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Free subchondral screws in tibial plateau fractures: do they hinder a total knee arthroplasty? Strategies to prevent complications

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Open reduction and internal fixation of extended lateral column tibial plateau fractures through a tibial condyle osteotomy and limited arthrotomy with the use of free subchondral locking screws is a straightforward and safe technique. However, these free subchondral screws are enclosed in the subchondral bone and therefore virtually impossible to remove after bone healing. The question arises whether these free subchondral screws might hinder a future total knee arthroplasty. In order to refute this, we retrospectively reviewed all surgically managed tibial plateau fractures in our tertiary center during one year and assessed the number, position and configuration of these in situ subchondral screws and K-wires. In addition, we performed a cadaver study, wherein we prepared 7 tibial plateaus for a total knee arthroplasty tibial component placement with free subchondral screws in situ. In this experiment, we demonstrated that free subchondral screws do not interfere with total knee arthroplasty, but they can increase operative time in some cases. We also provide recommendations to avoid difficulties and potential complications.

Keywords: tibial plateau fractures, extended lateral column, osteosynthesis, free subchondral screws, total knee arthroplasty, complications.

INTRODUCTION

The trauma mechanism based three-column classification approach has been proven very useful for the classification and preoperative planning of tibial plateau fractures[1-3]. Lateral column fractures that extend into the posterolateral corner (Figure 1) can usually be addressed well through a lateral approach with the use of a variable angle locking compression plate (VA-LCP)[4,5]. From a surgical technical standpoint, as well as due to more stable fragment fixation, articular reconstruction and fixation of comminuted extended lateral column fixation is frequently performed with the use of subchondral K-wires or screws[5,6]. These free subchondral screws are usually cross-configured with the VA-LCP locking screws to form a so-called jail construct. It is assumed that free subchondral screws provide an extra mechanical barrier on top of the VA-LCP locking screws[7,8].

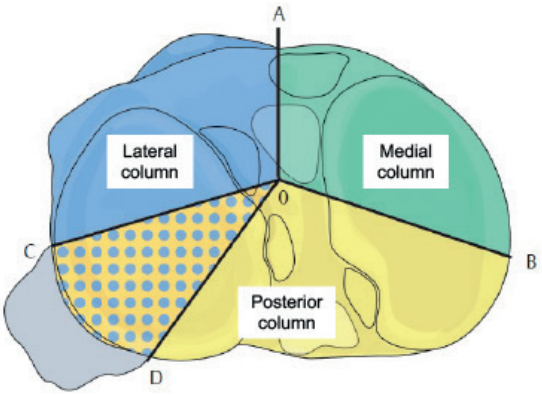

Figure 1 — According to the revised three-column classification (rTCC), lateral column fractures that extend into the posterolateral corner (dotted area - OED), are defined as extended lateral column fractures (OAD). Posterolateral corner fractures extending medially of the fibular head are referred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

However, if hardware removal is indicated, subchondral screws, other than VA-LCP and locking screws, are nearly impossible to remove. Performing a re-osteotomy is in theory the only way to remove free subchondral screws after bone healing. Therefore, these

Figure 2 — Coronal (2a) and sagittal (2b) peroperative X-rays of a 34-year-old patient who sustained a 2-column tibial plateau fracture (lateral and posterior column). The articular surface of the extended lateral column was reconstructed and with the use of additional subchondral screws (arrow heads). Unfortunately, the postoperative course was complicated by a severe fracture-related infection (St. Aureus), probably due to the postoperative fasciotomy for an imminent compartment syndrome. All osteosynthesis material was removed, except for the 2 free subchondral screws (2c-2d) that were left in situ. Because of the purulent infection (including the joint), there might be progressive joint degeneration in the long term, for which a TKA will eventually be indicated.

