Plate and Screw Osteosynthesis of Proximal Tibia Fractures

12

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12.1 Principal Considerations

The authors of the previous chapters described thoroughly the diagnostic and classification of proximal tibia fractures. The deeper background of this chapter is to identify very clearly the following issues:

1. Character of the fracture.
2. Key fragment.
3. Biomechanical instability.
4. Biological soft tissue.
5. Concomitant conditions such as:
   (a) Immunosuppression.
   (b) Age.
   (c) Osteoporosis.
   (d) Risk factors.
   (e) Timing.
   (f) Concomitant injuries.
6. Identification of optimal therapeutic plan.

After identifying the character of the fracture under the specific circumstances of the individual patients, the orthopaedic surgeon should create a therapeutic plan [6].

This plan comprises a procedure A followed by an identification of worst case scenarios with fulfilling this plan A. At each worst case scenario point, an additional plan B should be part of this therapeutic plan, and it is good if you have an additional plan C in the backhand.

Example: You plan to implant a simple screw as an osteosynthesis, you cut the skin and suddenly some obviously infected material occurs which has not been identified before, so you have to change to infection management such as external fixator, vacuum therapy etc. So you must be sure that you have all of this material available in your centre before you plan going to the OR.

12.2 Therapeutic Plan

As mentioned above it is critical to identify the character of the fracture. Principally it can be either a high-energy or low-energy trauma, a monocondylar, lateral or medial or a bicondylar or intercondylar eminentia fracture (see classification part). Moreover it is extremely critical to check the soft tissue which can be severely injured especially in high-energy fractures. So the orthopaedic surgeons have to check for concomitant vessel nerve or ligament injury [7], check the peripheral vascularity and neurology and check for compartment syndrome, etc. Especially in high-energy trauma, it is recommended to wait until the soft tissue problem has come down [1]. The maximum interval between injury and ORIF is about 14 days. After this time span, the bone

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healing process is starting to convert the haematoma into soft callus which jeopardizes reduction substantially [12]. In this respect the rescue management is always:

Span, Scan and Plan
So if you are not sure what to do, you better go this way and transfer the patient to a trauma centre [16].

The abovementioned classifications systems such as AO, Schatzker, ten fragment etc. have all one common target [14, 18]:

Identification of the Key Fragment
Many surgeons asked me: "How do you identify the key fragment?"

Since there is no scientific publication investigating this aspect, here is our expert's opinion:

- Which fragment will help to reduce fracture anatomically most?
- Which fragment contributes mostly to stability?
- Which fragment allows reconstruction of anatomic structures most appropriate with one implant?
- Which fragment fulfilling all of these characteristics will be reached by a direct anatomic approach allowing easy access for instruments such as driller, screwdrivers etc.?

12.3 Approaches

Choosing the approach has a substantial impact on many of the following decisions. And it is absolutely mandatory to take very serious considerations about that. Modern fracture treatment comprises these topics:

1. The approach should be able to allow the orthopaedic surgeon to reach the key fragment directly.
2. The approach should clearly be identified by anatomical landmarks.
3. It should avoid critical structures such as nerve vessels as far as possible.
4. It should allow placement of implants and proper fixation, such as drilling ankles, screwdriver positions etc.

Recent development of 360 degrees strategies to proximal tibia fractures identified several approaches [4, 8–11, 13]. Principally the anterolateral approach is the working horse for the majority of classical anterolateral fractures (Schatzker II and III, AO B type).

Medial fragments are mostly addressed by more posteromedial approaches since they allow a more anatomic reduction and respect the anatomic ligament structures such as hamstrings. By respecting these important stability-relevant anatomic structures, posteromedial approaches allow in most cases a very smooth anatomic reduction, with the distal fracture lines as reference line. After a thorough debridement and removal of reduction obstacles, the reduction of the posteromedial fragment often allows an anatomic joint line reduction without opening the medial joint compartment. In our experience it allows a much easier and better placement of plates as compared to the anteromedial approaches. Moreover postoperative outcome is much lesser compromised by implants pressed on the hamstrings [3]. A smart way to address bicondylar fractures is double-incision approach starting with a posteromedial approach followed by changing the position of the patient from prone to supine position and then addressing the anterolateral fragments by an anterolateral approach. However individual approach planning is for every different fracture mandatory. Important is to avoid soft tissue problems if double incisions are used. It has been demonstrated that there must be a minimal distance of five to seven centimetres skin between the incisions. Especially in complex bicondylar proximal tibia fractures with severe posterior fragments, the formerly used "one approach attempt" using a central approach frontally has induced substantial soft tissue problems since soft tissue preparation must be very wide among lateral and medial soft tissue structures to address the fragments properly. Sometimes the argument that this will be then be the same approach for a total knee replacement if the proximal tibia

