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## FRACTURE OF THE PATELLA AFTER THE ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

*PRELOM ČAŠICE KOLENA POSLE REKONSTRUKCIJE PREDNJEG UKRŠTENOG LIGAMENTA*

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### Summary

**Introduction.** Fracture of the patella, after harvesting the central third of the patellar tendon for a bone–tendon–bone autograft, is a rare complication. **Material and Methods.** We made 1714 reconstructions of the anterior cruciate ligament of the knee using bone–patellar tendon–bone technique, and 7 patients had fracture of the patella (0.42%). The fracture was immediately recognized in the patients with vertical non-displaced patellar fracture and the broken screw osteosynthesis was carried out without changes in the rehabilitation period. One patient was treated non-operatively and patellar fracture in four patients was treated with operative reduction and osteosynthesis. **Results.** The patients were invited for the check-up 5 years (2-8 years) after surgery on average. The mean Lysholm score was 92 (85-100). All of them continued to engage in sporting activities at the same or greater level after 9 months on average (6-12 months). In all patients the Lachman test was with the firm stop compared to the other leg. X-ray changes in the patella were found in 2 patients who had multifragmentary fractures. **Discussion and Conclusion.** The fracture of patella can be prevented by avoiding to take too much bone graft, by using the most precise tools for cutting, while rehabilitation must be carefully planned. The optimal treatment of the fracture of the patella after the reconstruction of the anterior cruciate ligament is a firm osteosynthesis, which allows healing of the bone and continuation of the rehabilitation program.

**Key words:** Patella; Fractures, Bone; Anterior Cruciate Ligament Reconstruction; Arthroscopy; Postoperative Complications

### Introduction

Bone–patellar tendon–bone (BTB) remains the most common graft material for anterior cruciate ligament (ACL) reconstruction, and has several advantages compared with soft tissue grafts. The BTB graft is the strongest of all biological substitutes; it achieves strong initial graft fixation using interference screws, and offers rapid bony integration at the fixation points of the reconstruction [1–4]. The results of its application are excellent in 80-90% cases with sporadic complications of the knee extensor

### Sažetak

**Uvod:** Prelom čašice kolena posle uzimanja kost–ligament čašice–kost kalema je retka komplikacija. **Materijal i metode:** Uradili smo 1 714 artroskopskih rekonstrukcija prednjeg ukrštenog ligamenta kost – ligamenet čašice – kost kalemom i kod sedam pacijenata je došlo do prelom čašice (0,42%). Kod pacijenta sa vertikalnim nedislokovanim intraoperativnim prelomom čašice, prelom je odmah prepoznat i izvršena je osteosinteza preloma zavrtanjem, bez promena u rehabilitacionom periodu. Jedan pacijent je lečen neoperativno dok je kod četiri pacijenta prelom čašice kolena lečen operativno krvavom repozicijom i osteosintezom. **Rezultat:** Pacijente smo pozvali na kontrolu prosečno 5 (2-8) godina posle operacije. Prosečan Lyscholm skor bio je 92 (85-100). Svi su nastavili da se bave sportskim aktivnostima na istom ili višem nivou. Kod svih pacijenata je Lachman test bio sa tvrdim zaustavljanjem u odnosu na drugu nogu. Radiografske promene su nađene kod 2 pacijenta sa višedelnim prelomima čašice. Povrtak sportskim aktivnostima bio je posle 9 (6–12) meseci. **Diskusija i zaključak:** U prevenciji ove komplikacije treba izbegavati uzimanje prevelikog koštanog kalema, koristiti što preciznije instrumente za sečenja, a rehabilitacija mora biti pažljivo dozirana. Optimalni tretman preloma čašice posle rekonstrukcije prednjeg ukrštenog ligamenta kolena je čvrsta osteosinteza, čime se omogućava zarastanje kosti i nastavljanje rehabilitacionog programa.

**KLjučne reči:** Patela; Frakture kosti; Rekonstrukcija prednjeg ukrštenog ligamenta; Artroskopija; Postoperativne komplikacije

mechanism, that is, BTB harvest site morbidity and disruption of the knee extensor apparatus [5,6]. Since 1983, when McCarrol [7] reported the first case of patella fracture that occurred 6 months postoperatively during a golf swing, few other authors have reported this complication [8–13].

The aim of this paper is to present the results of anterior cruciate ligament reconstruction in the patients in whom the intraoperative or postoperative fracture of the patella occurred and to show the underlying causes of these complications and possibilities of prevention.

