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TRAUMA SURGERY

Inside out rafting K-wire technique for tibial plateau fractures

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Abstract With the introduction of 3.5 anatomically pre-shaped plates, the rafting screw technique is gaining popularity in recent years for the management of lateral tibial plateau fractures with articular depression. To gain access to the depressed articular fragments, the split fragment is hinged open laterally. We elevate the depressed articular fragments to the normal level. The defect below is filled with bone graft or its substitutes. We then close the split fragment and apply rafting screws either through the screw holes of the plate or separately above the plate rather in a blind fashion. We therefore cannot be sure that the rafting screws are supporting the specific elevated fragments. For this reason some surgeons place the rafting screws from within and then close the lateral fragment over the screws. This so-called embedded rafting screw technique carries the risk of difficulty in removal, especially in case of an infection. Here we describe the inside out rafting technique to tackle this problem.

Keywords Tibial plateau fractures · Rafting screws · Rafting K-wires

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Technique

Between January 2006 and February 2010, open reduction and internal fixation was performed in 62 patients with plateau fractures at the author's institution. The proposed technique was used in 22 of these patients who had AO-OTA 41B, C fractures with articular depression on the lateral plateau. There were 16 males and 6 females with ages ranging between 24 and 73 years. There were eight 41B fractures and fourteen 41C fractures.

For the 41B fractures involving the lateral plateau, a longitudinal incision is made over the anterolateral aspect of the knee joint. The dissection is deepened down to the fascia in line with the skin incision. The split fracture line is identified and the overlying iliotibial band is incised along the vertical split fracture line. Then the coronary ligament is incised along its tibial insertion. The split fragment is hinged open laterally with the overlying soft tissues intact in order to preserve the vascularity of the lateral wall fragment. Direct visualization of the depressed articular fragments is then achieved. We have seen that the depressed articular fragments are often impacted with the surrounding cancellous bone at their periphery so we first cut-out (or shovel-off) the articular fragments from surrounding cancellous bones with the use of a small elevator. Then the articular fragments are meticulously elevated against the intact medial condyle from back to front. The amount of elevation is judged by referencing it with the intact articular surface. While we are elevating the articular fragments, a counteracting force is applied with a finger or with another elevator to prevent the articular fragments from being popped up inadvertently. Once the articular fragment is elevated to their normal level, a 1.6-mm K-wire is introduced right through the elevated fragment around 5–10 mm below the subchondral cortex toward the medial condyle (Fig. 1). We try to keep the direction of this K-wire as parallel as possible to the joint line under the guide of image intensifier. This K-wire is advanced in an oscillating mode until the tip of the K-wire comes out of the skin over the medial tibial condylar area. This K-wire is then retrieved from medial side until the lateral end of this K-wire is flush with the fracture surface (Fig. 2). The same procedure is repeated step by step until all depressed fragments are specifically rafted with the inside out rafting K-wires. The defect underneath the elevated articular fragments is filled with bone grafts. Then the lateral wall fragment is closed with a reduction forceps (Fig. 3). The retrieved K-wires are advanced back from the medial side towards lateral side until the tip of the K-wire comes out through the lateral condyle. Then the K-wire is retrieved laterally until the medial tip is slightly buried within the medial condyle to avoid any irritation (Fig. 4). The wires are cut and bent over the lateral condyle (Fig. 5). We then buttress the lateral wall fragment with pre-shaped 3.5 plates over the rafting K-wires. We evaluated the quality of reduction with post-operative CT scans and an example of a 41B fracture is presented (Fig. 6).

For the 41C fractures involving both medial and lateral condyles, reconstruction of the medial condyle is attempted as the first step. Medial condylar fragment was buttressed with 3.5 reconstruction or T-plate through a separate posteromedial incision. Screws from the medial side are strategically placed so as not to hinder the reconstruction from the lateral side later. Then we move to the lateral condylar reconstruction in the same manner as we described above. We try to pass the K-wires through the medial incision if possible.

