of the patella and ends at the top of the tibial tubercle. The tibial nail (unreamed tibial nail, Mathys, Switzerland) is then introduced in standard unreamed fashion. After manual reduction, the nail is passed across the fracture site. Two locking screws are placed proximally and distally.

With the knee flexed approximately 40°, a guide pin is inserted in the mid-line through the distal femoral cartilage, just above the intercondylar notch. The pin is checked by lateral fluoroscopy to ensure that it is just above Blumensaat's line. A rigid reamer is used to open the distal femoral metaphysis. An unreamed femoral nail (Mathys, Switzerland) or a retrograde nail (Zimmer, United States) is used without reaming of the diaphysis. Caution is given to the distal end so that it is not over the articular surface. The nail is locked statically. The knee incision is irrigated, and a suction drain is frequently placed into the knee.

Post-operative care

It is important to use early range of motion (ROM) exercises or a continuous passive motion machine in the early post-operative period. Weight bearing progresses as the femoral and tibial callus increases. Routine follow-up radiographs (anteroposterior, lateral and oblique) are obtained every 4 weeks until they show solid continuous callus formation.

All patients undergo a detailed clinical follow-up examination using the Karlstrom and Olerud grading system [8].

Results

There were four women and 14 men with an average age of 34.1 (range, 19–64) years. The average Injury Severity Score [2] was 18.8 (range, 9–38). Fifteen patients had associated injuries, and 12 patients had other fractures in the lower extremities. Two patients had bilateral femoral fractures, and three had bilateral tibial fractures.

Seventeen patients had full knee motion (Figs. 1 and 2). One patient who had a supracondylar–intercondylar femoral fracture had moderate limitation in knee motion. The nail tip extruded over the articular surface in this case. The patient obtained knee flexion to 100° and regained full range of motion after nail removal. Using the Karlstrom and Olerud rating system [8], this patient was graded as having an acceptable result. The other 17 patients were graded as having good (3) or excellent (14) results (Table 1).

Using the system of AO–OTA classification [14] of the femoral fractures, there were six type A, three type B and nine type C fractures. According to the Winquist–Hansen classification [19], there were four type 0, four type I, six

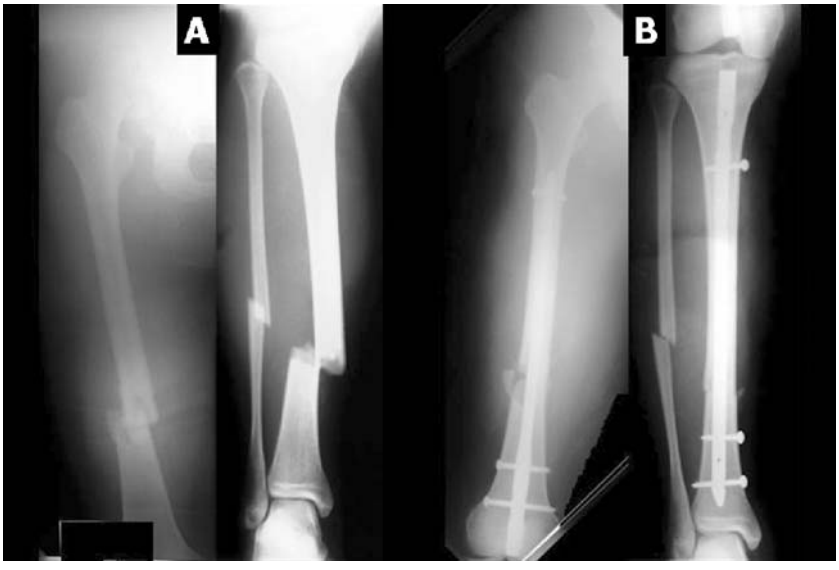

Fig. 1 **a** A 24-year-old woman with ipsilateral femoral and tibial shaft fractures on the right side. **b** She also had a posterior hip dislocation on the same side and a contralateral femoral fracture. Retrograde nailing of the femur and unreamed tibial nailing were performed.