**Abbreviations**

ACL	– anterior cruciate ligament
BTB	– bone-patellar tendon-bone

**Material and Methods**

In the period from 1996 to 2011, 1714 reconstructions of the anterior cruciate knee ligament were done at the Department of Orthopaedic Surgery, Clinical Centre of Vojvodina using the BTB technique which was similar for all the patients. A vertical incision was made from the middle of the patella to the inferior portion of the tibia tubercle with the knee flexed. Skin flaps were created and the incision was sharply carried down through the transverse fibres of the paratenon. The paratenon was incised at its midpoint, and the scissors were then used to extend proximally and distally and to expose the entire width of the patellar tendon. Next, the tendon was maintained in a stretched position by flexing the knee to incise the tendon first on one side of the graft followed by the other side to yield a 10-mm wide graft. Then, a blade oscillating saw was used to create the tibial bone plug by scoring the tibial cortex and removing an equilateral triangle of bone with the saw. The tibial bone block was temporarily left in place while we harvested the patellar bone plug. We cut the patellar plug as a trapezoidal shape, no more than 6 or 7 mm deep, and then we used a curved osteotome to lift the tibial bone plug carefully from its bed onto a lap pad followed by gentle removal of the patellar bone plug. The scissors were then used to remove any remaining soft tissue attachments, and the graft was removed by the harvesting surgeon. The BTB graft was prepared on a side table by an assistant. A standard anterolateral portal was used as a viewing portal and an anteromedial one was used as a working portal. The ACL stump was debrided. In the period from 1996 to 2005 we created a femoral tunnel with a limited notchplasty using the TT technique. Since 2005, we have been making a femoral tunnel through the anteromedial portal. The femoral tunnel was created first in order to avoid excess fluid loss. The knee was placed in flexion between 110 and 120°. The femoral guide (Karl Storz, Tutlingen, Germany) with an appropriate offset was introduced into the joint through the anteromedial portal. With the help of a femoral guide, a drill-wire was placed into the centre of the anatomic insertion of the ACL at 10 o'clock position and was overdrilled with a 10-mm diameter reamer. A suture was retrieved and a guide pin was drilled into the joint followed by a cannulated reamer with an equal diameter to the graft to create the tibial tunnel. A grasper was then placed through the tibial tunnel to retrieve the suture. Then the graft was passed through the tibia into the femoral socket, and once the graft was properly positioned in the tunnel, it was fixed with RCI – round cannulated interference screws (Grujić & Grujić, Novi Sad, Serbia). Firm traction was applied to the tibial bone block while the full range of knee

motion was being performed in order to pretense the graft and observe if the full extension caused any impingement. The graft was then tensioned using 60 N force (Karl Storz, Tutlingen, Germany) and fixed into the tibial tunnel with round cannulated interference screws (Grujić & Grujić, Novi Sad, Serbia). The knee stability was checked using Lachman and anterior drawer tests. Two drains were placed, the operative wound was closed in a usual way and the patient was taken to his room.

The patellar fracture occurred intraoperatively in two patients and postoperatively in 5 patients (0.42%) (**Table 1**). There were two men and 5 women, their mean age being 23.5 years (19-30) and they went in for the following sports: basketball (1), soccer (1), karate (2), handball (1), recreational activities (2). The left knee was injured in 4 patients and the right knee in 3 patients. In 6 patients a fracture of the patella was on the same leg where there was the reconstruction of the anterior cruciate ligament in the knee, and on the second one from which the graft was taken from the opposite knee. The fracture developed in two cases intraoperatively; in one case seven days after surgery; in two cases after two months; and in two cases 7 months after anterior cruciate ligament reconstruction. We had to adjust the layout without dislocation in two patients; in three patients there was a two-part fracture and transversal; in another two it was multi-fragmentary. The fracture was immediately recognized in the patients with vertical non-displaced patellar fracture, and the broken screw osteosynthesis was carried out (**Figure 1AB**), without changes in the rehabilitation period. One patient was treated non-operatively (**Figure 2ABC**) with plaster of Paris for 6 weeks which was followed by physical therapy (**Figure 3AB**). In four patients patellar fracture was treated with operative reduction and osteosynthesis with needles and wire (**Figure 4AB**).

The results were made based on the mean Lysholm score [14], arthrometric [15] and X-ray images.