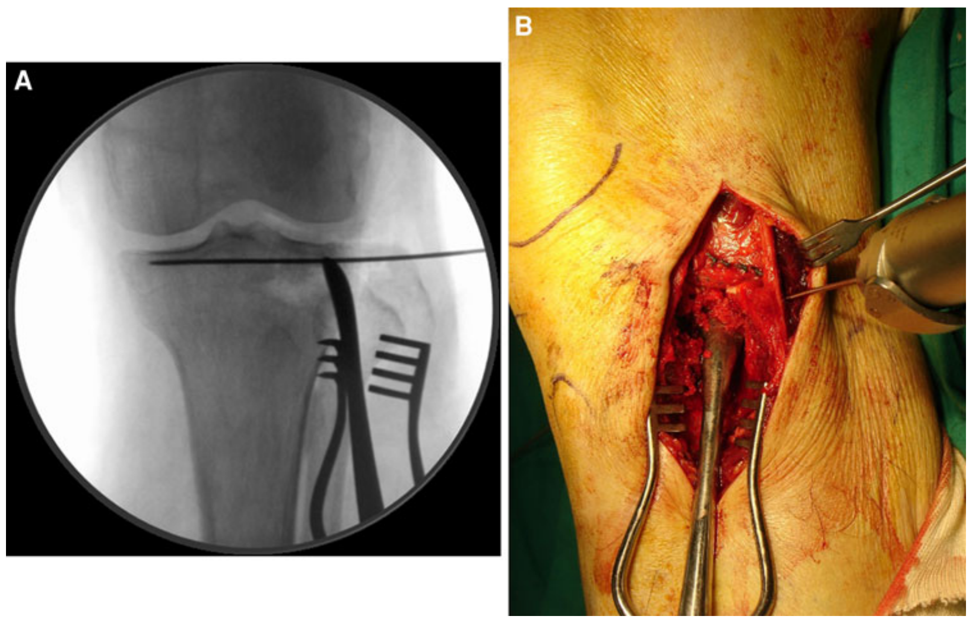

Fig. 1 Elevated articular fragment is supported with an inside out rafting K-wire. C-arm image (**a**), clinical photo (**b**)

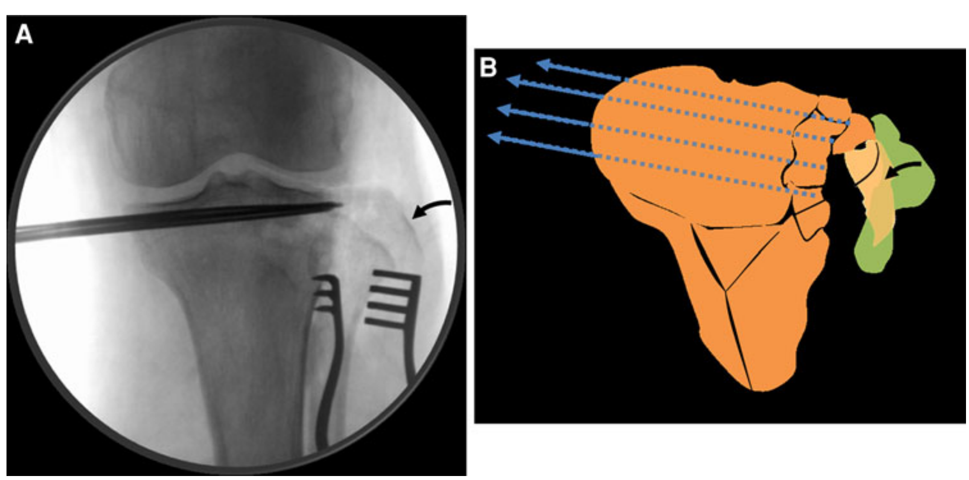

Fig. 2 Rafting K-wires are retrieved from the medial side until the lateral tip of the K-wire is flush with the articular fragments. C-arm image (**a**), illustration (**b**). *Curved arrows* indicate the split fragment that is hinged open laterally