fracture fails is not supported by scientific data since the time between healing of the lateral and medial approaches is far long enough to allow an additional frontal approach if required. On the other hand, the attempt of a frontal longitudinal approach for complex bicondylar fractures is very often accompanied by severe soft tissue failure, infection etc.

12.4 Placement

As mentioned above simple lateral proximal tibia fractures can be solved in supine position on the trauma table using a pillow underneath the knee to overcome flexion muscle forces. We use a trauma table and, if no contraindications are present, also a tourniquet. The following are important: Before sterile washing, check if the patient is secured sufficiently on the table; and if you can, visualize using your image intensifier the anatomic structures of the injured extremity in 360 degrees. If you plan to use combined postero-antero procedures, we made the experience, that it is easier to start in prone position, fix posterior medial components, close wounds and turn to supine, if swelling of soft tissue is increasing, close posterior, stopp surgery and go for anterior service after some more days of soft tissue calming. If substantial posterolateral service is required which is insufficient addressed by posteromedial approach, you can use the "double-incision" approach after turning the patient to supine position for the lateral corner [21]. Again, it seems important to mention that former attempts to completely solve complex fractures anteriorly have a high risk of soft tissue complication.

12.5 Reduction

In our experience, after preparation of approach these steps turned out to give a sufficient reduction [17]:

- Preparation of the fracture lines.
- Clearance from soft tissue interference for plate placement.
- Debridement from potential interpositioning material, such as small bone fragments, haematoma, callus, soft tissue etc.
- In case of classical anterolateral fragments:
- Check: if reduction and manipulation of joint line fragments are possible, use fracture gaps.
- If not, create a small square-shaped bone hole underneath the lateral tibia plateau with 10 mm scalpel, and use bone pusher under image intensifier control to direct the pusher right underneath the fragment, and then reduce carefully until the joint line is perfect. If you are not sure, open the joint using an arthrotomy securing the meniscus superior using a PDS stich; then, turn the leg into varus stress, and check reduction under direct inspection.
- In case of small fragments in the medial part of the lateral compartment, this can be supported by arthroscopic control [2]. Be careful with lateral splits which are difficult to see underneath the meniscus. C-type fractures are not good for arthroscopic reduction since the water pressure has a high risk of compartment; in some cases a "dry arthroscopy" might be used for reduction control.
- Check for subchondral bone voids, and fill them up with sufficient material, i.e. autologous cancellous bone grafting, artificial bone substitute etc.

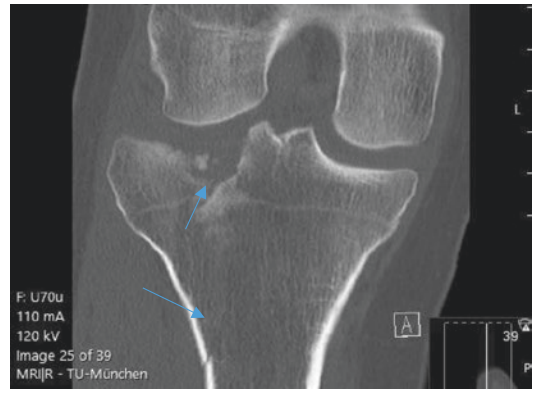
Then, temporary reduction using ball spike pins, bone rasps etc. with extremely thorough check if the reference lines demonstrate a "waterproof" reduction tolerance of reduction gaps is extremely low; generally, a step-off of more than 2 mm in vertical direction will not be accepted; in case of comminuted joint surface, after debridement sometimes horizontal gaps are unavoidable to prevent free-floating intra-articular bone-cartilage particles; however, these gaps should be reduced as much as possible. In case of subchondral bone void filling, it is important to be sure that the material is not dislocating into the joint through these gaps. If the sight is insufficient, consider usage of an external fixator system as distractor.

