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ORIGINAL STUDY

Bicondylar tibial plateau fractures involving the posteromedial fragment : morphology based fixation

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The aim of this study is to describe the morphology of the posteromedial fragment in the setting of bicondylar tibial plateau fractures and to use it as a base for selection of the method of fixation. Twenty two patients with bicondylar tibial plateau fractures involving the posteromedial fragment were included in this study. Plain X- ray and computed tomogram (CT) were performed in all patients. Thirteen patients were treated by dual plating while nine were treated by single lateral plate. The mean posteromedial fragment height was 39 mm. The cephalad surface area percentage of the posteromedial fragment relative to the entire tibial plateau ranged from 10% to 43%. with an average of 28%. The average knee motion at the final follow up was 110°. Two cases were complicated by implant failure. Morphological study of the posteromedial fragment could help in selection of the proper method of fixation.

Keywords : morphological study ; tibial plateau fracture ; posteromedial fragment.

INTRODUCTION

Displaced tibial plateau fractures with a large posteromedial fragment has been reported in the literatures (*1,3,4*). There is a controversy about the proper method of fixation of such fracture pattern. The anteroposterior fixation is commonly used in management of such fractures, but adequate reduction is sometimes difficult to achieve. Laterally applied fixed angle plate may be ineffective in treatment of this fracture. Medially based fixation will provide a stable and secure fixation but it requires a separate incision to reach the posteromedial fragment (*2,5,6*). Lack of information about the morphology of the posteromedial fragment might be a cause for this controversy about the method of fixation. The advent of computed tomography and its three dimensional reformation (3D) has allowed for an accurate assessment of this fracture pattern. In the last few years some studies have emerged to describe the morphology of this fracture based on the CT scan (*1,9,14*). These studies help to understand the geometry of this fracture pattern.

The aim the present study is to describe the morphology of the posteromedial fragment in the setting of bicondylar tibial plateau fractures and to use it as a base for selection of the method of fixation of this fragment.

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MATERIAL AND METHODS

Between March 2009 and August 2012, twenty two patients with bicondylar tibial plateau fractures involving the posteromedial fragment were treated in our institution. There were 7 females and 15 males. The ages ranged from 24 to 68 years with an average of 41 years. The injury was due to road traffic accidents in 11 patients, fall from a height in nine patients and fall of a heavy object over the leg in 2 cases. Five cases were initially treated by a spanning external fixator to manage the associated soft tissue problems. Cases with open fractures or compartment syndrome were excluded from the study. All patients were evaluated clinically and radiologically by plain X-ray and computed tomogram (CT). The morphological characteristics of the posteromedial fragment were described using the CT scan according to the parameters proposed by Barei *et al* (*1*). Three important parameters were measured ; the medial articular fracture angle (MAFA), the cephalad surface area percentage (CSAP) and the posterior cortical height (PCH). The medial articular fracture angle is determined on the transverse cut at the level of the articular surface by measuring the angle between the major fracture line of the medial tibial plateau and the posterior femoral condylar axis (Fig. 1A). The posterior femoral condylar axis (PFCA) is a line connecting the posterior aspects of the femoral condyles in the transverse cuts at the level of the femoral epicondyles. It acts as a neutral axis of the coronal plane (Fig. 1B).

The cephalad surface areas percentage (CSAP) of the major posteromedial fragment relative to the entire tibial plateau is determined on the transverse cuts taken at the level of the articular surface (Fig. 1C).

Comminution involving the articular surface along the major medial articular fracture line is also noted.

The posterior cortical height (PCH) is defined as the length of a straight line connecting the most posterior aspect of the articular surface with the most distal aspect of the posteromedial fragment on the sagittal cut or 3D reformations (Fig. 1D).

