

# The role of biological fixation with bridge plating for comminuted subtrochanteric fractures of the femur

## Parçalı subtrokanterik femur kırıklarında köprü plaklama ile biyolojik tespitin rolü

Cemil KAYALI,<sup>1</sup> Haluk AĞUŞ,<sup>1</sup> Gürhan ZİNCİRCİOĞLU<sup>2</sup>

### BACKGROUND

The surgical outcomes of comminuted subtrochanteric fractures result in high incidence of nonunion and malunion due to high energy trauma. Biological fixation offers decrease in these complications while preserving soft tissue vascularity. The aim of this study was to evaluate the results of patients treated with bridge plating for comminuted subtrochanteric femoral fractures retrospectively.

### METHODS

Ten patients with comminuted subtrochanteric femoral fractures between 1996 and 2002 were included into this study. All patients were male and mean age was 46±15.2 years (range: 29-76 years). Six patients had C-3-1 and four patients had C-3-2 type fractures according to AO/OTA classification. Bridge plating under fluoroscopy control, according to biological fixation principles was carried out on all patients. Pain, walking capacity, functionality, motion, daily activities, radiological assessment for Sander's criteria and shaft-neck angles of both fractured and the other sides were recorded for statistical analysis, at the last follow-up.

### RESULTS

Mean follow-up period was 62±20.9 months (range: 37-104 months). Partial and full weight-bearing were recommended at an average period of 3.3±1.1 (range: 1.5-4.5 months) and 4.8±1 months (range: 3-6 months) respectively (range: 3-6 months). There were eight excellent (80%), one good (10%) and one poor (10%) results according to Sanders' criteria. There was no statistically significant difference between the healthy and fractured sides with respect to femoral shaft-neck angles.

### CONCLUSION

We have concluded that biological fixation applied with bridge plating offered an alternative method in the treatment of comminuted subtrochanteric femoral fractures.

**Key Words:** Biological fixation; comminuted fracture; femur; retrospective studies; subtrochanteric femur.

### AMAÇ

Parçalı subtrokanterik kırıklar, yüksek enerjili yaralanma olmalarından dolayı cerrahi tedavi sonrası yüksek kaynamama ve kötü kaynama riski taşırlar. Biyolojik tespit yumuşak doku kanlanmasını korurken, bu komplikasyonları azaltmayı hedefler. Bu çalışmada amaç, parçalı subtrokanterik kırıklı olguların köprü plaklama sonrası geriye dönük olarak sonuçlarını değerlendirmektir.

### GEREÇ VE YÖNTEM

1996-2002 yılları arasında parçalı subtrokanterik kırıklı 10 olgu çalışmaya dahil edildi. Tüm olgular erkekti, ortalama yaş 46±15,2 yıl (dağılım 29-76) idi. AO/OTA sınıflamasına göre altı olguda C-3-1, dört olguda C-3-2 tip kırık mevcuttu. Tüm olgulara floroskopi kontrolünde biyolojik tespit kurallarına uygun köprü plaklama uygulandı. Son kontrolde Sander's kriterleri için, ağrı, yürüme kapasitesi, fonksiyonel durum, hareket, günlük aktiviteler, radyolojik değerlendirme, kırık ve sağlam taraf femur boyun-cisim açıları ölçüldü.

### BULGULAR

Ortalama izleme süresi 62±20,9 aydı (dağılım 37-104). Kısmi yüklenme ortalama 3,3±1,1 ayda (dağılım 1,5-4,5), tam yüklenme ortalama 4,8±1 ayda (dağılım 3-6) önerildi. Sander's kriterlerine göre sekiz çok iyi (%80), bir iyi (%10) ve bir kötü (%10) sonuç saptandı. Femur boyun-cisim açıları bakımından kırıklı ve sağlam taraflar arasında anlamlı fark saptanmadı.

### SONUÇ

Parçalı subtrokanterik femur kırıklarının tedavisinde, köprü plaklama ile uygulanan biyolojik tespitin alternatif bir yöntem olduğunu düşünüyoruz.

**Anahtar Sözcükler:** Biyolojik tespit; femur; parçalı kırık; retrospektif çalışma; subtrokanterik femur.

<sup>1</sup>Department of Orthopedics and Traumatology, Tepecik Training and Research Hospital, İzmir; <sup>2</sup>Department of Orthopedics and Traumatology, Tire State Hospital, İzmir, Turkey.

<sup>1</sup>Tepecik Eğitim ve Araştırma Hastanesi, Ortopedi ve Travmatoloji Kliniği, İzmir; <sup>2</sup>Tire Devlet Hastanesi, Ortopedi ve Travmatoloji Kliniği, İzmir.