Sometimes a reduction clamp might be helpful; however, be careful with soft tissue using classical Weber clamps; ball spike clamps are helpful. If the bone quality is inferior, put the clamp on the lateral side on the plate, so the spike will not sink into osteoporotic bone [5].

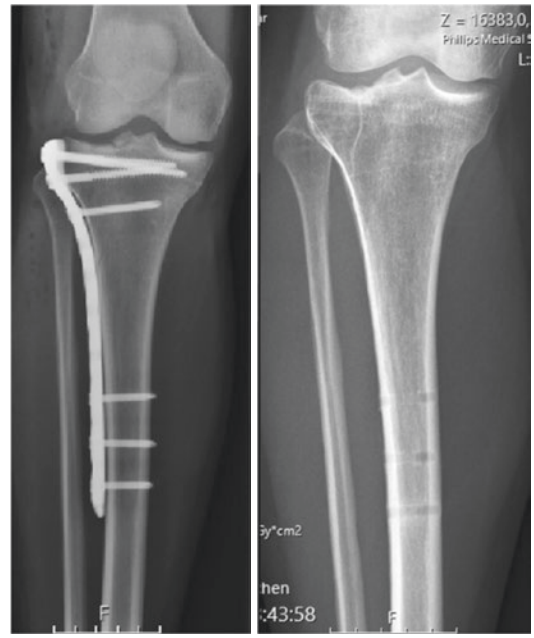
Especially in Schatzker II and III fractures, the width of the proximal tibia plateau must be reduced very thoroughly (sometimes "King Tong" or Vossberg clamps might be helpful). It is helpful to compare the width of proximal tibia plateau in ii check with the width of the distal femur; if the distal femur is not as wide as the tibia, reduction is insufficient.

- Temporary fixation using k-wires.
- Schatzker I fractures and sufficient bone quality screws are sufficient; in all higher-graded fractures, use anatomical preshaped polyaxial locking plates [19].
- Adjust plates.
- Fix them temporarily, i.e. using long holes and classical cortical screws.
- Check in image intensifier: Reduction waterproof? All critical joint parts visible? Position of plate correct?
- If screws are used, drill using ii checks and place screws minimum of 5 mm underneath the subcortical bone of the medial plateau.
- In case of locking plate, use distal cortical screw first to draw plate to the bone, check again in image intensifier and then fix proximal using locking screws.
- In case of insufficient bone support of tibial plateau, use cancellous bone graft or artificial bone material [15].

Case examples.
AO B type.

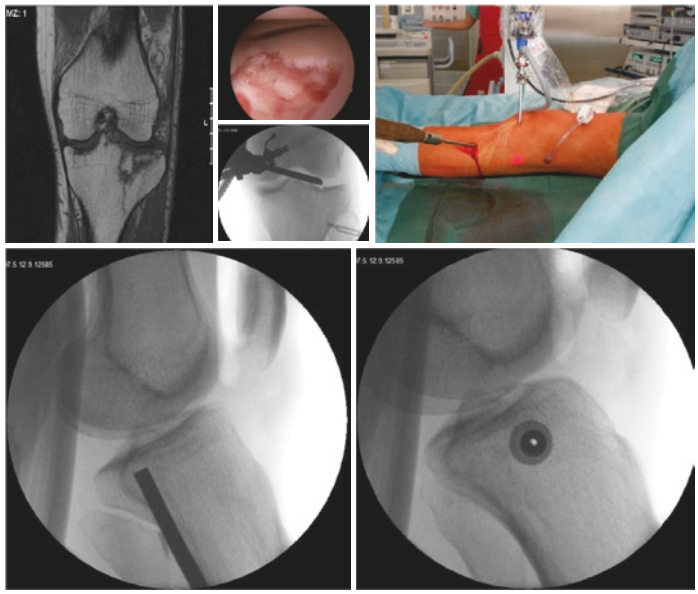


41B3.1, Schatzker II.



