Extended lateral column tibial plateau fractures. How do we do it?

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Abstract

We describe the operative management of extended lateral column fractures according to the revised three-column classification approach in a step-by-step fashion. We show that direct reduction and stable fixation of extended lateral column tibial plateau fractures via a limited arthrotomy and tibia condyle osteotomy, with the use of free subchondral 2.7 mm locking screws is a reliable technique. Subsequently, diverging VA-LCP locking screws further improve the structural properties. It is a straightforward technique and the single lateral approach (Lazy-S) facilitates direct reduction of the articular surface and stable fixation of the fracture fragments under direct vision with good radiological and fair functional outcome.

Introduction

According to the revised three-column classification (rTCC), lateral tibial plateau fractures that extend into the posterolateral corner are defined as extended lateral column fractures and treated via a single lateral approach (Fig. 1) [1]. It's an improvement of Luo's three-column concept, who defined the posterior border of the lateral column anterior of the fibula head [2]. However, with the introduction of variable angle – locking compression plates (VA-LCP) with a 30 degrees cone, we are now able to diverge the VA-LCP locking (rafting) screws posteriorly into the posterolateral corner, through the fracture and ensure adequate fixation and articular support of extended lateral column fractures. Moreover, free subchondral locking screws are used for reconstruction of comminuted subchondral fracture fragments, and are likely to improve fracture fixation and provide an extra mechanical barrier between the joint and proximal VA-LCP rafting screws [3]. The use of these free subchondral locking screws is in line with screws inserted in a jail technique that tend to strengthen structural properties (yield load, stiffness and displacement) in the reconstruction of lateral tibial plateau fractures [4,5].

In contrast to extended lateral column fractures, the bio- mechanical stability of lateral plate fixation of posterolateral column fractures is inferior to posterior buttress plate fixation [6,7]. Posterolateral column fractures are not limited to the posterolateral corner but also include tibial plateau fractures medial of the fibula head (Fig. 1). Krause's ten-segments classification (10SC) provides good insight in these posterolateral column fractures, especially posterolateral corner and cruciate ligaments avulsion fractures, however it is rather a morphologically exhaustive classification and its clinical applicability seems limited (Fig. 2) [8].

Here we describe in a step-by-step fashion the direct open reduction and internal fixation (ORIF) of extended lateral column tibial plateau fractures with use of free subchondral locking 2.7 mm screws, via an arthrotomy and tibia condyle osteotomy. The purpose of this technical note is to show that extended lateral column fractures can in fact sufficiently be treated via and a single lateral approach, using free subchondral screws and VA-LCP. We retrospectively assessed the quality of the reduction (existence of gaps and steps) and potential loss of reduction, as well as functional outcome and quality of life postoperatively. Moreover, we evaluated the 10SC and its value in the treatment of extended lateral column fractures (Fig. 3).

Surgical technique

The technique of direct ORIF via an arthrotomy and tibia condyle osteotomy using free subchondral 2.7 mm locking screws has previously described by us for lateral tibial plateau fractures [3]. For the treatment of extended lateral column fractures with sufficient exposure of the posterolateral, a lateral lazy-S incision over Gerdy's tubercle is made (Fig. 4) and the anterior tibial muscle and iliotibial band are partially detached before a submeniscal arthrotomy is performed (Fig. 5). Subsequently, an osteotomy of the lateral tibia condyle through the fracture and/or with the use of an oscillating saw (Fig. 6). The lateral condyle is flipped posteriorly leaving the posterior wall intact. The fracture fragment(s) can directly be reduced and the joint reconstructed under direct vision (possibly ex situ), and the fracture fragment (s) temporarily fixated (Fig. 7). After monitoring the reduction radiographically, the bone defect is filled with solid autologous or allogenic allograft (Fig. 8). Definitive fracture fixation is carried out by replacing the K-wires with subchondral 2.7 mm locking or headless screws (Fig. 9). The lateral tibia condyle is folded back and a VA-LCP is applied and the proximal locking screws diverging through the fracture, below the free subchondral screw (Figs. 10 and 11). Finally, the lateral meniscus is fixed, the fascia closed over the plate and the wound is closed in layers.