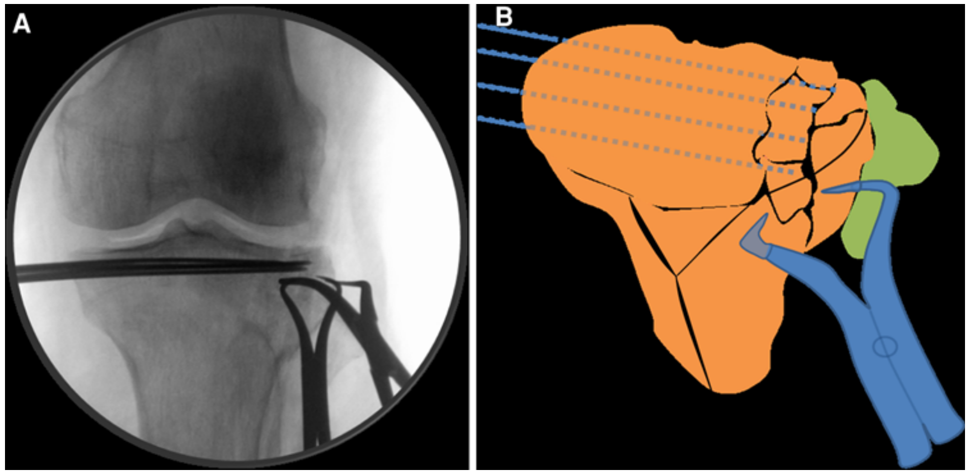

Fig. 3 Split fragment is reduced with reduction forceps. C-arm image (**a**), illustration (**b**)

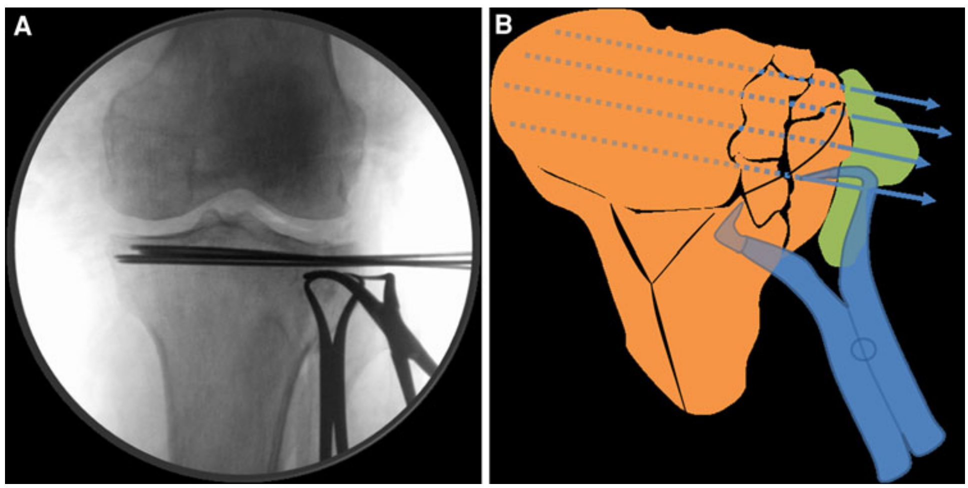

Fig. 4 K-wires are advanced back toward lateral side. C-arm image (**a**), illustration (**b**)

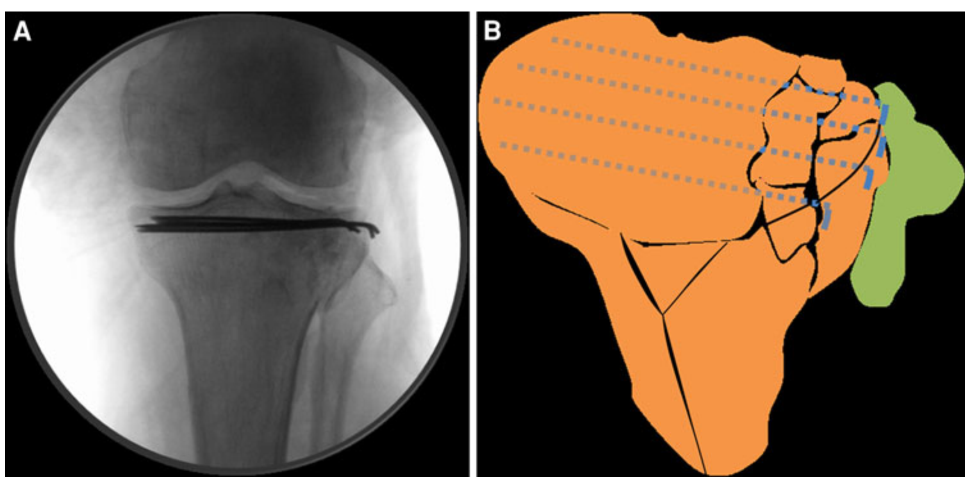

Fig. 5 K-wires are cut and bent over the lateral condyle. C-arm image (**a**), illustration (**b**)

