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Minimally invasive plate osteosynthesis in the treatment of femur fractures due to gunshot injuries

Ateşli silah yaralanması sonucu oluşan femur kırıklarının minimal invaziv plaklama tekniği ile tedavisi

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Amaç: Bu çalışmada, ateşli silahla yaralanma sonucu oluşan açık parçalı femur kırıklarının indirekt redüksiyonla tedavisi değerlendirildi.

Çalışma planı: Ateşli silahla yaralanma sonucu oluşan açık parçalı femur kırığı nedeniyle tedavi edilen 17 hasta (15 erkek, 2 kadın; ort. yaş 34; dağılım 15-67) geriye dönük olarak incelendi. Kırıklar AO sistemine göre sınıflandırıldı. Minimal invaziv perkütan plaklama yönteminin erken veya geç dönemde uygulanmasına karar verilirken Gustilo-Anderson açık kırık sınıflaması temel alındı. Kırıkların yedisi subtrokanterik, yedisi suprakondiler, üçü diyafiz bölgesindeydi. Vasküler patolojisi olan iki hastaya eksplorasyon ile birlikte damar tamiri uygulandı. Nörolojik yaralanması olan iki hastada sinir eksplore edilmedi. Yedi hasta erken dönemde ortalama 1.3 günde (dağılım 1-2 gün), 10 hasta geç dönemde ortalama 11.1. günde (dağılım 7-15 gün) ameliyat edildi. Ortalama izlem süresi 25 ay (dağılım 14-42 ay) idi.

Sonuçlar: On altı hastada ortalama 4.4 ayda (dağılım 2.5-7 ay) kaynama elde edildi. Dört hastada kavitasyon ve defekt görülmesi üzerine geç dönemde primer, bir hastada dördüncü ayda kaynama gecikmesi üzerine sekonder otojen kemik grefti uygulandı. Ameliyat sonrası dönemde komplikasyon olarak bir olguda (%5.9) yüzeyel enfeksiyon, bir olguda derin enfeksiyon, sekiz olguda (%47.1) 0.5-2 cm arasında ekstremite eşitsizliği ve ortalama 5° (3-8°) varus-valgus açılanması gözlendi. İzlem süresince tekrarlayan kırık görülmedi.

Çıkarımlar: Ateşli silah yaralanması ile oluşan tip IIIA ve tip IIIB açık femur kırıklarında minimal invaziv perkütan plakla tespit yönteminin uygun bir tedavi seçeneği olduğunu düşünüyoruz.

Anahtar sözcükler: Kemik plağı; femur kırığı/etyoloji/cerrahi; kırık fiksasyonu, internal/yöntem; cerrahi prosedür, minimal invaziv/yöntem; yaralanma, ateşli silah/fizyopatoloji/cerrahi.

Objectives: The results of treatment with minimally invasive plate osteosynthesis were evaluated in open comminuted femur fractures due to high-velocity gunshot injuries.

Methods: Seventeen patients (15 males, 2 females; mean age 34 years; range 15 to 67 years) with open comminuted femur fractures due to high-velocity gunshot injuries were included. The fractures were classified according to the AO system. Timing of minimally invasive percutaneous plate fixation was determined according to the classification of open fractures in the Gustilo-Anderson system. There were seven subtrochanteric, seven supracondylar, and three diaphyseal fractures. During surgical exploration, two patients underwent vascular repair for related pathologies. No exploration was performed in two cases with neurological damage. Seven patients were operated on in the early period (mean 1.3 days; range 1 to 2 days) and 10 patients in the late period (mean 11.1 days; range 7 to 15 days). The mean follow-up was 25 months (range 14 to 42 months).

Results: Union was obtained in a mean of 4.4 months (range 2.5 to 7 months) in 16 patients. Autogenous grafting was performed in four patients who presented with a cavitation and defect in the late period and in one patient due to delayed union in the postoperative fourth month. Complications included superficial infection in one patient (5.9%), deep infection in one patient, and leg length discrepancy (0.5 cm to 2 cm) with a varus-valgus angulation (mean 5°, range 3 to 8°) in eight patients (47.1%). No refractures occurred during the follow-up period.