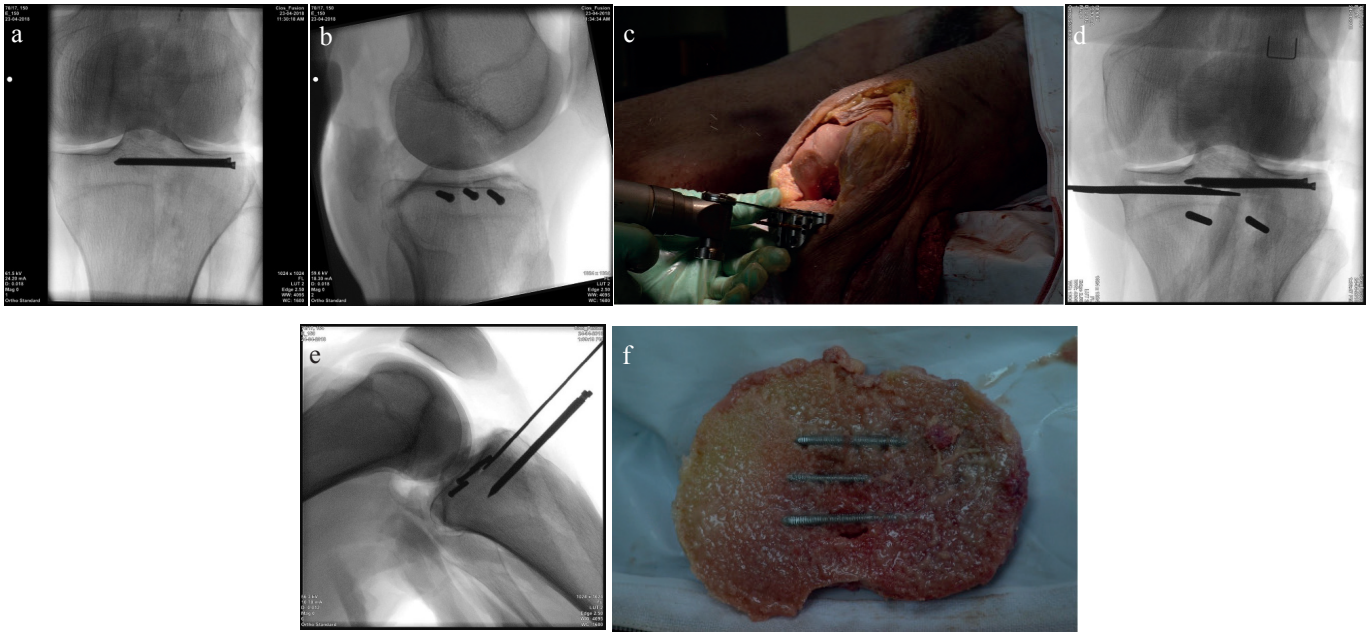

Figure 3 — In the majority of the cases the free subchondral screws for the treatment of extended lateral column fractures did not hinder a total knee arthroplasty placement at all. Anteroposterior (3a) and sagittal (3b) view of the left knee, with 3 free subchondral screws in situ for a supposed extended lateral tibial plateau fracture. The resection guide was placed on the lower leg with care being taken for adequate alignment (3c). The tibial cut was determined on 10mm resection under the medial compartment. All screws were resected within the tibial cut (3d-3e). There was no conflict with saw (3f).

free subchondral screws are normally left *in situ* and might pose a potential conflict here for a future total knee arthroplasty (TKA) (Figure 2a-2d). Although the 10-year likelihood ratio of a TKA after a tibial plateau fracture for end-stage post-traumatic osteoarthritis or residual instability is not very high, approximately 5%, the presence of free subchondral screws might be very aggravating[9-15].

In order to determine to what extent these subchondral screws can interfere with the placement of a TKA, we retrospectively reviewed all surgically managed tibial plateau fractures in our tertiary center during one year and assessed the number, position, and configuration of these *in situ* subchondral screws and K-wires. Next, we performed a cadaver study, wherein we prepared the tibia plateau for a TKA tibial component placement