Discussion

We have shown that direct ORIF of extended lateral column tibial plateau fractures via a limited arthrotomy and tibia condyle osteotomy with the use of free subchondral locking screws is a good technique. Between 2014–2017 a total of 34 patients were treated with VA-LCP for an acute (< 3 weeks) single extended lateral column fracture with >2 mm articular depression. Demographics, clinical and radiological characteristics of these patients are summarized in Table 1. None of the patients experienced neuro- vascular complications. All fractures were classified on a preoperative CT and 29 patients got a CT at a median of 3.0 months (IQR 2.78–3.45) postoperatively. Despite adequate fracture rafting by means of the proximal VA-LCP lock screws and the use of free subchondral screws (Fig. 12), only one patient showed loss of reduction (i.e. articular collapse) due to devitalization of the lateral tibia condyle. It concerned a 76yo male patient with severe osteopathic bone, preexisting gonarthrosis and multiple subchondral geodes on the preoperative CT. 2 Patients were lost in the follow-up. The remaining 32 patients reported a fair functional outcome and quality of life (KOOS - Knee injury and Osteoarthritis Outcome Scale) at a median follow-up of 17.6 months (IQR 13.6– 29.2), although worse compared to nonoperatively treated patients and the general population (Fig. 13) [[13]]. Especially function in sports and recreation, and quality of life were affected.

Subsequently, all fractures were mapped according to the 10SC and could be categorized into five fracture types (Fig. 14). The majority suffered from combined laterolateral and laterocentral tibial plateau

fractures. Although the intercondylar eminence is considered as 2 independent segments with the attachment of the cruciate ligaments, no association was found between involvement of the anterocentral or posterocentral segment and cruciate ligament associated knee instability. Despite accurate description of the articular fracture morphology, the 10SC seems not to be a very helpful surgical guiding tool in addition to the rTCC.

Classically, depressed fractures of the lateral and medial tibial plateau are reduced using a plunger. Although this is a proven technique for the treatment of articular depressed fractures without cortical interruption (zero column fractures), it carries an increased risk for (irreparable) articular injury (i.e. perforation) especially in osteoporotic bone and with which the patient just get worse. In contrast, in most cases an anterolateral cortical fracture facilitates an osteotomy, easily allowing the lateral condyle to flip posteriorly and direct ORIF.

Here, we present a technical note on direct ORIF of extended lateral column tibial plateau fractures using free subchondral 2.7 mm screws. The reconstruction of the articular surface is carried out under direct vision by an arthrotomy and tibia condyle osteotomy. This way, the reduction of the articular surface can very well be controlled. An lazy- S incision sufficiently exposes the entire extended lateral plateau, wherein even a retractor can be placed behind the posterior wall medially of the fibula head. Meniscal tears can immediately be repaired. The great advantage however, free subchondral screws maintain the articular reduction and stable fixation of (multiple) fracture fragments. Like the jail technique, free subchondral locking screws for the reconstruction of (extended) lateral column fractures, are positioned between the articular surface and VA-LCP rafting screws and improve structural properties. Moreover, migration of frequently used free K-wires is thus avoided. Instead of using lag screws, locking screws (or headless screws) better sink into the subchondral bone. In the case of a limited subchondral bone stock, 1 mm K-wires can be used as an alternative, however, this results in less stability and a risk of K- wire migration.

Nevertheless, possible adverse effects include a risk for devitalization of the lateral tibia condyle due to the osteotomy. In addition, there are orthopaedic surgeons who claim that the free subchondral screws might hinder a future total knee arthroplasty (Fig. 15).