**Results**

All patients were invited for the check-up 5 years after surgery on average (2-8 years). The mean Lysholm score was 92 (85-100). All of them have continued to engage in sporting activities at the same or greater level after 9 months on average (6-12 months). In all patients the Lachman test was with the firm stop, arthrometric 2 (1-3) mm compared to the other leg. X-ray changes in the patella were found in 2 patients, who had multi-fragmentary fractures.

**Discussion**

The use of patellar tendon autografts for ACL reconstruction is widespread and is deemed to provide good, reproducible clinical results [16]. Fracture of the patella, after harvesting the central

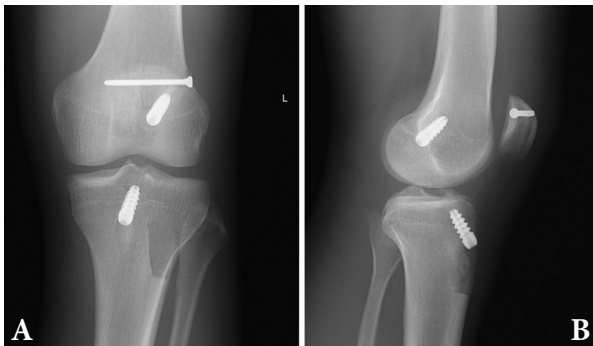
**Table 1.** Patients with knee patellar fracture after anterior cruciate ligament reconstruction using BTB autograph  
**Tabela 1.** Pacijenti sa prelomom čašice kolena posle rekonstrukcije prednjeg ukrštenog ligamenta korišćenjem autokalema "koštani deo čašice-ligament čašice-koštani deo golenjače"

Case No Pacijent broj	1	2	3	4	5	6	7
Gender/Pol	Male/Muški	Female Ženski	Female Ženski	Male/Muški	Male/Muški	Male/Muški	Male/Muški
Age/Starost	19	22	18	23	29	30	24
Knee/Koleno	Left/Levo	Left/Levo	Left/Levo	Right/Desno	Right/Desno	Right/Desno	Left/Levo
Sporting activity Sportska aktivnost	Football Fudbal	Handball Rukomet	Handball Rukomet	Basketball Košarka	Recreational football Rekreativno fudbal	Recreational fitness Rekreativno fudbal	Karate Karate
Fractures after surgery Nastank preloma posle operacije	Intraoperatively Intraoperativno	7 days 7 dan	7 months 7 meseci	7 months 7 meseci	2 months 2 mesec	2 months 2 mesec	Intraoperatively Intraoperativno
Type of fracture Tip preloma	Vertical Vertiklani	Transverse Poprečni	Transverse Poprečni	Transverse Poprečni	Multifragment Višedelni	Multifragment Višedelni	Vertical Vertiklani
Treatment Lečenje	-	Reposition and osteosynthesis Repozicija i fiksacija	Reposition and osteosynthesis Repozicija i fiksacija	Reposition and osteosynthesis Repozicija i fiksacija	Reposition and osteosynthesis Repozicija i fiksacija	Plaster immobilization Gipsna imobilizacija	Reposition and osteosynthesis Repozicija i fiksacija
Resume sport activities Povratak sportu	6 meseci 6 months	8 months 8 meseci	12 months 12 meseci	11 months 11 meseci	10 months 10 meseci	10 months 10 meseci	6 months 6 meseci
Lyscholdm scor Artrometar measurements in mm Artrometarsko merenje u mm	100	85	96	90	84	87	100
X-ray findings RTG nalaz	Repaired anatomically Saniran anatomski	Repaired anatomically Saniran anatomski	Repaired anatomically Saniran anatomski	Repaired anatomically Saniran anatomski	Reconstructed step 2 mm Saniran stepenik 2 mm	Reconstructed step 2 mm Saniran stepenik 2 mm	Repaired anatomically Saniran anatomski

third of the patellar tendon for a BTB autograft is a rare complication whose incidence ranges from 0.23% to 2.3% [9,13,17-19]. We made 1714 reconstructions of the anterior cruciate ligament of the knee using BTB technique, and had fracture of the patella in 7 patients (0.42%). In all but one patient the fracture was on the same side where the anterior cruciate reconstruction was done. In one case of the re-reconstruction of the ACL there was a fractured patella of the opposite knee from which graft was taken ten days after surgery.