Comminuted subtrochanteric femoral fractures are high-energy injuries in adults. The continuity of the medial cortex is disrupted due to the injury and this discontinuity is leading to important biomechanical consequences. In the proximal part of the femur the medial cortex is subjected to compressive loads and the lateral cortex to tensile forces during weight bearing. Comminution of medial cortex may lead difficulty in anatomic reconstruction of this area. The blood supply of the comminuted fragments may be compromised in subtrochanteric region with predominantly cortical bone which has less healing capacity than metaphyseal region. Therefore, one should consider the biomechanics of mechanism of injury and preoperative plan for stability based on those assumptions.<sup>[1-3]</sup>

Minimally invasive surgery performed via limited incisions and providing axial and torsional alignment of the fractured extremity without damaging vascularity of comminuted fractures should be considered as an alternative treatment in comparison with traditional fixation methods.<sup>[4-6]</sup> Minimal invasive surgery provides relative stability and less surgical trauma that result in rapid healing of the fracture. Bridge plating method applied with minimally invasive surgery principles is one of these approaches.<sup>[7,8]</sup>

The purpose of our study was to evaluate the functional and radiological outcomes of comminuted subtrochanteric femoral fractures treated via bridge plating.

## MATERIALS AND METHODS

Ten patients who were treated between 1996-2002 years were enrolled into this study. All patients were male and mean age was  $46 \pm 15.2$  years (range: 29-76 year). The fractures were sustained in traffic accidents in seven and falls from a great height in two cases. One fracture was the result of an occupational accident. One patient had an additional injury as third-degree open fracture and 3-4 metatarsal fractures at the ipsilateral tibia. Six of the subjects (60%) had C-3-1 and four of them (40%) had C-3-2 type fractures according to AO/OTA classification.<sup>[9]</sup>

All patients had subjected to preoperative femoral supracondylar skeletal traction following routine radiographic examination upon admission to emergency room. The patients were kept in traction until their conditions were stabilized and appropri-

ate for an operation. Prior to the operation femoral X-ray examinations of the healthy extremity were also obtained to decide on a suitable plate type and length. Average time from admission to surgery was  $9.5 \pm 5.5$  days (range: 6-25 day). A 135° dynamic hip screw was utilized in five of the subjects; 95° dynamic condylar screw was used in three of the subjects, 95° bladed plate in one of them and LC-DCP in another one.

### Surgical technique

All the operations were performed on standard operating table. In order to allow access to the image intensifier the patient was placed in the supine position. The drapes were arranged properly to control length and position of the patella intraoperatively. Longitudinal traction was applied to the extremity. After observing satisfactory reduction and defining the correct size of the plate on the fluoroscopy equipment, we used two different techniques depending on the type of fixation material.

*a) Fixation with dynamic hip or condylar screw and blade plate:* When we determined the correct entry point for screw under fluoroscopy control, an incision about 4-5 cm long was done. After subcutaneous dissection, guide wire and screw were put into the femoral neck. Then the plate was introduced from proximal to distal facing to the surgeon, beneath the muscle and over the periosteum, without stripping the surrounding soft tissues of the fracture. Then a distal mini-incision and exposure were done. At this moment, the traction was released and plate was rotated 180°. If the traction was not released, surgeon was in difficulty while rotating the plate. Then plate was engaged with screw and traction was done again. The proximal part of the femur was fixed to the plate. Positions of the fracture, length of extremity, axial and rotational alignment were re-checked on the fluoroscopy equipment, then the plate was fixed to the distal femur through distal incision. Cable test, trochanter minor and hip rotation tests, defined for minimal invasive surgery, were performed during this inspection.<sup>[8]</sup> For the blade plate case, correct site of entry point of blade was prepared in the proximal femur with starter and the plate was advanced from proximal to distal facing to the surgeon. The plate was then rotated and fixed on the distal end bone by applying traction and then it was placed into the proximal access si-