Conclusions

The rTCC approach for the treatment of extended lateral column fractures has proven to be reliable. VA-LCP provide whole articular support and compression osteosynthesis, and stabilizes the metaphysis against axial forces, allowing immediate functional treatment and plantar touch (approximately 10–20 kg weight-bearing) for 8 weeks until full load. A knee brace is reserved only for patients with instability. Subsequently, free subchondral screws provide stable fixation, prevent secondary loss of reduction and facilitate cartilage healing. Overall, since this technique is relatively straightforward and offers an excellent exposure of the fracture, it facilitates reduction of the articular surface and stable fixation of the fracture fragments with good radiological and fair functional outcome. No added value of the 10SC was found.

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Figures

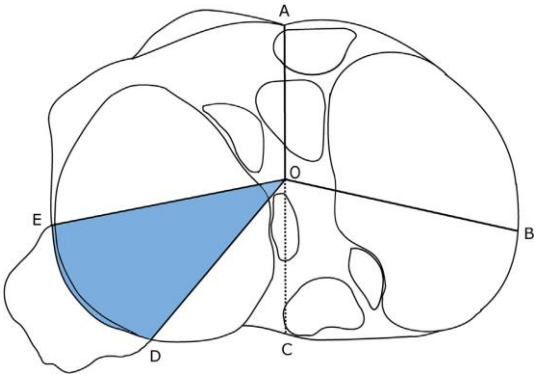

Fig. 1. Revised three-column classification (rTCC). According to the rTCC, lateral column fractures that extend into the posterolateral corner (blue area - OED), are defined as extended lateral column fractures (OAD) and treated via a single lateral approach. Posterolateral corner fractures extending more medially of the fibular head are referred to as posterolateral column fractures (OEC) and should be treated via a posterior approach (OEB).

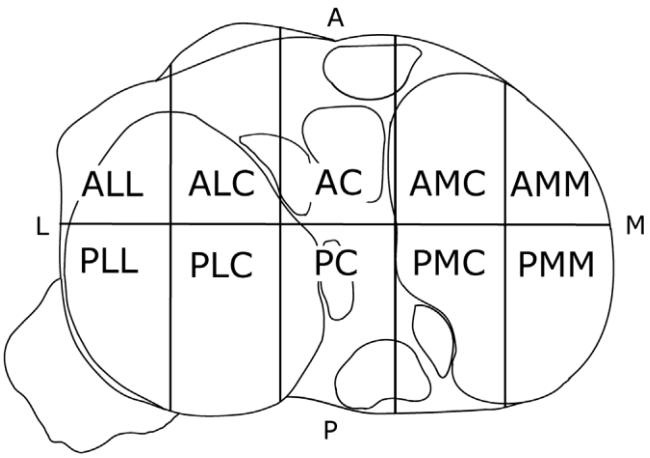

Fig. 2. Ten-segment classification (10SC). The 10SC divides the tibial plateau in the axial plane in an anterior and posterior half. Both halves are subdivided into 5 equal segments: ALL, anterolateral; ALC, anterolateralcentral; AC, anterocentral; AMC, anteromediocentral; AMM, anteromediomedial; PMM, posteromediomedial; PMC, posteromediocentral; PC, posterocentral; PLC, posterolateralcentral; PLL, posterolateralateral

A B C

Fig. 3. Preoperative CT images of a patient with an extended lateral column fracture. Coronal (A), sagittal (B) and axial (C) view.