Case example: 45-year-old male, ski accident; see the deep punched fragment and the split downwards (arrows). On the right hand side after ORIF and implant removal perfect reconstruction of joint surface and leg axis.

AO 41B3.1x/Schatzker II.



Example for arthroscopically supported screw “closed reduction internal fixation” (CRIF).

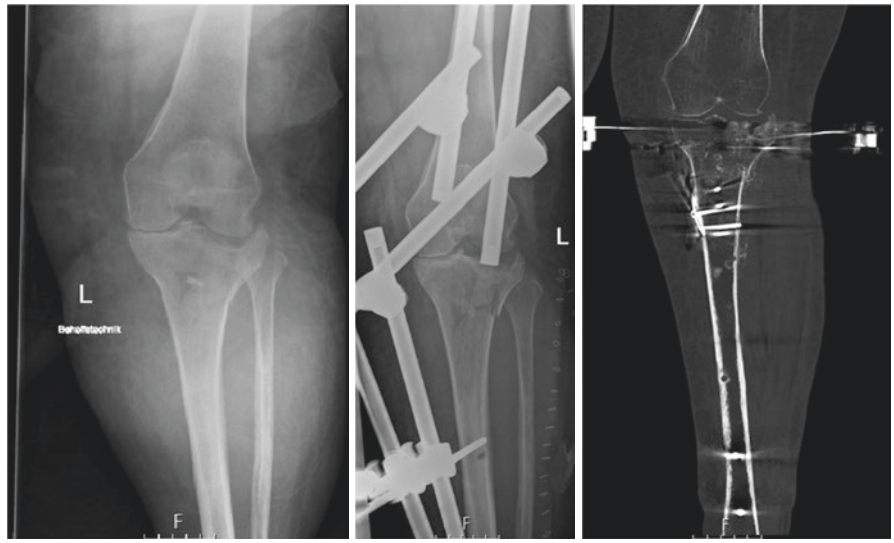
AO C type.

AO 41C1.2/Schatzker V.

These images demonstrate the complexity of multi-fragmentary fractures and the importance of the proposed 360° strategy.

External Fixation Systems

Some additional annotations should be given according to external fixation. In desperate situations of extremely bad soft tissue, inacceptable perioperative conditions, such as chronic dialysis, immunosuppression etc., an external fixation system might be appropriate. In this respect a proximal ring using Ilizarov wires and distal fixation using classical Schanz screws is the most recent approach in hybrid fixateurs [20, 22].



Case example: 60-year-old female patient, maximum obesity, chronic dialysis due to renal failure felt; AO type C/Schatzker VI fracture. Initially, span, scan and plan and then hybrid fixation using posteromedial plate and hybrid Sheffield frame.

The scientific literature has not clarified so far if this concept has an advantage. A very recent published meta-analysis by Zheng et al. analysed 17 studies on more than 1100 patients finding that the incidence of infection and pseudarthrosis was higher in the fixateur group; however, parameters of long-time outcome remained unaffected. Most trauma surgeons are following the strategy, to restore the anatomic shape of the joint as good as possible if the surrounding parameters allow this. If these parameters are in conflict of ORIF, hybrid fixation is a good option to avoid substantial malposition of fragments using just conservative therapy. However, no clear recommendation can be made due to the lack of good studies in this respect. Hence, every surgeon has to identify the optimal therapeutic way for its own individual patient and the surrounding options.

12.6 Conclusion

Patients with proximal tibia fractures present with an extremely wide range of different fracture types and outcomes. Hence, a highly differentiated therapeutic approach is required; our recommendations are:

- All get a CT.
- Clarify therapeutic way conservative/surgical thoroughly according to.
- Patient individual situation in respect of demand, perioperative risk and rehabilitation potential

If surgical:

Identify key fragment(s).

Respect timing and soft tissue.

Choose most appropriate approach using 360° strategy.

Use modern anatomical preshaped locking plates.

Be careful with indication for revision due to risk of infection.