**Table 1.** Results of patients

No	Age	Sex	Etiology	Operation time (min.)	Additional injury	Follow-up (months)	ROM (flex.-ext.)		SNA		Late complication	Functionality
							Injured	Healthy	Injured	Healthy		
1	41	M	Traffic accident	72	–	37	145	145	133	134	–	Excellent
2	58	M	–	205	Ipsilateral 3rd degree open tibial fx., 3-4 metatarsal fx.	75	120	140	129	136	2 cm shortening moderate limitation of hip and knee	Good
3	58	M	–	80	–	51	140	140	135	135	–	Excellent
4	30	M	–	98	–	53	145	145	135	137	–	Excellent
5	33	M	Occupational accident	100	–	49	135	135	134	136	–	Excellent
6	47	M	Traffic accident	62	–	72	130	135	131	131	–	Excellent
7	29	M	Fell down	75	–	104	135	140	130	131	–	Excellent
8	35	M	Traffic accident	96	–	40	135	135	132	134	–	Excellent
9	53	M	–	100	–	82	140	145	133	136	–	Excellent
10	76	M	Fell down	92	–	57	130	145	100	130	Plate bending 2.5 cm shortening	Poor

ROM: Range of motion; SNA: Shaft neck angle; M: Male.

te. At least four cortical screws were used in the distal femur and as many as the fracture allowed in the proximal end of the femur.

*b) While using LC-DCP or anatomical plates there was no need for rotation of the plate:* They were inserted on to bone in correct position. First the plate was sledged from proximal incision to distal over the periosteum. Traction was applied and when satisfactory reduction was observed on fluoroscopy device plate was fixed to femur first proximally and second distally.

We also fixed the plate to the bone near the fracture site through stab incisions to shorten the moment arm. For this reason, we used the same length plate to determine screw entry points. The second plate was laid on to skin beginning with the first plate's end point. Then the screw holes were determined by using the Kirschner wires. At this stage, cannulated perforator was used and screws were put through into the protector canula.

The average operation time was  $98 \pm 39.8$  minutes (62-205 minutes). The case with the 205 minutes of operation time underwent another surgical intervention at the same time because of an open tibia fracture and metatarsal fractures. All the patients received prophylactic antibiotics for two days and low molecular weight heparin for seven days. None of the subjects needed post-operative additional fixation. An isometric quadriceps exercise prog-

ram was initiated on the post-operative first day and the patients were mobilized with the help of crutches. Partial weight-bearing was allowed when callus was observed on fracture line in a single plane X-ray image and full weight-bearing upon observation of callus in two plane X-rays images. Radiographs were obtained immediately after the operation and 1.5, 3, 6 and 12 months after the operation, as well as at the final control (Fig. 1a, b). Hip and knee range of motion, length of both lower extremities and femur shaft-neck angle (SNA) were measured at the final visit (Table 1). Mann-Whitney U-test was used for statistical evaluation. Statistical analyses were performed using SPSS for Windows version 9.0.

## RESULTS

The mean follow-up period was  $62 \pm 20.9$  months (range: 37-104 months). The patients were hospitalized for an average of  $20 \pm 5.1$  days (range: 14-33 days). This hospitalization time comprised of preoperative skeletal traction and postoperative rehabilitation program including continuous passive motion (CPM) device and active exercises. Partial weight-bearing was recommended for the patients who were observed to have callus tissue clinically and radiographically during control examination, at an average of  $3.3 \pm 1.1$  months (range: 1.5-4.5 months). Full weight-bearing was commenced at an average of  $4.8 \pm 1$  months (range: 3-6 months). Ave-



**Fig. 1.** (a) Male, 33 year-old, radiography prior to operation. (b) Forty-ninth month post-operative follow-up, final stage radiography.

rage time to return to work was  $6.4 \pm 0.9$  months (range: 5-8 months) for the seven subjects with employment.

Union was achieved in all of the fractures. Bone union was defined as the visualization of callus bridge on 3 planes radiologically, and as painless full weight-bearing clinically. Deep infection occurred on the 18th day post operation in the case with ipsilateral open tibia and metatarsals fractures. Methicillin-resistant *Staphylococcus aureus* (MRSA) was isolated at the wound culture. Lavage-debridement with case-sensitive antibiotherapy was begun. Although the drainage was reduced, it did not disappear completely. The fixation devices were removed at the 28th month post-index surgery. This patient had 2 centimeters of shortening and moderate limitation in knee and hip movements on the final visit. Then, it was also observed that the drainage and the infection had completely disappeared. This case was accepted as a good result. Due to full weight bearing without crutches, loss of reduction was observed in one case although all our warnings. Re-operation was proposed but was not accepted. The subject had an approximate angulation of thirty degrees. Collo-diaphyseal angle was 100 degrees. He had a second-

dary complication due to angulation, in the form of shortening of 2.5 centimeters. It was accepted as poor result.