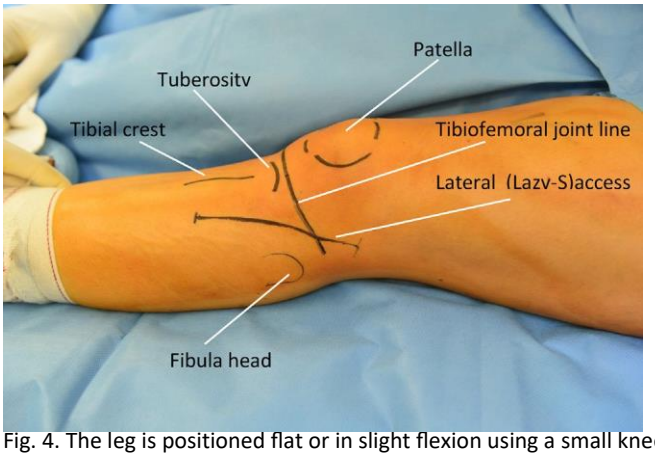

Fig. 4. The leg is positioned flat or in slight flexion using a small knee roll. The relevant anatomical landmarks are marked: fibular head, tibial crest, tuberosity, patella, tibiofemoral joint line and lateral access are marked. A the sterile tourniquet is applied. The lateral approach starts distally 2–3 cm off the tibial crest. While brought proximally, a posterior direction is taken over Gerdy's tubercle. Next, the incision bends slightly towards posterior and straightened a couple of centimeters above the knee joint (lazy-S).

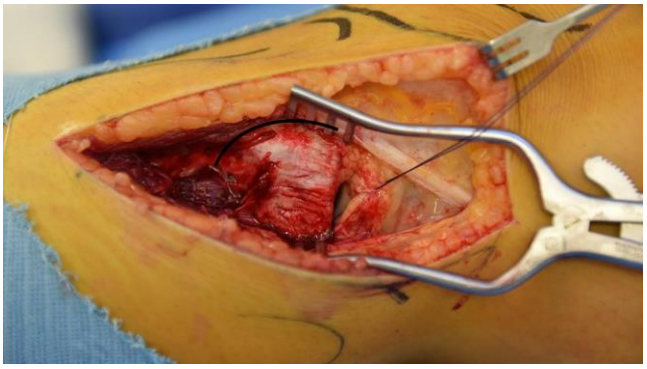
Fig. 5. Next, the origin of the anterior tibial muscle and iliotibial band are gentle detached from Gerdy's tubercle. After an arthrotomy, the meniscus is dissected laterally and elevated to visualize the articular surface.

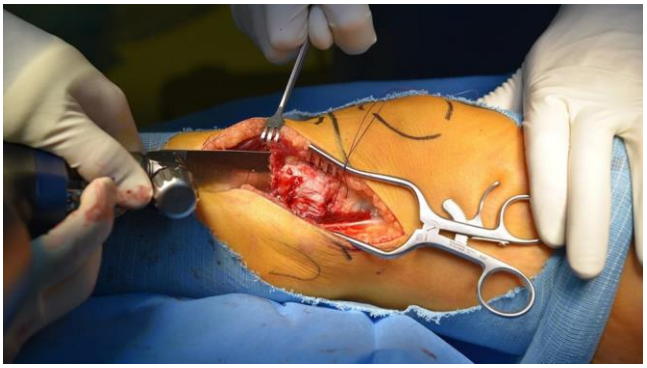
Fig. 6. In this step, an osteotomy of the lateral tibial condyle is performed through the fracture and/or with the use of an oscillating saw. In order to get sufficient exposure of the fracture and preserve the blood supply of the lateral condyle, a substantial osteotomy leaving the posterior cortex intact is necessary.

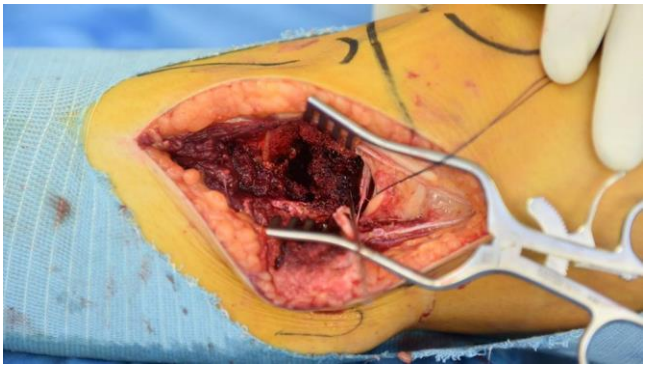

Fig. 7. The lateral condyle or facet can then be flipped posteriorly and placed behind a distractor. Subsequently, direct fracture reduction is possible. In addition, a retractor can be placed behind the posterior wall. The reduction is temporarily held in place using 1.6 mm subchondral Kirschner wires. In case of small osteochondral fracture fragments, 1.0 mm Kirschner wire can be left in place permanently. The reconstruction of the articular surface of comminuted fractures can be done either in or ex situ in order to reach good congruence of the articular surface.