Conclusion: Minimally invasive percutaneous plate fixation can be considered an alternative technique in type IIIA and IIIB open fractures resulting from high-velocity gunshot injuries.

Key words: Bone plates; femoral fractures/etiology/surgery; fracture fixation, internal/methods; surgical procedures, minimally invasive/methods; wounds, gunshot/physiopathology/surgery.

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Gunshot injuries are searched in three groups according to the type of the gun and the shooting distance: low velocity, high velocity and close-distance shots. Although these types of injuries are different in terms of their ballistic effects, fractures due to gunshot injuries are classified and treated as open fractures .[1,2] If the speed of the bullet is more than 600 m/sec it is called high velocity gunshot injury. Wounds occur as temporary or permanent cavitation of the tissues by smashing of the tissues on the way of the bullet and the tissue tension formed by the shock waves. Tissue damage generally is more than the observed damage from the outside. More tissue necrosis is observed especially in high velocity gunshots than the low velocity gunshots by the secondary effect of fractured and scattered bone pieces.[3,4]

The aim of the treatment in open femoral fractures is to prevent the infection, to treat the fracture and to re-gain the former functions of the injured extremity like all open fractures.[4-7] Acceptable infection rate and appropriate duration of healing are reported by basic debris cleaning and early closed intramedullar nailing of femur injured by low velocity gunshots.[8,9] Treatment protocol is not well established for high velocity gunshots. Minimal invasive percutanous plaque placement can be considered as an appropriate treatment option because of the stabilization problems especially in nail and external fixation procedures, wire root infections, wrong union, ununion and limitation of the motions of the knee. [10-13] This fixation method which is also defined as biological fixation, internal plastering, bridged plaque placement and indirect reduction, is introduced by Mast and Kinast for the first time at 1984.[14,15] Bone perfusion is not effected and no harm is added to the injured site by this technique.[16-20]

In our study, treatment results by indirect reduction of the femoral fractures due to gunshot injuries were retrospectively investigated.

Patients and method

17 patients (15 male, 2 female, mean age is 34, distribution is 15-67) were evaluated who were performed fixation by condylar plaque, dynamic compression plaque or cobra plaque placement by minimal invasive percutanous method for femoral fractures formed by gunshot injuries at 1995-2002.

Information like the age, gender of the patients, width of the wound, type of the fractures, type of the gun or bullet caused the injury were recorded. Also, additional traumas and systemic pathologies were searched. Antero-posterior and lateral radiograms of the hip and knee joints of the effected side were taken. Fractures were grouped due to their localization as diaphys, supracondylar, subtrochanteric and classified according to the AO system. Peripheric vascular and neurological status of the patients were evaluated and recorded. Angiograms were performed to 5 cases in which the trace of the bullet was close to the femoral artery for investigating the vascular pathology. 0.5 mL of tetanic toxoid was administered to all patients. First generation of cephalosporins or aminoglicoside antibiotics was administered according to the results of culture-antibiogram. Injuries were low velocity type in 13 patients and high velocity type in 4 of them. In our study there was no full-contact shooting. While deciding to perform minimal invasive percutanous plaque placement method at early or late time period, Gustilo-Anderson open fracture classification, duration of admission to hospital, condition of the wound and systemic vital symptoms of the patient were taken into consideration. Type III-A (n=5) patients who were brought to hospital in the first 6 hours after injury and Type III-C (n=2) patients who had vascular damage were operated at early time period (mean 1.3 days, distribution 1-2 days). Necrotic tissues were precisely removed. Additional traumas were avoided as much as possible, only the fragments which had no link with soft tissue were removed. The cases which were operated in late time period (mean 11.1 days, distribution 7-15 days) (n=10) were all type IIIB. 9 of these patients were followed by skeleton traction through tibia and one by external fixation. Wounds were closed by primary sutures in 6 of the patients and by skin grafting in 2 of them. 2 cases had peroneal nerve injury due to trauma were not explorated during the operation.