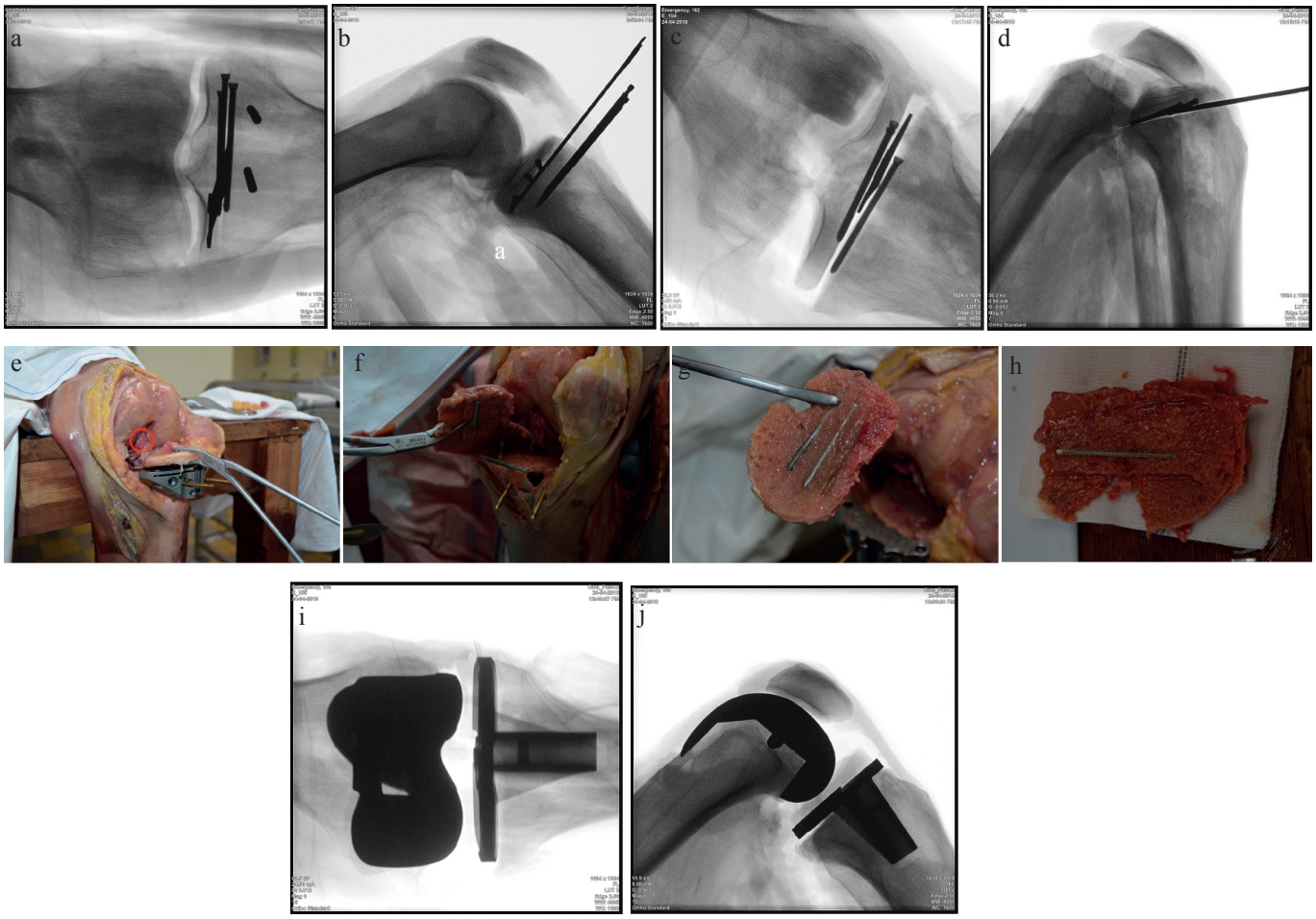

Figure 4 — In 2 cases the subchondral screws were at the level of the tibial cutting plane, which led to a clear (audible) conflict with the saw (4a-4d). As a result, not all subchondral screws were in the tibial cut, but the remaining subchondral screws could be removed manually from the cutting plane. (4e-4f). This was rather easy since they were loosened due to the saw hitting these screws. (4g-4h). After preparing the femoral component (with a new saw) the TKA (Zimmer NexGen) was placed (4i-4j). Note, in one case procedure was performed in reverse with first the femoral component being prepared, before performing the tibial cut (4c-4d).

with free subchondral screws *in situ* and evaluated whether or not they complicate the procedure.

MATERIAL AND METHODS

A retrospective cohort study was conducted in our level 1 trauma center. All consecutive operatively treated patients sustaining an (extended) lateral tibial plateau fracture (Figure 2) between January 2019 and December 2019 were evaluated for eligibility. Preoperative CT imaging was mandatory to classify all fractures according to the revised three-column classification[3,4]. Postoperative CT images were used to assess the number, position, and configuration of the *in situ* subchondral screws and K-wires. This study was completed in compliance with national legislation and the guidelines of the ethics committee of the University Hospitals Leuven (S57871).