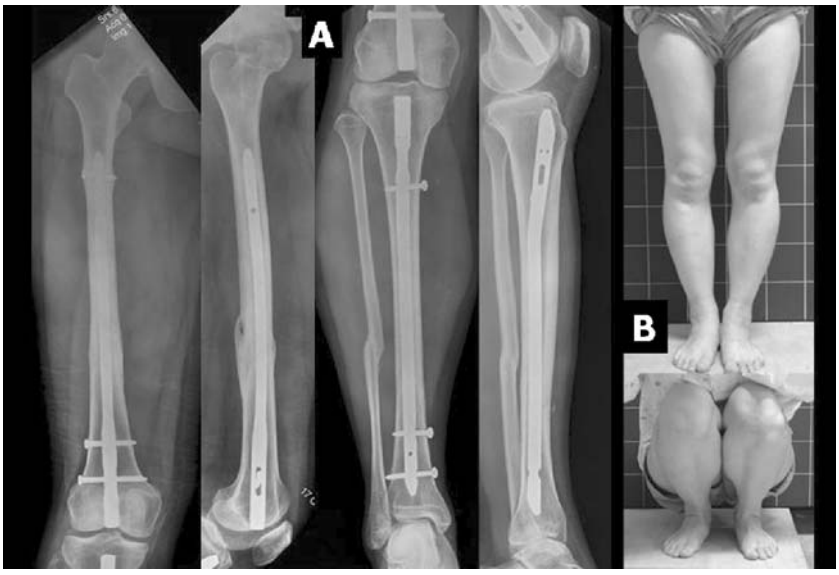

Fig. 2 **a** Bone union of both femur and tibia occurred, with good alignment. **b** Three years later, she had excellent knee function.

type II, one type III and three type IV fractures. There were three grade 1 open fractures [5]. Fifteen fractures were in the middle one-third area, one was in the distal one-third, one was supracondylar and intercondylar and one was subtrochanteric. The subtrochanteric fracture required additional percutaneous plating to aid stability at the time of the nailing procedure. Seventeen of the 18 femoral fractures united. The average time to union of the femoral shaft fractures was 27.6 (range, 18–40) weeks.

Of the tibial fractures, three were in the proximal one-third, 12 were in the middle one-third and three were in the distal one-third. According to the AO–OTA classification,

Table 1 Ipsilateral femoral and tibial fractures treated with retrograde and antegrade nailings from knee. *ISS* Injury Severity Score, *AO–OTA* fracture classification according to AO–OTA, *NA* not available in the calculation of union time, *Knee function* clinical evaluation according to Karlstrom–Olerud criteria, *Knee LOM* in this patient, the tip of the retrograde femoral nail extruded over the articular surface, which caused limited knee flexion of 100°

Number	Age	ISS	Femur fracture			Tibia fracture			Knee function	Complication—its treatment
			Open	AO–O TA	Union time	Open	AO–OTA	Union time		
1	19	9		A	24	2	B	28	Excellent	
2	30	38		A	32	3c	C	NA	Good	Tibia—bone graft
3	26	34		A	20		A	20	Excellent	
4	30	19		A	18		A	18	Excellent	
5	24	14		A	28		A	24	Excellent	
6	32	17		A	28	1	B	28	Excellent	
7	45	22		B	NA		B	22	Excellent	Femur nail failure—nail change and bone graft
8	22	22	1	B	30	2	B	30	Excellent	
9	29	14		B	20		A	20	Excellent	
10	23	27	1	C	24	1	A	20	Excellent	LLD; 7 mm
11	37	27		C	40	1	C	22	Excellent	
12	38	22		C	36	3b	B	28	Excellent	
13	64	9		C	32	1	A	22	Acceptable	Knee LOM
14	54	10		C	28		B	28	Good	
15	26	13		C	36		B	30	Excellent	
16	47	10		C	26	1	C	26	Good	
17	34	13		C	20	2	B	NA	Excellent	Tibia—bone graft
18	35	19	1	C	28	3a	B	26	Excellent	
Mean	34.1 years	18.8			27.6 weeks			24.5 weeks		

Fig. 3 **a** This patient had ipsilateral femoral and tibial fractures with intra-articular extension. **b** Retrograde femoral nailing and antegrade tibial nailing were performed, but the distance from the fracture to the proximal locking screw was too short.

there were six type A, nine type B, and three type C fractures. There were seven closed and ten open tibial fractures. Open tibial fractures were graded as grade 1 (five fractures), grade 2 (three), grade 3A (one), grade 3B (one) and grade 3C (one). One patient required an arterial bypass graft, and one patient required a gastrocnemius muscle flap for coverage. Sixteen tibial fractures united without any secondary procedures. Two patients with initial bone loss required a bone graft in order to achieve union. The average time for the tibial fractures to unite was 24.5 (range, 18–30) weeks.

Non-union developed in one femoral fracture and two tibial fractures. In the case with femoral non-union, there was metal failure with breakage of the nail. It was treated with bone grafting and antegrade nailing (Figs. 3, 4). The tibial non-unions occurred in open fractures with bone loss. They were treated with early bone grafting. In three tibial fractures, there was breakage of the locking screws, but the patients did not have clinical symptoms. One patient had a femoral shortening of 7 mm. There was no mal-union exceeding 10° of angulation or rotation in either fracture. There was no deep infection. But two patients with open tibial fractures experienced a superficial infection, which eventually healed.