Surgical technique

Epidural or spinal anesthesia was used for the operations. Skin was passed through by standard lateral incision at all localizations. Entrance or exit holes of the bullets were excised similar to the fistula repairs. Manual traction was performed for fracture reduction. Linea asprea, femoral anteversion,

axis passing through the condyles and the length of the other extremity were taken into consideration for the distal and proximal compliance of the femur. Condylar plaque placement was performed by pushing the plaque through proximal and distal over the periosteum and under the muscle tissue. Plaque was fixed at distal after removing the blade. Fracture region was not opened. Reduction or dissection was not applied to the fragments. 95º of condylar plaques were applied to the subtrochanteric and supracondylar region. AO dynamic compression plaque was placed in two patients who had diaphyseal fracture at femur and cobra plaque was used for one of the patients. Fracture region was not opened. Reduction or dissection was not applied to the fragments. Grafting was not done for the cases that were operated at early time period. But, four of the patients having wide defects and cavitations and who were operated at late time period, corticospongious graft taken form iliac wing was applied. In these cases, graft was applied from the proximal or distal of the fracture without traumatizing the soft tissues by the help of a long nipper.

Isometric exercises for quadriceps were started at the postoperative second day. Patients were mobilized with crutches at the postoperative forth day.

The patient whose wound cares were completed were discharged after teaching the home-exercise program. Loading on the injured extremity was started after the radiographic controls postoperatively. Monthly clinical and radiographic follow up was performed in the first 6 month and once in two months for the rest. Mean follow up was 25 months (distribution was 14-42 months).

Results

7 of the fractures were at subtrochanteric (1 AO type B2, 3 type B3, 1 type C3 – figure 1a-c), 3 were at diaphysis (1 type C3, 2 type C1 – figure 2a-c, 3a-c) and 7 were at suprachondylar (6 type A3, 1 type C3 – figure 4a-e) region. Additional injuries existed in 3 cases (thorax, forearm, humerus). No complication was seen during operation.

Superficial infection seen in one patient (5.9%) in postoperative early period was treated successfully by antibiotics and wound care. Radical cleaning and resection of infected site were performed in one patient who had no union and deep infection, and implant was removed in this patient. This patient treated by external fixation and internal bone transplantation later. Vessel repairing, indirect reduction and fixation were performed in two patients who had vessel injury.

Figure1. Radiograms taken from a male patient at 34 year of age with type IIIA **(a)** preoperatively **(b)** postoperatively (anteroposterior), **(c)** at 14th month postoperatively.

Graft was applied to a patient at the 4th month who had ununion due to wide defect. Union was reached at mean 4.4 month in 16 patients (distribution 2.5-7 months). Plaque insufficiency was seen at 10th day due to premature loading out of our control in one patient who had organic brain syndrome (delirium tremens). Reduction was achieved by the same technique with re-operation. No plaque insufficiency was observed in any of the other cases.

Complete remission was observed in one of the two patients who had sciatic nerve lesion. Falling of