Discussion

Use of 4.5 mm large fragment system especially in a dual plating configuration has been frequently associated with soft tissue irritation and breakdown. Karunakar et al. [1] reported a biomechanical study comparing the resistance to the local depression loads between the L-buttress plate and the raft of 3.5-mm subchondral screws. Split depression fracture of the lateral plateau were instrumented with an L-buttress plate, four 3.5-mm subchondral raft screws with

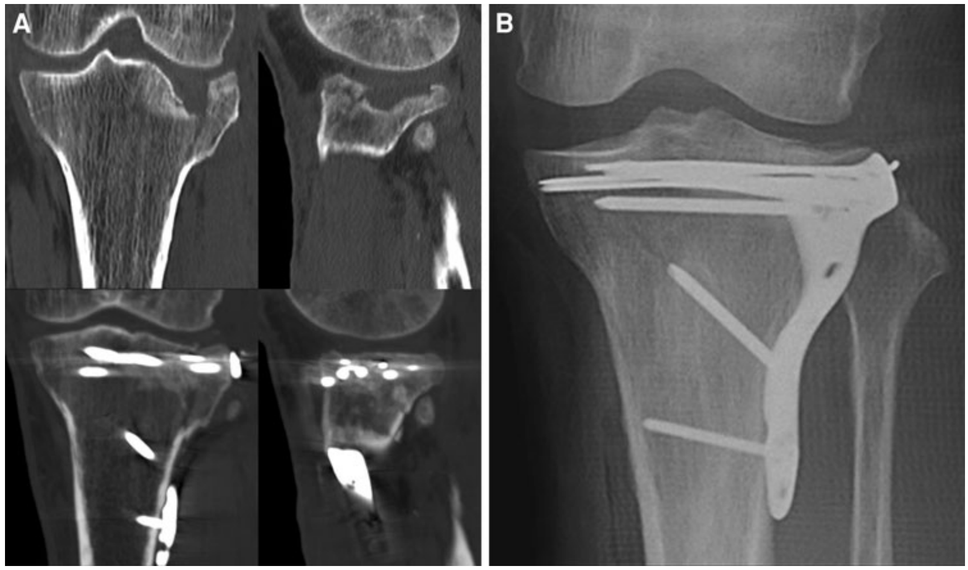

Fig. 6 Pre-operative CT scan showing depression of the articular surface. Post-operative CT scan showing anatomical restoration of the articular surface and precise supporting of the elevated articular fragments with rafting K-wires (**a**), post-operative plain AP view (**b**)

an anti-glide plate, an L-buttress plate with cancellous allograft, or four 3.5-mm subchondral raft screws placed through a periarticular plate. They found no significant difference in the overall construct stiffness between the four fixation-constructs. They concluded that the fixation constructs with a raft of subchondral screws either through the periarticular plate or separately were more resistant to local depression loads. Patil et al. [2] later did a similar biomechanical study with the synthetic bones. They simulated Schatzker III fracture both in osteoporotic and in a normal bone quality. They found that the mean force needed to produce a depression of 5 mm was 700.8 N with the four-screw construct and 512.4 N with the two-screw construct in the osteoporotic model. This difference was statistically significant. There was no statistically significant difference in the mean force required to produce same depression between the two 6.5 cancellous screws and the subchondral raft of four 3.5-mm cortical screws, but they observed an increased fragmentation of the synthetic bone fragments with the two-screw construct and not with the four-screw construct. They concluded that a raft of four 3.5-mm cortical screws is biomechanically stronger than two 6.5-mm cancellous screws in resisting axial compression in osteoporotic bone.