We did not perform grafting on any of the subjects and postoperative splints or fixators were not used. As it was shown in Table 1, shaft-neck angle (SNA) and range of motion of the hip joint (ROM) of the injured and healthy sides were measured at the last follow-up, and there was no significant difference between them ( $p > 0.05$ ). Sanders' traumatic hip index for subtrochanteric fractures was used for clinical assessment.<sup>[10]</sup> Eight cases were observed with excellent (80%), one case with good (10%) and one case (10%) with poor outcomes.

## DISCUSSION

The manner in which the comminuted subtrochanteric femoral fractures are sustained and their treatment biomechanics are factors determining the outcome. When the medial cortex is under compression forces, the lateral cortex is subjected to tensile forces. Therefore, the fixation device should be of the correct type and shape to bear these forces.<sup>[2,11,12]</sup> In Wenda's study, it was proposed that a long plate biologically applied though the lateral side better

strengthen the lateral cortex against tensile forces and decrease the fixation device deficiency risk. Sufficient time is available to develop supportive effect as the load per unit is less. It was reported that the good results, obtained with minimal invasive percutaneous plating, could be explained by rapid fracture healing due to preserved blood supply. For comminuted fractures affecting the large part of the femur, insertion of the plate using mini skin incisions minimizes surgical trauma.<sup>[13]</sup>

Intramedullary nails have been considered the technique of choice for addressing simple type subtrochanteric femoral fractures throughout the literature.<sup>[14,17]</sup> However, various problems have been met in intramedullary nail applications especially in AO classification type C fractures.<sup>[3,18,19]</sup> Although results have been satisfactory for stable or non-fragmented fractures, various complications have been encountered in comminuted fractures, such as non-union, delayed union, varus deformity, peroneal nerve paralysis, shaft fracture during surgery, fracture of the trochanter major, perforation in the femoral neck or knee joint and fixation device breakage.<sup>[16,20,21]</sup> Bergman observed that five subjects out of the 131 subtrochanteric femoral fracture cases he treated had non-union. All of the fractures were unstable, comminuted and had a posteromedial butterfly fragment. Nail breakage and varus deformity were among the complications encountered.<sup>[3]</sup> Kempf performed closed intramedullary nailing on 49 comminuted femoral fractures and observed delayed union in five of the cases for various reasons.<sup>[15]</sup>

Amount of protection through the stability provided with biological plating and might be given to the femur which is subjected to a large amount of load has been a major concern. Intramedullary nails offer higher stability to take on greater loads particularly for the cases with fracture in the medial cortex. Therefore, hardware failure risk exists for biological plating. Ruling out hardware failure is the major advantage of biological plating, since callus develops rapidly in the postoperative phase.<sup>[4,22]</sup> However, one case in our study had a plate bending problem due to premature weight-bearing against our advice which resulted in poor clinical consequences.

Kinast, who compared the treatment options for subtrochanteric fractures with direct and indirect reduction, utilized condylar blade plate for both groups. In the direct reduction group 16.6% non-

union and 20.8% infection problems were observed. Thus, fewer complications and better healing time was reported in the indirect reduction cases.<sup>[11]</sup> Many authors published their results concerning biological fixation in comminuted femoral subtrochanteric fractures after the 1980's. They all reported that union was achieved in 4-5 months in general and there was no complication regarding union and infection.<sup>[1,8,23]</sup> Some authors observed that even the use of grafting had no effect on the consequence.<sup>[23]</sup> However, one detriment of those studies was the fact that type A and B fractures according to AO classification were also enrolled. Union in type A fractures in particular is considerably faster than that of those in group C. Therefore, mean healing time, if it is not given exclusively for a homogenous fracture type, can be misleading. As a result, we have only enrolled type C 3-1 and C 3-2 fractures in our study.

Fracture healing was acquired for all cases in the study group and mean bone healing time was 4.8 months. Two patients had shortening. Only one case had moderate limitation in hip and knee motion. Also in that case early infection developed but it was treated with preventive therapy. The patients' shaft-neck angles for both hips were compared. There was no significant difference between the healthy and fractured side ultimately. Therefore, it was concluded that the patients who were treated with biological fixation achieved a close-to-normal anatomy following surgery and maintained this state throughout the follow-up period. When the subjects were assessed with Sanders' traumatic hip index, eight cases were observed with excellent (80%), one case with good (10%) and one case (10%) with poor clinical outcomes. It was noted that these results corresponded well with those of similar fracture groups in the literature.<sup>[23-26]</sup>

In conclusion, it is more difficult to establish a treatment approach in unstable fractures such as type C. Bridge plating is an approach to be considered for the treatment of patients with limited indications. We believe biological fixation can help patients to return to their daily routines presently by assuring rapid bone healing and decreased infection rates.

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