Discussion

Concomitant ipsilateral fractures of the femur and tibia, the so-called “floating knee”, are important because of high mortality with associated injuries [16, 18]. The mortality rates from floating knees range between 5% and 15%, and amputations are reported in approximately 25% of patients [16, 17]. In this study, there was one death and one vascular injury. The average Injury Severity Score was 18.8, which is similar to those reported previously. The high rate of open fractures in the current series also shows that these

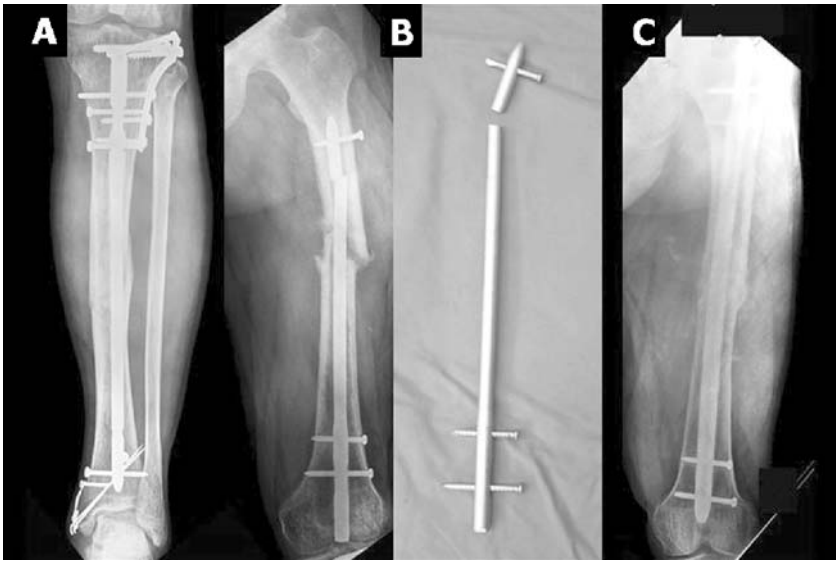

Fig. 4 **a** Nine months after the operation, although the tibia was well healed, **b** the femoral nail was broken with non-union. **c** Exchange nailing with a bone graft was performed.

combined fractures were more severe than just the bony injuries.

Operative treatment has both systemic and musculoskeletal benefits, and has resulted in fewer systemic complications and better functional outcomes than conservative treatment [4, 6]. Immediate or early fixation of the femoral fracture stabilises the patient's condition and permits early mobilisation, thus reducing the possibility of adult respiratory distress system (ARDS) or fat embolism [7]. This allows for the early assessment of the knee joint and prevents knee stiffness. It is noteworthy that there were no cases of post-operative fat embolism in our series.

Intramedullary nailing of both femoral and tibial fractures has been preferred to external fixation, which is a more demanding method and has more complications. The severity of soft-tissue injury in the tibia is known as one of the important predictive factors of the outcome [20]. Using un-reamed nailing, the union rate of tibial fractures was excellent in our series and the complication rate low, nevertheless with a high percentage of open fractures. We think that intramedullary nailing has certain advantages over external fixation. It provides better reduction, allows for early weight bearing, and requires fewer secondary operations, without increasing the risk of infection.

Standard antegrade nailing is generally accepted in femoral fractures. The floating-knee injury, which has a higher incidence of associated injuries, benefits from a quick procedure that has no adverse effects from positional change to the chest, spine or abdominal area. From this viewpoint, the retrograde femoral nailing technique used in our study would seem to be attractive in the management of ipsilateral fractures of the femur and tibia [11, 15], as it reduces intra-operative patient manipulation and overall operative time. We found no residual symptoms or functional impairment after retrograde nailing although there had been concerns regarding impaired knee function due to possible damage to the articular surface of the knee [12].

The final outcome of ipsilateral femoral and tibial fractures of earlier studies have shown many un-favourable results [10, 16, 18]. In this study, however, 94% of the patients had good or excellent results. This is similar to other studies using intra-medullary nailing of both fractures, regardless of whether the femoral nailing is done by an antegrade or retrograde technique [4, 15].

In the contributing factors to the functional outcome of floating-knee injuries, involvement of the knee joint is an important factor [16, 20]. The only result that was classified as 'acceptable' in our study also had an intra-articular fracture of the distal femur. We think that retrograde nailing is not suitable for the very distal femoral fracture, which was partly responsible for the poor outcome. Otherwise, our study has shown that this technique can provide positive results for diaphyseal femoral fractures and confirms other reports [1, 4].