The causes of patella fractures after anterior cruciate ligament reconstruction are manifold. First of all, taking a bone graft from the patella leads to a significant weakening of the bones (**Figure 1B**). The recommendations for minimizing the risk of patella fracture include avoiding

the use of osteotomes to make the initial bone cuts and to remove no more than 25 to 30 mm of the length of the patella, and no more than 9 to 10 mm of its width. The front part of the patella is the strongest and most resistant to the load, and its resistance after taking the graft [5] is reduced by 30%-40% without a significant increase in pressure between the patella and the femur [20,21]. Friis and al. [22], who investigated the biomechanical strength of the patella after taking the graft, found that the patella from which the graft was taken was more sensitive to stress than normal, and that the striped graft taken caused less stress on the bones than the oval or trapezoidal graft. The main conclusion of this study is that the lower part of the bone taken, the less stress on the patella, and the graft length should not exceed the

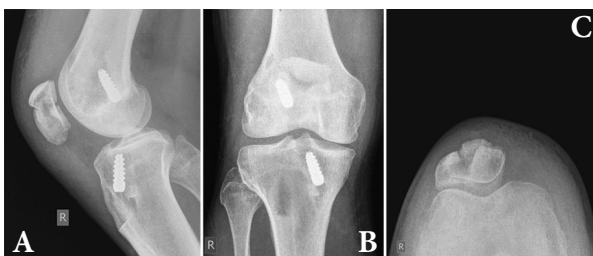


**Fig. 1AB.** Profile and AP radiograph of the left knee with patellar fracture occurred intraoperatively and immediately executed osteosynthesis with screw (Patient No. 7)

*Slika 1AB.* Profilni i AP rendgenski snimak levog kolena sa intraoperativno nastalim prelomom čašice kolena i odmah izvršenom osteosintezom zavrtnjem. (Pacijent br. 7)

equator of patella. Malek et al. [23] believe that the depth of the graft taken should not be more than one third of the patella thickness. Additionally, the technique of taking graft is critical. Osteotomy should be used carefully after the initial cuts made by saw. Making a 45-degree angle to the upper pole of the graft during the intake may reduce postoperative stress. Jackson and al [24] propose the application of semi-circular oscillating saw with a smaller graft taken, and to form a smooth rounded bottom, which probably causes less stress than traditional methods in the angles.

McCarroll [1] presented the theory that the transverse patella fractures are similar to stress fractures due to reduced vascularization of the central parts of the patella. Benson and Barnett [25] described the patella vascularization and collateral blood flow after taking the graft. Extraosseal blood supply surface of patella comes from geniculates artery that are stored while taking graft. The intraosseous blood flow has three components: middle-patellar, polar and system from tendon and muscles quadriceps. The first two supply the middle third and lower pole of patella. If the damage occurs while taking graft, it can slow down the



**Fig. 2ABC.** Profile, AP and tangential radiograph of the knee, indicating the multifragment fracture of the patella. (Patient No. 6)

*Slika 2ABC.* Profilni, AP i tangencionalni rendgenski snimak kolena na kome se vidi višedelni prelom čašice. (Pacijent br. 6)



**Fig. 3AB.** Profile and AP radiograph of the patient No. 6 after two years. Fracture of the patella treated non-operatively, only with plaster immobilization, is repaired, but there are steps on the articular surface.

*Slika 3AB.* Profilni i AP rendgenski snimak pacijenta broj 6 dve godine kasnije. Prelom čašice kolena lečen neoperativno gipsanom imobilizacijom je saniran ali postoji stepenica na artikularnoj površini.

healing process on the graft, and affect the surrounding normal bone.

Bonami et al [6] studied the quality of tissue that filled the place where graft had been taken from during healing. A defect in the patellar ligament and patella filling fibrous tissue, which also reduces the strength and resistance of the anterior cortex of patella, predisposes fracture. Many authors [26-28] recommend filling the defect in the patella with spongy bone to preserve the anatomical integrity of the donor sites.

The majority of the described fractures happened during early postoperative period [8,25,29,30,31], an average of 57 days following BTB anterior cruciate ligament reconstruction, with an interval between 24 and 121 days. Christen et al. [9] described 6 intraoperative and 3 postoperative patella fractures in a series of 490 patellar autograft ACL reconstructions. Two of our patients sustained fractures of the patella,



**Fig. 4AB.** Profile and AP radiograph of the knee after a bloody repositioning and osteosynthesis patellar fracture (patient No. 5)

*Slika 4AB.* Profilni i AP rendgenski snimak kolena na posle krvave repozicije i osteosinteze preloma čašice (Pacijent br. 5)



one after seven days, two after two months and two after 7 months, the average being 78 days (0-210).