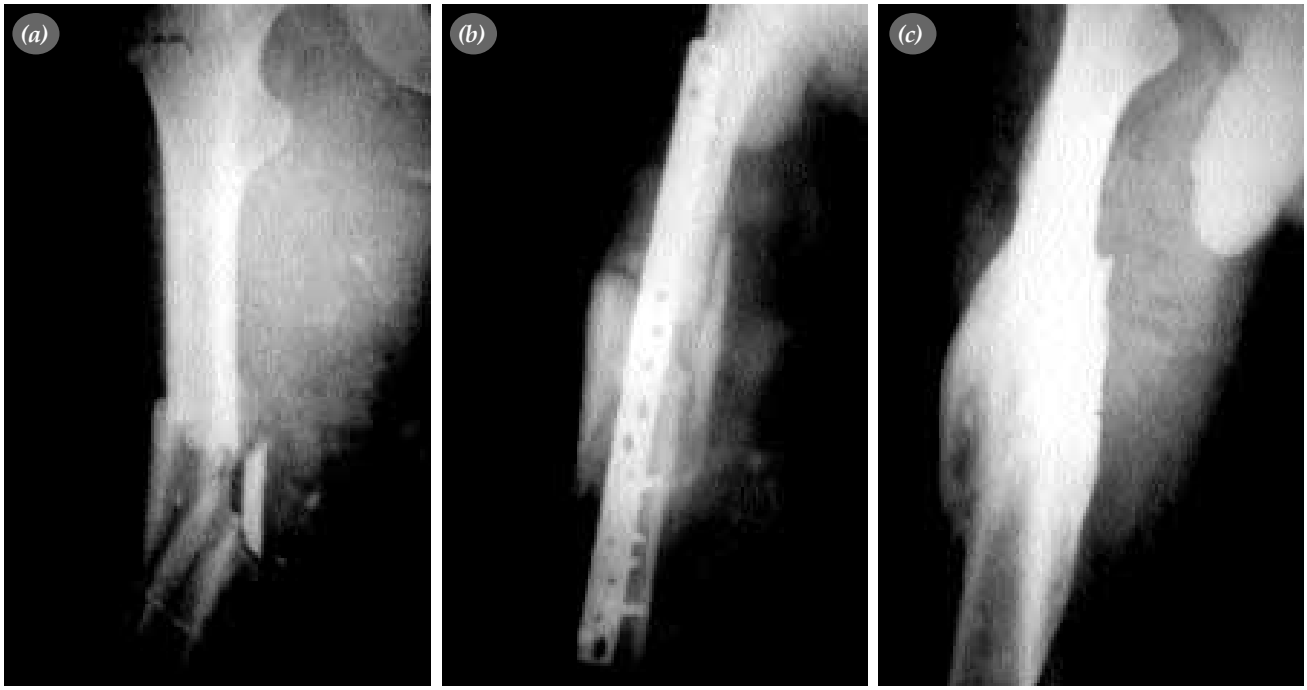

Figure 2. Anteroposterior radiograms taken from a male patient at 48 year of age with type IIIB **(a)** preoperatively **(b)** postoperatively at 3rd month, **(c)** at 2nd year postoperatively.

Figure 3. Anteroposterior radiograms taken from a male patient at 27 year of age with type IIIA **(a)** preoperatively **(b)** postoperatively at the 1st month, **(c)** at 5th month postoperatively.

the foot was observed in the other patient as a sequel. Lower extremity discrepancy was observed in 8 patients (47.1%) as 0.5-2 cm. The biggest difference was observed in the case who had comminuted suprachondylar fracture. Deviation of varus-valgus was 5° (distribution 3-8°).

Flexion limitation of the knee was observed in 5 patients in whom suprachondylar fractures existed 4 of them. Average 30° of limitation existed in the patients with suprachondylar fractures. Re-fractures or excessive rotational deformity was not seen.

Discussion

Treatment is difficult in femur fractures due to gunshot injuries because of the serious concomitant soft tissue damage. In ballistic studies, it has been shown that different types of injuries may exist due to the mass, diameter, form and the velocity of the bullet, groove set and shooting distance.[1,21]

Soft tissue status is one of the most important factors directing the treatment. High velocity fractures can be evaluated as type IIIA or IIIB according to GA classification if no vessel damage exists. In these cases wound closure is recommended to be applied lately after washing the wound and cleaning as much and as wide as it needs.[22,23] Early fixation was performed in 5 patients with GA type IIIA and 2 patients with GA type IIIC in our study. 10 cases with type IIIB fractures operated at late time period.

Figure 4. Male patient with type IIIC open fracture at 37 years of age **(a)** preoperative radiogram showing suprachondylar femoral fracture together with popliteal vein injury. Anteroposterior radiograms taken **(b)** postoperatively **(c)** postoperatively at 6th month and **(d,e)** clinical appearance at 8th month postoperatively.