In this study, most femoral and tibial fractures had primary union without a secondary procedure. Only one femoral fracture had non-union due to metallic failure. This was one of the earlier cases of our study, which was thought to include the technical mistake of using a short nail. It is recommended that the tip of the nail reaches the level of the lesser trochanter [11] when using retrograde femoral nailing.

In comparison with femoral fractures, the tibia seemed to have more problems with non-union and infections [4]. It is documented that the tibial fracture generally is a more severe injury that includes a higher prevalence of open fractures. Unreamed nailing of the tibial fracture, used in our series [13], decreased the complication rate. We also achieved favourable results although more than one-half of the tibial fractures were open.

The treatment of patients with ipsilateral femoral and tibial fractures using retrograde femoral and antegrade tibial nailing with a single incision showed high union rates and a positive functional outcome.

References

1. Anastopoulos G, Assimakopoulos A, Exarchou E, Pantazopoulos T (1992) Ipsilateral fractures of the femur and tibia. Injury 23:439–441
2. Baker SP, O'Neill B, Haddon W Jr, Long WB (1974) The Injury Severity Score. A method for describing patients with multiple injuries and evaluating emergency care. J Trauma 14:187–196
3. Bone LB, Johnson KD, Weigelt J, Scheinberg R (1989) Early versus delayed stabilization of femoral fractures. A prospective randomized study. J Bone Joint Surg Am 71:336–340
4. Gregory P, DiCicco J, Karpik K, DiPasquale T, Herscovici D, Sanders R (1996) Ipsilateral fractures of the femur and tibia: treatment with retrograde femoral nailing and unreamed tibial nailing. J Orthop Trauma 10:309–316
5. Gustilo RB, Anderson JT (1976) Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: retrospective and prospective analyses. J Bone Joint Surg Am 58:453–458
6. Hee HT, Wong HP, Low YP, Myers L (2001) Predictors of outcome of floating knee injuries in adults: 89 patients followed for 2–12 years. Acta Orthop Scand 72:385–394
7. Johnson KD, Cadambi A, Seibert GB (1985) Incidence of adult respiratory distress syndrome in patients with multiple musculoskeletal injuries: effect of early stabilization of fractures. J Trauma 25:375–384
8. Karlstrom G, Olerud S (1977) Ipsilateral fractures of the femur and tibia. J Bone Joint Surg Am 59:240–243
9. Krettek C, Miclau T, Grun O, Schandelmaier P, Tscherne H (1998) Intraoperative control of axes, rotation and length in femoral and tibial fractures. Technical note. Injury 29(Suppl 3): C29–C39
10. McAndrew MP, Pontarelli W (1988) The long-term follow-up of ipsilateral tibial and femoral diaphyseal fractures. Clin Orthop 232:190–196
11. Moed BR, Watson JT (1995) Retrograde intramedullary nailing, without reaming, of fractures of the femoral shaft in multiply injured patients. J Bone Joint Surg Am 77:1520–1527
12. Morgan E, Ostrum R, DiCicco J, McElroy J, Poka A (1999) The effects of a retrograde intramedullary nail on the patello–femoral articulation. J Orthop Trauma 13:13–16
13. Oh CW, Park BC, Ihn JC, Park HJ (2001) Primary unreamed intramedullary nailing for open fractures of the tibia. Int Orthop 24:338–341
14. Orthopaedic Trauma Association Committee for Coding and Classification: Fracture and Dislocation Compendium (1996). J Orthop Trauma 10(Suppl 1): v–ix, 1–154
15. Ostrum R, DiCicco J, Lakatos R, Poka A (1998) Retrograde intramedullary nailing of femoral diaphyseal fractures. J Orthop Trauma 12:464–468

16. Paul GR, Sawka MW, Whitelaw GP (1990) Fractures of the ipsilateral femur and tibia: emphasis on intra-articular and soft tissue injury. J Orthop Trauma 4:309–314
17. Theodoratos G, Papanikolaou A, Apergis E, Maris J (2001) Simultaneous ipsilateral diaphyseal fractures of the femur and tibia: treatment and complications. Injury 32:313–315
18. Veith RG, Winquist RA, Hansen ST (1984) Ipsilateral fractures of the femur and tibia. A report of fifty-seven consecutive cases. J Bone Joint Surg Am 66:991–1002
19. Winquist RA, Hansen ST, Clawson DK (1984) Closed Intramedullary nailing of femoral fractures: a report of 520 cases. J Bone Joint Surg Am 66:529–539
20. Yokoyama K, Tsukamoto T, Aoki S, Wakita R, Uchino M, Noumi T, Fukushima N, Itoman M (2002) Evaluation of functional outcome of the floating knee injury using multivariate analysis. Arch Orthop Trauma Surg 122:432–435