Specimens were prepared by the Anatomical Skills Center, Vesalius Institute of the KU Leuven. 3 Subchondral 2.7mm *locking* screws (46-48mm, DePuy Synthes) were placed percutaneously in the extended lateral column of the left tibia plateau by an experienced trauma surgeon (Figure 3a-3b). These screws were positioned into the subchondral bone, at least 10 mm deep (measured from the lateral cortex) and fluoroscopy controlled, recorded, and blinded for the surgeon preparing the tibial placement of the TKA. Next, the specimens were placed on an anatomical table with the leg hanging free and the ability to place the foot on the table, to flex the knee sufficiently and prepare the proximal tibia. A mid patellar longitudinal incision was made. Skin flaps were retracted to both sides, followed by a medial arthrotomy. The patella was flipped over to the lateral side. Hoffa was excised as well as the lateral and medial meniscus. We resected the

anterior cruciate ligament. Next, the standard approach for the placement of a total knee (Zimmer NexGen): the resection guide was placed on the lower leg (Figure 3c), care was being taken for getting adequate alignment with the second toe and the tibial crest. It was decided on a 10mm resection under the medial compartment because all knees contained subchondral screws placed for a supposed extended lateral tibial plateau fracture. During the resection X-rays were obtained to monitor the position of the saw in relationship to the screws (Figure 3d-3e, Figure 4a-4d). During and after removal of the tibial compartment, digital photos were taken to see the screws in relation to the tibial cut (Figure 3f, Figure 4e-4h). Subsequently, we prepared the femoral component and placed the TKA (Figure 4i-4j).

RESULTS

In our tertiary center, 4% of all tibial plateau fractures required conversion to a TKA within 10 years of follow up (4% operative *vs.* 1% non-operative treated patients)[15].

After reviewing all tibial plateau fractures admitted to our hospital in 2019, 43 tibial plateau fractures were treated with open reduction and internal fixation. Additional subchondral screw fixation was performed in 16 cases (37.2%). The demographic and radiologic data is summarized in Table I.

All these patients got a postoperative CT scan to confirm adequate articular reduction. Average screw distance from the articular surface was measured on postoperative CT scans, subsequently. Average minimal screw distance to the articular surface was 2mm (range 0-6 mm) and the maximal distance was 9mm (range 2-18 mm).

Only one patient with a three-column tibial plateau fracture, who was treated operatively with the use of subchondral screws, suffered valgus collapse and had to be converted to a TKA. After initial surgery, this patient was not allowed full weight-bearing for eight weeks (routinely). The first CT scan at four months postoperatively showed an acceptable alignment without signs of collapse. However, seven months postoperatively, the patient suffered from functional deterioration and radiographic examination showed collapse of the tibial plateau. To that end, the decision was made to remove all removable implants and prepare for a TKA. Four subchondral screws remained *in situ*. Three were oriented latero-medially, and one was oriented antero-posteriorly in the medial plateau. Despite sterile perioperative cultures, three sonication cultures of the removed implants produced a multisensitive Staphylococcus epidermidis. The patient was treated for a (low grade) fracture related infection with clindamycin initially, but due to intolerance over time it was decided to switch to moxifloxacin in order finish her six week course of antibiotics.

The conversion to a TKA was performed in two stages. In the initial stage, three months after removal of the implants, a resection arthroplasty and cement spacer insertion was performed. Since the most distal subchondral screw was located 8mm below the articular surface, all four screws could easily be resected. The second stage of the revision was performed six weeks later, during which she was treated with moxifloxacin again. A hinged TKA with a femoral and tibial stem was implanted.

Seven fresh human cadavers were used in this study. In all 7 knees it was reasonably easy to make the tibial cut. In 5 of the 7 cases all screws were resected within the tibial cut (Figure 3f). In 3 cases we experienced an audible contact between the saw and the subchondral screw(s), wherein in 2 cases the subchondral screws had to be removed manually from the tibial cutting plane after resection of the tibial cut. This was rather easy since these were hit by the saw and loosened. Surprisingly, being blinded for the preoperative X-rays it was relatively easy to make the tibial cut. However, we experienced some difficulties preparing the femoral component of the total knee, due to bluntness / damage of the saw after audible contact between the saw and the screws.