Intraoperative fracture of the patella occurred during bone block removal and usually vertical splits without dislocation. Out of 6 intraoperative fractures reported by Christen et al. [9], 3 were treated with internal fixation. In our first case we noted the existence of fracture without dislocation of the control X-ray that was made 6 weeks after surgery when the patient complained of constant pain in his patella. We slowed the rehabilitation program, and the fracture healed without affecting the final result. In another patient, a crack was heard and a non-displaced fracture of the longitudinal patella was noted after cutting the patella and lever strong chisels manipulation. We immediately made an osteosynthesis with one screw. The fracture healed without slowing down the rehabilitation program and it did not affect the final result.

Postoperative fractures occur with a direct blow results and impaction injury with the fracture being stellate or Y-shaped, while rapid eccentric quadriceps contraction, which may occur as the result of a fall, typically results in a transverse fracture pattern [32]. These fractures cause significant functional deficit that is manifested clinically as a loss of active knee extension. Rigid fixation to allow early mobilization is the recommended treatment for most isolated patella fractures [33] as well as for patella fractures in the postoperative period after ACL reconstruction. Non-operative treatment and treatments requiring extended immobilization should be reserved for those patients unwilling or unable to undergo surgery, or a fracture pattern that cannot be rigidly fixed. Once a patella fracture occurs, the short-term rehabilitation goals for the patient should be altered in order to enhance the likelihood of long-term success. Fracture healing without displacement is critical. There is a variety of fixation methods. Tension-band fixation has been reported with successful results [11]. However, as reported in the trauma literature, 22% of patients treated with tension-band wiring and early motion had displacement of more than 2 mm, and over 10% of patients will require hardware removal due to overlying irritation from the wire [34]. Other options include cannulated screw fixation, with or without a tension-band augment, or bicortical (superior to inferior) small or large fragment screw fixation. Biomechanical testing of a modified tension-band compared to either 4.5-mm screws or an anterior tension band placed through 4.0-mm cannulated screws showed the cannulated screws and tension band to be the strongest construction [35]. Regardless of the method selected, the surgeon must achieve reduction of the articular surface with stability throughout a range of motion. Once the fracture is reduced and stabilized, the knee must be taken through a range of motion to ensure no displacement is observed prior to clo-

sure. Postoperatively, the patient is allowed a protected progressive range of motion in a brace, but weight-bearing is allowed only in full extension. Hardware need not be routinely removed [36], but if symptomatic, it can be removed after the fracture has healed and ACL rehabilitation is complete.

The prevention of complications after reconstruction of anterior cruciate ligament rehabilitation has an important role. When postoperative quadriceps and hamstring muscles are impaired, they allow abnormal patellar mobility, which causes increased stress on the graft taken place. An early training of leg muscles with the return of neuromuscular proprioception is important for maintaining the knee stability and reducing the abnormal mobility of the patella [37].

The ways of avoiding an intraoperative patella fracture is to avoid larger bone plugs, minimize crosscuts that can act as stress risers, avoid deep cuts that might violate the articular surfaces, avoid levering the graft with osteotomes, and backfilling the defects with bone graft obtained at graft harvest or during tibial tunnel creation [38]. Postoperatively, it is important not to overload the patella in the first 6 to 8 weeks. Intraoperative fractures should be immediately treated with a firm osteosynthesis, and since they are usually without significant dislocations, they do not affect the rehabilitation process and the end result of ACL reconstruction. Fractures without dislocation are generally treated conservatively with immobilization; fractures with dislocation are treated by open reposition and internal fixation. Strong osteosynthesis allows early mobility and knee muscle exercises. The ultimate outcome of the reconstruction of the ACL does not change after post-operative fracture patella, it is the same as for an uncomplicated anterior cruciate ligament reconstruction of knee. If a patellar fracture occurs after the anterior cruciate ligament reconstruction, the best treatment is a firm osteosynthesis, which enables the healing of the bone, and immediate continuation of the previously resumed rehabilitation program. However, this complication prolongs the rehabilitation period and slows down the return to the sport field.

### Conclusion

Patella fracture after anterior cruciate ligament reconstruction of the knee can be a serious problem in the total rehabilitation of the patient, and that possibility should be considered during anterior cruciate ligament reconstruction. These complications can be prevented by avoiding taking too much bone graft, by using the most precise tools for cutting, while rehabilitation must be carefully planned. After the reconstruction of the anterior cruciate ligament an optimal treatment of fractures of the patella is a firm osteosynthesis, which allows healing of the bone, continuation of the rehabilitation program and a good end result.

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