From these measurements ; the medial articular fracture angle (MAFA), the posterior cortical height (PCH) and the cephalad surface area percentage (CSAP), we could have a good idea about the size and orientation of the posteromedial fragment and its fixation is designed accordingly. The following protocol of management was used ; if the surface area percentage of the posteromedial fragment is less than 25% of the entire tibial plateau or the posterior cortical height is less than 30 mm the posteromedial fragment is fixed by screws taken through the lateral plat. But, if the surface area percentage is more than 25% of the entire tibial plateau or the cortical height is more than 30 mm or if there is comminution along the MAFA, the posteromedial fragment is fixed by a separate plate through a posteromedial incision. The medial articular fracture angle (MAFA) gives an idea about the orientation of the fracture line and help to direct the fixing screws to be perpendicular to it. Nine cases met the first criteria and were fixed by inter-fragmentary screws taken through the lateral side and directed towards the posteromedial fragment (Fig. 2). The patient is positioned supine on a radiolucent table. The lateral tibial plateau fracture is reduced and fixed by a plate through an anterolateral approach. The posteromedial fragment is then reduced percutaneously by a reduction clamp and fixed with one or two screws taken through the lateral plate. The screws were taken outside the plate in one case in which the fracture line was aligned in a more coronal way.

Thirteen patients met the second criteria and were treated by dual plating. We start with the posteromedial approach, to provide a stable medial column to which the lateral plateau can be reduced and stabilized. The incision is centered over the joint line, passing proximaally over the medial femoral epicondyle and distally over the posterior tibial border at level of the metadiaphyseal junction. External rotation of the ipsilateral hip and knee flexion (30 degrees) are required to allow a good access to the posteromedial part of the proximal tibia. After dissection of the subcutaneous fatty layer, the fascia is incised between the pes anserinus anteriorly and the medial head of the gastrocnemius posteriorly. The medial collateral ligament is kept intact anteriorly. The semimembranosus insertion can be released off the bone using an elevator if more access is needed posteriorly. In that case, it should be reattached after fracture fixation (*24*). The fracture is then reduced. If the posteromedial fragment is large enough and not comminuted, we did not expose the articular surface, and limit the dissection to the fracture apex. However, in case of comminution, a submeniscal arthrotomy is done to visualize the joint directly. After reduction, the fracture is fixed with an antiglide buttress plate. In the same supine position, a separate anterolateral approach is used concomitantly for the associated lateral plateau fracture. The lateral articular surface is inspected from a submeniscal arthrotomy. The fracture is reduced and fixed with plate and screws. Any metaphyseal defect is grafted with autogenous bone graft. The wounds are then closed over drains.