DISCUSSION

The use of subchondral screws and K-wires for reconstruction and fixation of joint fractures is widespread. From a technical point of view, subchondral screws or K-wires allow one to reconstruct the joint more easily. In particular for (extended) lateral tibial plateau fractures, the use of subchondral screws is also a good strategy for more stable fixation of more comminuted joint fracture fragments. Despite it being suggested that the use of subchondral screws may pose potential problems for a future TKA, we demonstrated in our experiments that this is not the case. The free subchondral screws used for the fixation of extended lateral column fractures did not hinder the TKA, more specifically the placement of the tibial component. Considering that the subchondral screws are positioned to about 10mm below, parallel to the joint surface, the tibial cut could be performed without any problem. Nevertheless, one should be aware that the saw can be blunt or damaged to some extent and should be changed

Table I. — Demographic and radiographic data

Number	Age	Sex	Schatz.	# col	Use	# subch. screws	# subch. K wires	Min dist.	Max dist.	Orientation
1	47	M	2	1	0	0	0			
2	16	M	1	1	0	0	0			
3	75	F	2	1	1	0	2	1	4	0
4	48	F	2	1	1	1	0	1	6	0
5	76	F	3	1	1	2	0	2	5	2
6	21	F	2	2	1	1	0	1	4	0
7	38	F	2	2	1	1	0	3	8	0
8	61	M	2	0	0	0	0			
9	52	M	5	1	0	0	0			
10	73	F	2	2	0	0	0			
11	60	M	3	1	1	2	0	4	9	1
12	55	M	2	2	1	2	0	0	9	0
13	36	M	6	2	0	0	0			
14	53	F	2	2	0	0	0			
15	22	M	2	2	0	0	0			
16	46	M	1	1	0	0	0			
17	85	F	2	1	1	0	2	0	60	0
18	37	M	6	2	0	0	0			
19	63	F	5	2	1	2	0	1	18	0
20	47	M	6	3	0	0	0			
21	48	M	5	3	1	1	0	2	13	0
22	69	F	2	1	0	0	0			
23	62	F	6	3	0	0	0			
24	46	M	5	3	0	0	0			
25	46	M	5	2	0	0	0			
26	80	M	2	1	0	0	0			
27	61	F	2	1	0	0	0			
28	61	F	3	1	0	0	0			
29	67	F	5	3	0	0	0			
30	45	F	4	1	0	0	0			
31	48	F	6	3	0	0	0			
32	52	F	2	1	1	2	0	3	11	1
33	60	F	3	1	0	0	0			
34	65	F	1	1	1	2	0	2	8	0
35	86	F	4	2	0	0	0			
36	43	F	2	1	1	2	0	6	10	0
37	57	F	6	3	1	1	0	0	8	0
38	67	F	3	1	0	0	0			
39	66	F	3	1	0	0	0			
40	52	M	2	2	1	1	0	1	17	0
41	70	F	6	3	1	4	0	1	8	0
42	57	F	2	2	1	2	0	4	15	0
43	71	F	4	1	0	0	0			

Number: anonymized patient number; Age: patient age; Sex: patient sex; Schatz.: classification according to the Schatzker classification; # col: amount of columns involved according to the revised three-column classification; Use of subchondr. screws: whether subchondral screws and/or K wires were used; # subch. screws: amount of subchondral screws used; # subch. K wires: amount of subchondral K wires used; Min dist.: minimal distance measured from the articular surface to the screw or K wire; Max dist.: maximal distance measured from the articular surface to the screw or K wire; Orientation: orientation of the subchondral screw(s) or K wire(s) in the transverse plane. 0 = mediolateral/lateromedial, 1 = anteroposterior, 2 = oblique.

during the procedure. Some surgeons prefer performing the tibial cut first during TKA. To reduce the negative effects from a blunt saw, we recommend resurfacing the patella first (if indicated), and then using the femur first measured resection technique.

As with any TKA, it is important to preserve as much bone stock as reasonably achievable. This is particularly important in the tibia, since an overly distal tibial resection in TKA has some major consequences. Since the proximal tibia is funnel-shaped, a more distal resection will leave a smaller surface for the implant. This increases the risk of a tibiofemoral component size mismatch, which will lead to edge loading, polyethylene wear and implant failure, subsequently[16]. Moreover, there is also an increased risk of aseptic loosening. Due to excessive distal resection, the tibial component will be smaller and placed more posterior and lateral, with a smaller medial support surface[17,18]. Higher amounts of tibial strain have been measured due to an increased lever arm effect[17]. The use of a thicker polyethylene insert turned out not to be a direct cause of early failure here[19]. Furthermore, Hvid and Hansen have shown that the cancellous bone support surface becomes weaker as the tibia cut is more distal, which is another cause for early implant failure[20-22].

Finally, a more distal resection also has consequences for the ligamentous structures that find their insertion on the proximal tibia. Van Opstal et al. demonstrated that on average 67% of the PCL insertion was removed in routine primary knee arthroplasty, especially with increasing posterior slope[23,24]. Patients are also at risk of valgus instability in flexion when the tibia is cut more distally, as demonstrated by Sappey-Marinier et al.[25].