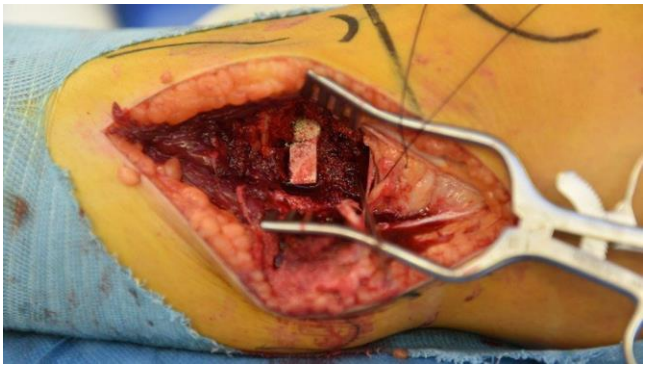

Fig. 8. We recommend to fill the larger metaphyseal bone defects with autologous or allogenic bone. Here lyophilized (freeze dried) radiation-sterilized allograft, was used. For larger defects, a freeze-dried femoral head allograft may be necessary to provide biomechanical support of the joint.

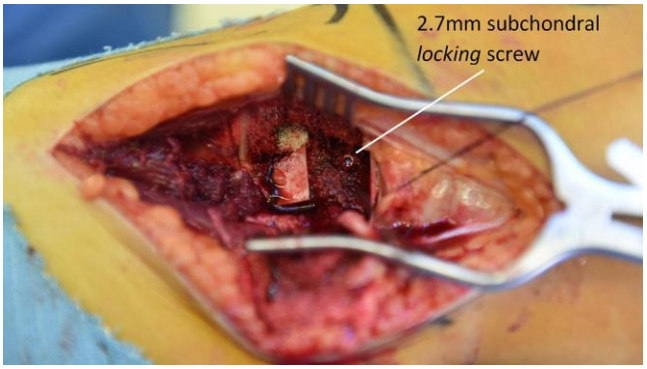

Fig. 9. Fracture fixation is carried out with free subchondral 2.7 mm locking screws. These are isolated screws that secure the reduction extremely well. The use of locking screws (although they do not lock) or headless screws is advisable, since these screw heads sink easily into cancellous bone flush under the cartilage. The screw position is checked using intraoperative fluoroscopy. The Kirschner-wires, which were used for the temporary fixation can be removed now.

Fig. 10. Folding back the lateral tibial condyle and temporary fixation with a Kirschner wires.

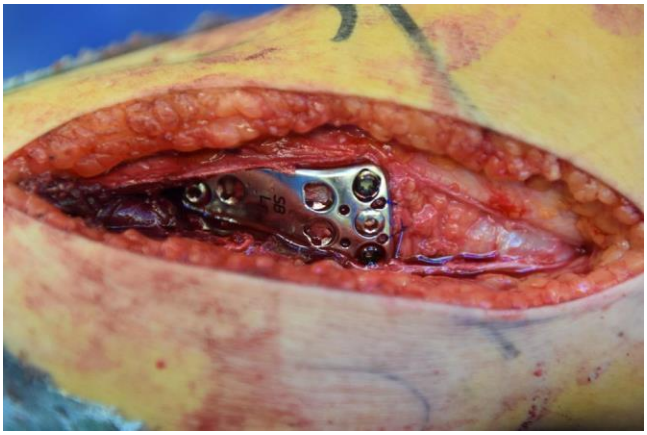

Fig. 11. An anatomic variable angle – locking compression plate (VA-LCP) is applied over the (cut) Kirschner wire. The exact height of plate is checked using fluoroscopy. The plate is fixed with a metaphyseal lag screw first. A second lag screw proximally in order to achieve compression of the fracture fragments is optional. The protruding Kirschner wires are then removed. The proximal VA-LCP locking (rafting) screws provide full articular support by diverging them both anteriorly and posteriorly. Ideally, the VA-LCP locking screws positioned are under and cross the free subchondral screws to further support the joint surface. The lateral meniscus is loosely fixed at the plate with slowly absorbable sutures. The wound is closed in layers. The fascia should be closed over the plate.