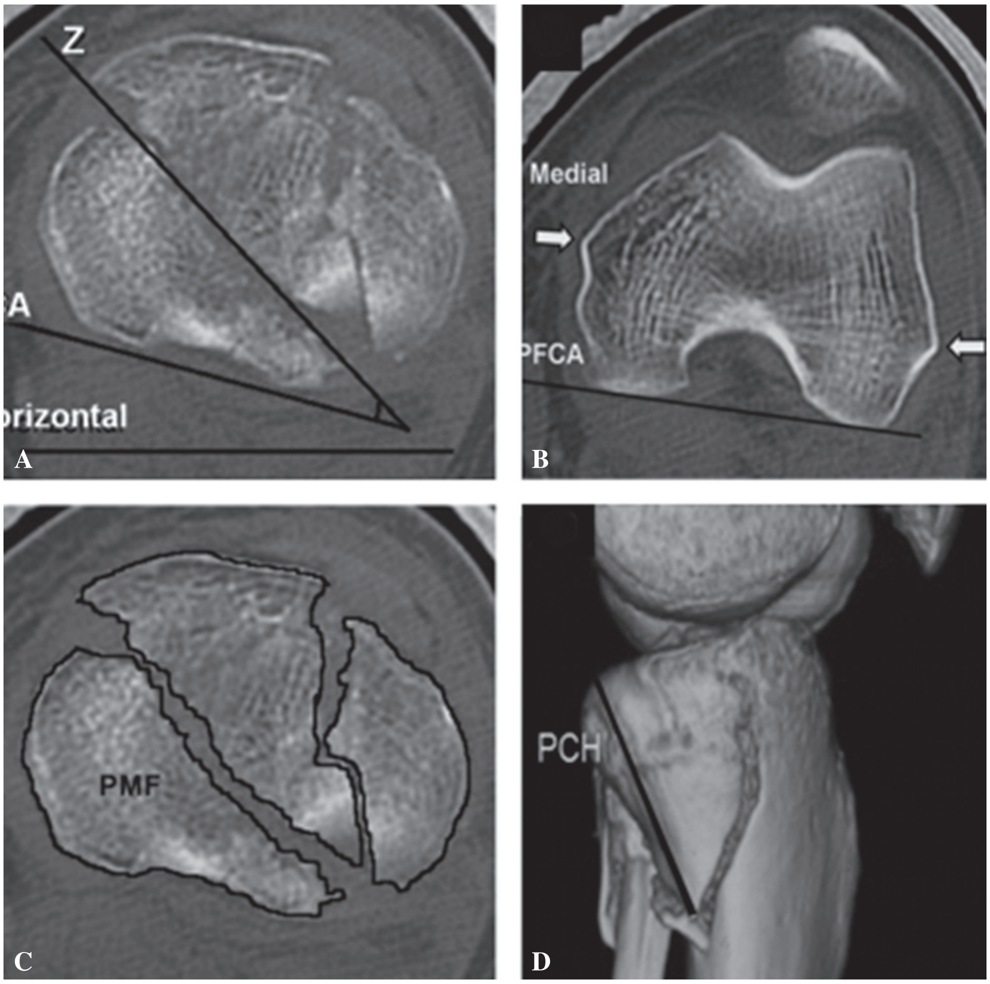

Fig. 1. — A : The medial articular fracture angle is the angle between the major fracture line of the medial tibial plateau (Z) and the posterior femoral condylar axis (PFCA). B : The posterior femoral condylar axis (PFCA) is the line connecting the posterior aspects of the femoral condyles in the transverse cuts at the level of the epicondyles (whit arrows) of the ipsilateral distal femur. It acts as a neutral axis of the coronal plane. C : The cephalad surface area percentage of the posteromedial fragment (PMF) is expressed as a percentage of the whole tibial plateau. D : The posterior cortical height (PCH) is obtained by measuring the straight-line distance from the most distal extent of the fragment to the most posterior aspect of its articular surface on the sagittal CT.

Postoperative care includes early mobilization with active assisted and passive range of motion exercises starting on the second postoperative day. Weight bearing is restricted during the first eight weeks then progressive weight-bearing is allowed according to the bone healing on serial radiographic examination. At the final follow-up, the range of motion of knee joint was measured and the Modified Hospital for Special Surgery knee scoring system was used for evaluation of the patients (*16*).

RESULTS

The cephalad surface area percentage of the posteromedial fragment relative to the entire tibial plateau ranged from 10% to 43% with an average of 28%. The MAFA ranged from -3 to 46 degrees with a mean of 25 degrees external rotation relative to the PFCA. The cortical height of the posteromedial

Fig. 2. — A : The radiographs of a 35 year-old patient with bicondylar tibial plateau fracture with a small posteromedial fragment. B : The sagittal CT cut showing the PCH of the posteromedial fragment. C : The anteroposteror and lateral radiograph showing the fixation of the posteromedial fragment through the lateral plate.

fragment ranged from 15 to 62 mm with a mean of 39 mm. Three of the 22 fractures (14%) demonstrated comminution of the articular surface along the major medial fracture line separating the posteromedial and anteromedial fragments. The time from injury to surgery ranged from one to 17 days with a mean of 5 days. The average time of hospital stay was 11 days (range ; 6 to 25 days) The average follow-up period was 27 months (range ; 16 to 44 months). The articular reduction was satisfactory (≤ 2 mm step or gap) in eighteen patients (82%), while it was unsatisfactory (> 2 mm step-off) in four patients. All patients had an accepted sagittal and coronal plane alignment after surgery. The fractures healed in all cases except two. The average time of healing was 3.2 months (range from 2 to 4.5) months. One patient had a superficial wound dehiscence after operation which healed with local care. The time to full weight bearing averaged 13 weeks. The average range of knee movements was from 0°-110°. Two cases from the first group (single plate fixation) were complicated by varus collapse and loss of fixation from the posteromedial fragment. They were treated by reduction and refixation by a buttress plate through a posteromedial approach. All cases of the second group healed in a proper alignment and none of them showed implant failure or non union (Fig. 3). The Modified Hospital for Special Surgery Knee Score for the patients ranged from 48 to 95 with an average of 79. No cases were complicated by neuro-vascular injury.