To avoid difficulties and complications, we recommend performing a preoperative CT scan to check the location and orientation of the subchondral screws. If the screws are introduced more or less parallel to the joint surface, it should be possible to make a tibial cut as one would do if there weren't any subchondral screws in situ. Often, the screws will then be resected (Figure 3f) or left *in situ* just distal to the tibial cut and can be removed easily (Figure 4f). If screws are removed from the proximal tibia, distal to the cut, the resulting bone defects can be filled with bone cement once the definitive component is inserted. If the screws are buried deeper (i.e., more distal) and not interfere with the stem or fin of the tibial component, then these screws should be left *in situ*.

The posterior slope of the tibial cut might also be impacted by screw contact. The slope might be increased or decreased as the saw gets directed off its desired angle by passing under or over a screw, respectively (Figure 5a-5b) To combat this issue, we recommend removing any screws that have surfaced once the tibia plateau has been resected. If the saw is redirected superiorly due to a subchondral screw, this might cause a decreased posterior slope. Increased risk of subsidence is a known complication of a decreased posterior slope. This will also cause increased tightness in flexion. A second pass with the saw will prevent these complications[22].

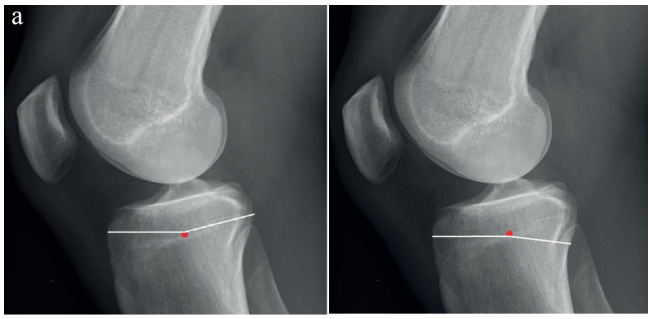

Figure 5 — a demonstrates the first situation, where the saw is redirected superiorly by screw contact, resulting in a decreased posterior slope when implanting the tibial component. b is an example of the reversed situation. These examples show the reason it's harder to correct situation B in comparison to situation A.

The reversed situation is harder to solve. When the saw gets redirected inferiorly by a subchondral screw, the posterior slope will be increased. This problem can be solved by either cementing the tibial component using the anterior tibial edge as a reference. Another option is using the shift holes on the resection guide to resect slightly more, after the subchondral screws have been removed. This will allow the surgeon to get an accurate tibial cut, at the cost of losing some bone stock.

Finally, we recommend using at least a posterior stabilized tibial insert when performing a TKA in a patient with subchondral screws in situ, since it might be hard to preserve part of the posterior cortex where the posterior cruciate ligament (PCL) inserts[23,24]. An overly distal resection might also increase the risk of damage to the patellar tendon or even the tibial tubercle, which is to be avoided at all costs.

There are some limitations of our cadaver study. Almost all subchondral screws were positioned perfectly parallel to the articular surface. Postoperative Metal Artefact Reduction (MAR) CT scans show that this is often not the case in our study cohort patients (Table I). This is often the case when these subchondral screws are used to reconstruct the articular surface from multiple small fragments, especially ex situ (on

the table). More oblique screw placement might make the tibial cut more difficult.

In our daily practice we noticed that the subchondral screws that weren't cut out with the tibial resection, weren't as easily removed as they were on the cadavers. The subchondral bone is more sclerotic in the posttraumatic setting than in a healthy knee, causing the screws to be harder to remove. These can be removed with a small chisel. In our experience, this takes about 10 to 15 minutes, but rarely causes a defect large enough to warrant a change of plans (e.g. using a tibial stem).

CONCLUSION

The use of subchondral screws for reconstruction and fixation of (extended) lateral tibial plateau fractures does not appear to have a negative impact on a possible future TKA, provided that the screws are not positioned too distally and preferably parallel to the joint surface. To avoid unnecessary complications, a preoperative MAR CT is recommended and it goes without further saying that the tibial cut should not be made too distally. Any bone defects due to removed subchondral screws can be filled with bone cement.

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Ethical approval: This study was completed in compliance with national legislation and the guidelines of the ethics committee of the University Hospitals Leuven.

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Statements and Declarations: Competing interests: none.

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