Back in 1996 Beris et al. [3] reported a biomechanical study using rafting K-wires. They created 3 cm^2 sized cylindrical defect on the lateral tibial condyle. The defect was supported with seven different configurations of rafting K-wires. Cancellous bone graft without mechanical support was also tested to compare the stiffness. They measured the relative resistance to depression by the percent stiffness of the intact condyle. In their study, bone grafting with cancellous bone provided only 14.8% of an intact bone, while K-wire reinforced pairs achieved up to 30% of intact bone. They found out that there was no difference in relative resistance to depression between four K-wire configuration and the six K-wire configuration.

All of these biomechanical studies support the concept that a raft of either 3.5 cortical screws or K-wires supports the collapse of the elevated articular fragments effectively.

In the experimental studies, the location of the K-wires can be precisely controlled. In the clinical setting though, rafting screws are placed in a rather blind way because we insert the rafting screws after closing the split fragment. The location and pattern of the articular depression also varies from one patient to the other. So we actually do not know whether the rafting screws placed in this way are effectively supporting the elevated articular fragments or not. Some surgeons advocate inserting the rafting screws at the time of elevation from inside and bury them within the bone by closing the split fragment over the screws. This so-called embedded rafting screw technique carries a serious risk when it gets infected because it is difficult to take them out.

The authors have come up with an inside out rafting K-wire technique to tackle this problem. In this technique, the rafting K-wires can be placed precisely through or right beneath the elevated articular fragments according to their thickness. We prefer to place the K-wires through the fragments 5–10 mm beneath the subchondral cortex. For the thin articular fragment through which we cannot place K-wires we just insert the K-wire right beneath the fragment to support them. So we believe we can rather specifically support the elevated fragments with this inside out subchondral raft of K-wires. We do not want to bury these K-wires within the bone, so we retrieve the K-wires toward medial side and then advance them back toward the lateral side after closing the lateral split fragment. The tip of the

K-wire is bent over the lateral cortex. With this technique we can place rafting K-wires more precisely through or beneath the elevated articular fragments, still keeping them outside the bone for possible implant removal. Because these K-wires are placed close to the subchondral cortex, we can apply 3.5 periarticular plates without any hindrance.

Surgeons who prefer using 3.5 cortical screws over the K-wires may replace K-wires with 3.5 screws. Instead of bending them over the lateral cortex, the K-wires can be used as the guide to place the 3.5 cortical screws right beneath the K-wires. Or even the rafting K-wires can be used as a guide wire for the placement of 3.5 cannulated screws if it is necessary. Of course the size of the K-wires should be chosen accordingly from the beginning.

We must emphasize the technical pitfall that should be avoided in the use of inside out rafting K-wire technique. At the time of insertion, the K-wires must be as parallel as possible to the joint line and to the posterior surface of the tibia. If the K-wires are directed a bit inferomedially they go up towards the joint on the lateral side at the time of re-advancement. And if the K-wire is placed in the anteromedial direction, it goes back towards posterolateral corner. Placing the inside out rafting K-wire parallel to the posterior tibial surface from the posterolateral corner is difficult as the split fragment is blocking the starting point. In this situation, the K-wire can be placed first through the split fragment and then through the elevated articular fragments. A curved gouge may be used to guide the K-wire when it comes out through the lateral cortex of the split fragment to protect the peroneal nerve injury. We had a 60-year-old lady (41B) who complained of annoying pain on the medial side due to irritation over a protruded K-wire tip. We had to take it out 6 weeks after operation to facilitate rehabilitation. So, careful evaluation with both the oblique views is required to avoid such an annoying complication.

The use of rafting screw technique has been advocated in clinical setting too [4]. In their report of using 3.5 T-plate for the fixation of the lateral tibial plateau fracture, Ballmer et al. [5] claimed that rafting effect of multiple small screws increased load tolerance of plateau depression, though they all placed rafting screws in a blind manner.

In summary, the inside out rafting K-wire technique is a useful method to specifically support the elevated articular fragments in plateau fracture management.

Conflict of interest The authors of this manuscript have no financial or proprietary interest in the subject matter discussed in the manuscript in one way or another. The completion of this manuscript has been achieved in order to contribute to the knowledge of the surgical management of trauma.

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