DISCUSSION

The key objectives in treatment of tibial plateau fractures are : anatomical reduction of the articular surface, maintenance of normal knee alignment, and stable fixation to allow for early joint movement (*20,21,22*). The posteromedial fragment in the setting of bicondylar tibial plateau fractures seems to be under-recognized or recognized but undertreated. Failure to address this fragment may allow the medial femoral condyle to rotate and subluxate posteriorly causing instability, pain, and progressive joint degeneration (*11,12*). Management of this fracture pattern remains difficult and controversial. The most commonly used approach to treat medial tibial plateau fractures is fixation with an anteromedial plate through a medial parapatellar incision (*25*). This approach however does not give adequate exposure. Attempts to reduce and fix the posteromedial fragment may be difficult and result in extensive soft tissue dissection (*21,25*).

When it is fixed with a lateral locked plate, the screws fail to capture the posteromedial fragment because it is frequently parallel to the fracture line (*18*). Locking screws directed from the lateral plate to secure the medial fragment possess a limited ability to lag the medial fragment and rely on the lateral screw-plate interface to withstand shearing forces (*5*). Gosling *et al* (*6*), reported a series of bicondylar tibial plateau fractures treated with single lateral locked plate. In that series, 26% of the cases demonstrated loss of reduction secondary to failure

Fig. 3. — A : The radiographs of a 47 year-old male patient with right bicondylar tibial plateau fracture with a large posteromedial fragment. B : The transverse CT cut showing that the posteromedial fragment represents about 38% of the entire tibial plateau surface area. C : The early post operative radiograph after dual plating. D : After healing of the fracture. E : The patient with good alignment and good range of knee movements.

to reduce or stabilize the posteromedial articular fragment. Recent biomechanical evidence implies that dual plating increases resistance to subsidence when compared with a unilateral locking plate in bicondylar fractures (*8*).

But does every medial fragment require a separate plate for its fixation ?

Better understanding of the different fracture patterns helps to formulate a good treatment plan. To date, most of descriptions of tibial plateau fractures have concentrated on their appearance on the antero-posterior radiograph, with little comment on any primary displacement in the sagittal plane (*15,19, 23*). Hackl *et al* (*7*) found that 40% of the fractures classified with plain radiographs and the AO system had to be changed after performing a CT scan. Therefore, most authors now recommend a pre-operative CT scan to analyze bicondylar tibial fracture (*7,10,13*).

We hypothesize that the size of the posteromedial fragment may have a role in selection of its fixation method. The bigger the fragment the more the sheer force applied to it and the less likely of its stabilization through a single lateral plate. Bari *et al* (*1*) described the frequency and morphology of the posteromedial fragment in bicondylar tibial plateau fractures based on the CT study. They found that ; increasing posterior cortical height is significantly associated with the absolute surface area percentage of the posteromedial fragment (P, 0.001). Thus, the posterior cortical height and the surface area percentage give an idea about the actual size of the posteromedial fragment and the medial articular fracture angle (MAFA) gives an idea about the orientation of the fracture line. So, these parameters were used to formulate the protocol of management in the present study.

All cases that were treated by dual plating healed in a good alignment and none of them showed implant failure while two of the cases that were treated by screws through the lateral plate showed implant failure and varus collapse. The cephalad surface area percentages of the posteromedial fragment in these two cases were 21%, and 24% respectively. They were treated by re fixation by a buttress plate through a posteromedial approach and they united in a proper way. Thus, by the end of our study we could recommend single plate fixation for bicondylar tibial plateau fracture with a small posteromedial fragment (CSAP ≤ 20% or PCH ≤ 30 mm) and dual plating for cases with a large posteromedial fragment (CSAP more than 20% or PCH more than 30mm). The presence of comminution along the posteromedial fracture is an exception and it requires a separate buttress plate from the same side as it is difficult to be fixed by screws from the opposite side. Open reduction and internal fixation of bicondylar tibial plateau fractures has a high rate of postoperative complications, mainly due to severe concomitant soft tissue injury (*2,17*). In this series there were no infection or soft tissue problems after dual plating because the bilateral approaches through the posteromedial and anterolateral incisions leaves a large vital skin flap between the 2 incisions that minimize the risk of soft tissue complications.

CONCLUSION

Morphological study and careful preoperative planning of the surgical treatment of this fracture pattern could help in selection of the proper method of fixation and improve the final outcome.

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