Stabilization procedure in open femur fractures have used to be performed at late time period after wound care, but after 1980 it used to be performed at early time period by anterograde and retrograde intramedullar nailing. While successful results about infection and healing of the fracture were being reported in open femur fractures, high rates of wrong union was reported in subtrochanteric fractures by Wiss et al [23] and Bergman et al [24] and in suprachondylar fractures by Tornetta et al. [9]

Minimal invasive percutanous plaque placement may be chosen as an alternative to the closed intramedullar nailing for achieving a sufficient fixation without interrupting the circulation and increasing the infection risk at the fracture site. In many clinical and experimental studies, there is a consensus about the better results with indirect reduction method compared to classical plaque placement and osteosynthesis in terms of the duration of healing and rates of infection.[15,16,25,26] Treatment of comminuted fractures effecting subtrochanteric region by intramedullar nailing is difficult because of the high risk of shortness and rotational deformity.[13,27] Fixation done according to the minimal invasive plaque placement with condyle plaque with 95° of angle is reported to provide complete axis compliance and better biomechanical balance.[17,25] Plaque can compensate the short arm of lever due to its properties in proximal and distal femur fractures. In our study, plaque insufficiency due to premature loading was seen only in one of the 14 patients who were applied condyle plaque with 95° of angle because of proximal and distal femur fractures.

No significant difference was seen between the cases who were operated at early or late time periods in terms of complications except the ones with vascular pathology. Stabilization can be done by early indirect reduction in the cases especially having no wide soft tissue damage and having stable hemodynamic situation.

Grafting can be done if soft tissue is preserved and fracture line is not opened. Some authors advocate that soft tissue dissection is inevitable and grafting is contraindicated in these cases.[17, 25,26] We think that grafting without soft tissue dissection in the patients with wide defects operated at late time period would be more suitable.

Ununion rates change between 0.7-1% in gunshot injuries in the literature.[5,22,23,26] In our study one ununion was observed (5.9%), mean duration for union was 4.4 months.

Antibiotic use in gunshot injuries is controversial. Howland and Ritchey[4] reported that they do not use antibiotic except the infected cases. However some authors recommended the use of cephalosporines as monotherapy or combined with aminoglycozides. There is a consensus about the prophylactic use of antibiotics in high velocity injuries.[2,28,29] In our study combination of two antibiotics were administered for 5 days.

The complications seen in gunshot injuries are vascular and peripheral nerve injuries, infections, ununion or delayed union, discrepancy of extremities, angular deformity and rotational dysfunctions. Vascular injury is seen by 1% in femoral injuries. [30,31] In our study there were only two cases (11.7%) of vascular injury after high velocity gunshot injury. Superficial infection was seen in one of these cases and deep infection was seen in the other. Infection development was due to the long operation duration, wide soft tissue damage due to vessel repair. Brumback et al [32] reported 9% of infection rate in 27 patients with type IIIB treated by intramedullar nailing without engraving. Although nailing without engraving was recommended for decreasing the rate of infection, results were reported to be close to each other by the methods with or without engraving. [9,23,32]

Nerve injury is an important complication because of its effects on daily life and leaving sequels in long term.[21] Peripheral nerve injury is seen by 1-2% by blunt traumas and goes up 9% in gunshot injuries.[21,33] Nerve exploration is not performed in our two cases with peroneal nerve damage. Complete remission was achieved in one of these cases. The other had falling of foot as a sequel.

High rate of discrepancy of extremities was reported in gunshot injuries especially in AO type C3 fractures due to the lack of cortical continuity of the ends.[19] These are also the most difficult cases for applying minimal invasive plaque placement technique. Follow up with scopes may be appropriate in these cases. We concluded that the discrepancy of 1.25 cm in our 6 patients might be caused by the

muscle contracture due to inappropriate traction and excessive distraction during the operation leading to delay in union. Fracture was at suprachondylar region in 4 of 5 patients in whom limitations in the range of motion occurred. This limitation was thought to originate from the lining of surgical incision to the site of joint and insufficient rehabilitation. Angling and rotation are expected in these types of fractures. Angling of 5° did not cause a severe problem in our cases.

In conclusion, minimal invasive percutanous plaque placement with cleaning and vascular repairing can be used as limited indication in open fractures type IIIC and can be used in both early and late time period in type IIIA and IIIB due to gunshot injury. Very low risk of soft tissue damage is possible by biological fixation compared to classical plaque placement. This method has advantages over intramedullar nailing like no need for complicated equipments, better stabilization in comminuted fractures of proximal and distal femur, lower cost and easy technique. So, we think that minimal invasive percutanous plaque placement in gunshot injuries is a suitable treatment option.

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