References

1. Acklin YP, Potocnik P, Sommer C. Compartment syndrome in dislocation and non-dislocation type proximal tibia fractures: analysis of 356 consecutive cases. Arch Orthop Trauma Surg. 2012;132:227–31.
2. Philipp A, Gunther S, Jan B, et al. Balloon osteoplasty–a new technique for reduction and stabilisation of impression fractures in the tibial plateau: a cadaver study and first clinical application. Int Orthop. 2012;36(9):1937–40.
3. Aldebeyan W, Liddell A, Steffen T, et al. Proximal tibial fracture following anterior cruciate ligament reconstruction surgery: a biomechanical analysis of the tibial tunnel as a stress riser. Knee Surg Sports Traumatol Arthrosc. 2015;
4. Frosch KH, Balcarek P, Walde T, et al. A new posterolateral approach without fibula osteotomy for the treatment of tibial plateau fractures. J Orthop Trauma. 2010;24:515–20.
5. Alexander H, Stanislav G, Thorsten G, et al. Autologous iliac bone graft compared with biphasic hydroxyapatite and calcium sulfate cement for the treatment of bone defects in Tibial plateau fractures: a prospective, randomized, open-label, multicenter study. J Bone Joint Surg. 2020;102(3):179–93.
6. Honkonen SE. Indications for surgical treatment of tibial condyle fractures. Clin Orthop Relat Res. 1994;302:199–205.
7. Hughston JC, Jacobson KE. Chronic posterolateral rotatory instability of the knee. J Bone Joint Surg Am. 1985;67-A:351–9.
8. Johnson EE, Timon S, Osuji C. Surgical technique: Tscherne-Johnson extensile approach for tibial plateau fractures. Clin Orthop Relat Res. 2013;471:2760–7.
9. Krause M, Preiss A, Müller G, et al. Intra-articular tibial plateau fracture characteristics according to the "ten segment classification". Injur. 2016;47:2551–7.
10. Lobenhoffer P, Gerich T, Bertram T, et al. Particular posteromedial and posterolateral approaches for the treatment of tibial head fractures. Unfallchirurg. 1997;100:957–67. (In German)
11. Luo CF, Sun H, Zhang B, et al. Three-column fixation for complex tibial plateau fractures. J Orthop Trauma. 2010;24:683–92.
12. Moore TM. Fracture–dislocation of the knee. Clin Orthop Relat Res. 1981;156:128–40.
13. Morin V, Pailhé R, Sharma A, et al. Moore I posteromedial articular tibial fracture in alpine skiers: surgical management and return to sports activity. Injury. 2016;47:1282–7.
14. Müller ME, Koch P, Nazarian S, et al. The comprehensive classification of fractures of long bones. Berlin, Heidelberg: Springer-Verlag Berlin Heidelberg; 1990. p. 148–91.
15. Noble J, Alexander K. Studies of tibial subchondral bone density and its significance. J Bone Joint Surg. 1985;67-A:295–302.
16. Prat-Fabregat S, Camacho-Carrasco P. Treatment strategy for tibial plateau fractures, an update. EFORT Open Rev. 2016;1:225–32.
17. Rüedi TP, Buckley RE, Moran CG. AO principles of fracture management second expanded edition, vol. 2. Thieme Verlag; 2007. p. 830 ff.
18. Schatzker J, McBroom R, Bruce D. The tibial plateau fracture, the Toronto experience 1968–1975. Clin Orthop Relat Res. 1979;138:94–104.
19. Dominik V, Markus N, Heike E, et al. Outcome after polyaxial locking plate osteosynthesis in proximal tibia fractures (VALCP ® vs. NCB-PT®): a prospective randomized clinical trial. Orthop J Sports Med. 2020;8(5 suppl):4.
20. Yoon YC, Sim JA, Kim DH, et al. Combined lateral femoral epicondylar osteotomy and a submeniscal approach for the treatment of a tibial plateau fracture involving the posterolateral quadrant. Injury. 2015;46:422–6.
21. Yu B, Han K, Zhan C, et al. Fibular head osteotomy: a new approach for the treatment of lateral or posterolateral tibial plateau fractures. Knee. 2010;17:313–8.
22. Li Z, Wang P, Li L, et al. Comparison between open reduction with internal fixation to circular external fixation for tibial plateau fractures: a systematic review and meta-analysis. PLoS One. 2020;15(9):e0232911.