Fig. 12. Postoperative coronal (A) and sagittal (B) radiographs, as well as VRT (volume rendering technic) CT with MAR (metal artefact reduction) coronal (C), sagittal (D) and axial (E) images show the free subchondral screws and the diverging VA-LCP locking (rafting) screw that provide articular support.

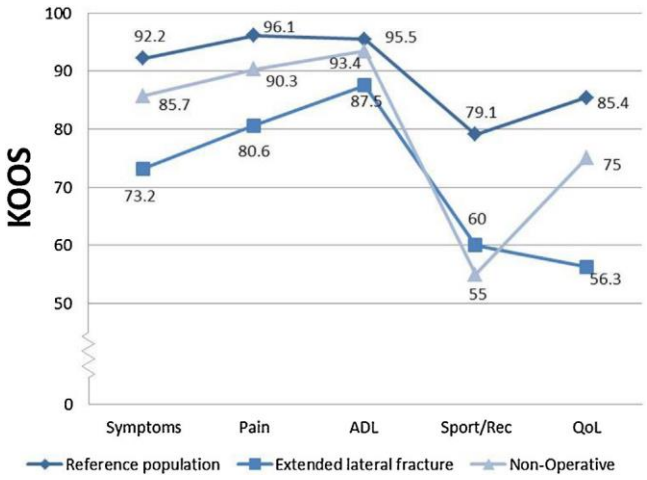

Fig.13. Knee Injury and Osteoarthritis Outcome Score (KOOS). KOOS subscales for extended lateral fractures compared to nonoperatively treated tibial plateau fractures and the general population [13]: symptoms; pain; ADL, activities of daily living; Sports/Rec, function in sports and recreation; QoL, Quality of Life. A normalized score (100 indicating no symptoms and 0 indicating extreme symptoms) was calculated for each subscale.

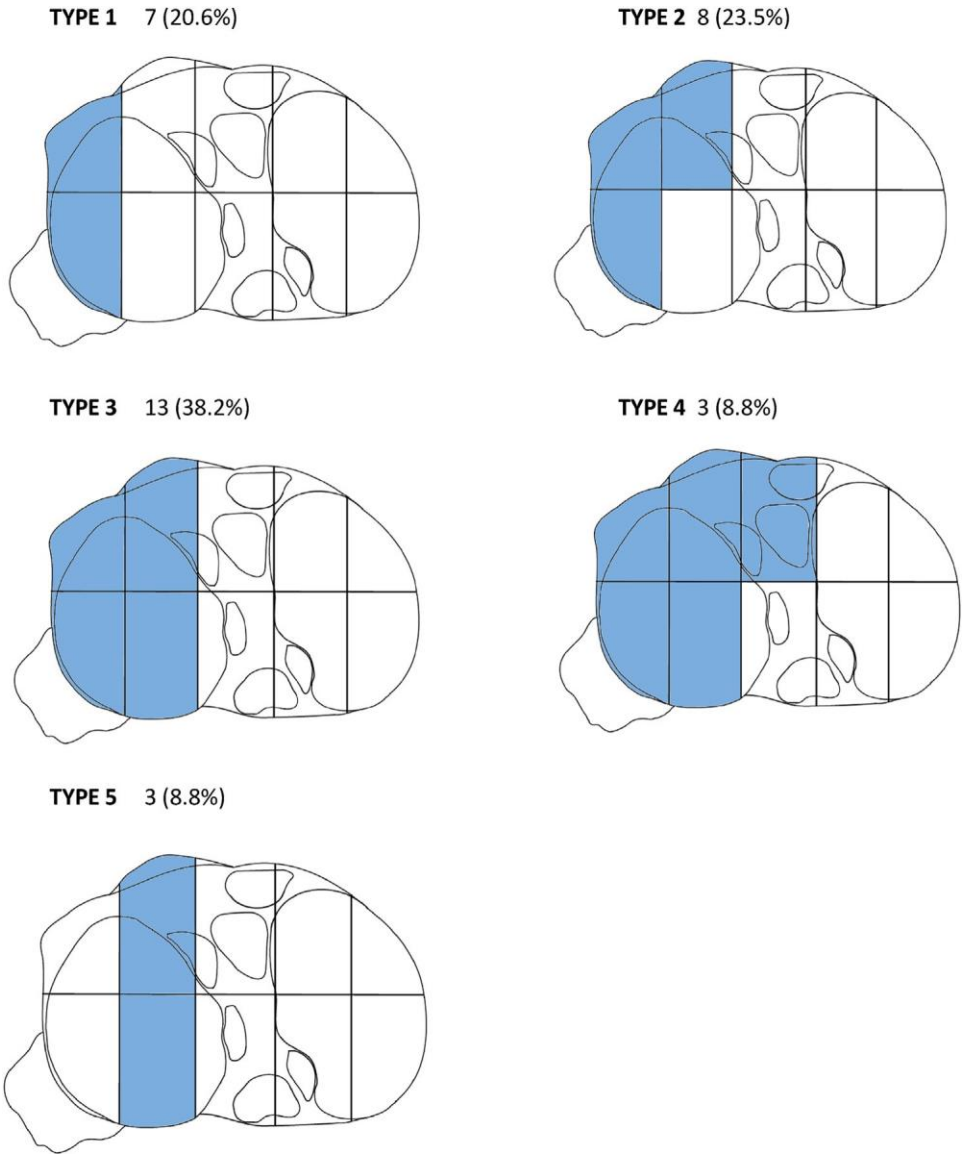

Fig. 14. Fracture mapping according to the Ten-segment classification (10SC). All extended lateral column fractures were mapped according to the 10SC and could be categorized into five fracture types.

A B

Fig. 15. Free subchondral screws refers to the subchondral 2.7 mm locking screws enclosed in the bone and left in situ after plate removal. Coronal (A), sagittal (B) view.

Tables

Table1. Demographic, clinical and radiological characteristics (n = 34).

Demographics	
Age (years)	45.5 (30.0–66.5)
Gender	
Male	15 (44.1%)
Female	19 (55.9%)
ASA-score	
1	12 (35.3%)
2	16 (47.6%)
3	6 (17.6%)
BMI (kg/m^2)	24.0 (21.2–27.6)
Smoking	6 (17.6%)
Diabetes mellitus	4 (11.8%)
Other CVRF	9 (26.5%)
Fracture side	
Left	18 (52.9%)
Right	16 (47.1%)
Fracture rafting	34 (100%)
Posterior proximal tibia angle (81 ±5)	84.4 (82.0–88.6)
Lateral proximal tibia angle (93 ± 5)	93.3 (90.0–94.7)
Additional subchondral fixation	
None	8 (23.5%)
Subchondral screws	24 (70.6%)
Subchondral screws and K-wire	2 (5.9%)
Post-operative knee instability	4 (11.8%)
Articular gap and/or step	11 (32.4%)
Loss of reduction	1 (2.9%)
Postoperative complication rate	
Infection after fracture fixation	1 (2.9%)
Nonunion	1 (2.9%)
Other complications	2 (5.9%)
Reintervention rate	
Material removal	9 (26.5%)
Total knee arthroplasty	1 (2.9%)

Continuous variables are expressed as median and interquartile range, and categorical variables as number and percentages. The quality of the reduction was assessed and marked as failed in the presence of articular gap and/or step >2 mm [9,10]. Infection after fracture fixation and nonunion were defined according to the literature [11,12]. Loss of reduction was defined as secondary depression >2 mm on CT postoperatively. Abbreviations: ASA, American Society of Anesthesiologists; BMI, Body Mass Index; CVRF, cardiovascular risk factors.