Posterior cruciate ligament injuries and its treatment

Uszkodzenia więzadła krzyżowego tylnego i jego leczenie

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Streszczenie

Więzadło krzyżowe tylne (WKT) jest strukturą anatomiczną stanowiącą główny ogranicznik tylnego przemieszczenia kości piszczelowej względem kości udowej. Funkcjonalnie można je podzielić na kilka części, z których najważniejsze są: pęczek przednio-boczny i pęczek tylno-przyśrodkowy. Pęczek przednio-boczny napina się przy kolanie zgiętym do 90°, tylno-przyśrodkowy przy kolanie zgiętym do 30°. WKT ma 38 mm długości, około 13 mm średnicy, jest położone wewnątrzstawowo, ale na zewnątrz błony maziowej, którą wpukla od tyłu do stawu tak, że tworzy ona grubą warstwę synowialną przykrywającą WKT z trzech stron.

Dodatkowymi elementami tylnego kompleksu więzadłowo-torebkowego stawu kolanowego są więzadła łąkotkowo-udowe przednie (Humphreya) i tylne (Wrisberga). Więzadło Wrisberga rozpoczyna się na rogu tylnym łąkotki bocznej, tylnym brzegu kości piszczelowej, przechodzi skośnie i ku tyłowi od WKT i ma swój osobny końcowy przyczep na kości udowej, może mieć grubość do 50% WKT, przeciętnie 20%. Więzadło przednie Humphreya zaczyna się na rogu tylnym łąkotki bocznej, przebiega wzdłuż przedniego brzegu WKT i przyczepia do kłykcia przyśrodkowego kości udowej. Przy uszkodzonym WKT więzadła te mają pewne znaczenie w redukowaniu objawu szuflady tylnej. WKT jest grubsze od WKP, ale jego parametry mechaniczne u ludzi młodych obciążenia końcowe – 1627 ± 491N i sztywność liniowa – 204 ± 66 N są zbliżone do WKP, wg Harnera pączek przednio-boczny ma 2,5x większą wytrzymałość niż tylno-przyśrodkowy i 5x większą od więzadeł łąkotkowo-udowych.

Wg Butlera WKT odpowiada za 95% siły blokującej tylną transpozycję kości piszczelowej w szufladzie tylnej. Uszkodzenie elementów kompleksu tylnego powoduje narastanie niestabilności szpotawiącej i zwiększenie rotacji zewnętrznej piszczeli, co zaburza tzw. „screw-home mechanism", w którym piszczel rotuje się na zewnątrz, gdy kolano zbliża się do pełnego wyprostu. Wg Skyhara bardzo zwiększa to obciążenie styczne w stawie rzepkowo-udowym i przednio-przyśrodkowym przedziale stawu kolanowego powodując jego stopniowe uszkodzenie.

W WKT jest dość trudno ustalić punkty izometryczne, wydaje się, że najbliższy izometrii przyczep udowy stanowi punkt w miejscu przecięcia się linii w 1/3 pomiędzy dalszym brzegiem chrząstki stawowej i brzegu bliższego bruzdy międzykłykciowej na godzinie 2 dla kolana prawego i 10 dla kolana lewego.

Doniesienia na temat częstości występowania uszkodzenia WKT bardzo się różni, od 1 – 40% ostrych urazów stawu kolanowego. Fanelli obserwował uszkodzenia WKT u 38,3% pacjentów z ostrym urazem kolana, tylko 3% między nimi stanowiły uszkodzenia izolowane, pozostałe to były urazy wielowięzadłowe. Shelbourne obserwował tylko 8% uszkodzeń WKT w urazach ostrych. Do uszkodzenia WKT dochodzi najczęściej przy urazach o dużej intensywności – sportowych, motocyklowych itp. Najczęstszym mechanizmem urazowym jest przyłożenie skierowanej ku tyłowi siły do nasady bliższej piszczeli, niekontrolowany przeprost itp.

W badaniu klinicznym najistotniejszy objaw stanowi test szuflady tylnej w zgięciu kolana do 90°, zwracając szczególną uwagę na to, by zawsze porównywać badanie kliniczne obu nóg i przed badaniem doprowadzić kończynę do pozycji neutralnej uwzględniając fizjologiczne wysunięcie piszczeli 1 cm ku przodowi spod kości udowej. Zwiększenie rotacji zewnętrznej stopy ponad 10 – 15°, w porównaniu z nogą zdrową, jest patognomoniczne dla uszkodzenia struktur „rogu tylnego".

Urazy WKT mogą być ostre lub zastarzałe, przedstawiono 4-stopniowy podział wg Coopera.

Ze względu na grube pokrycie maziówkowe WKT ma znacznie większy potencjał do samoistnego gojenia, niż WKP i w znacznej części przypadków ulega wygojeniu. Ze względu na ten fakt, jak i obawę przed zwółknieniem stawu w przypadku operacji „na ostro" zaleca się przyjęcie postawy wyczekującej i przez 6 tygodni raczej nie ma wskazań do re-

konstrukcji WKT. Wyjątek mogą stanowić złożone urazy z uszkodzeniem struktur „rogu tylnego”, które szybko bliznowacieją i po 2 – 3 tygodniach problem stanowi ich identyfikacja i skuteczna reinsercja. Część autorów uważa to za wskazanie do przyspieszenia decyzji operacyjnej.
Materiałem do przeszczepu mogą być zarówno allo- jak i autoprzeszczepy. Zastosowanie znajdują alloprzeszczepy ścięgna Achillesa z blokiem kostnym, przeszczepy więzadła własnego rzepki z dwoma blokami kostnymi, złożone ścięgna mięśni smukłego i półścięgnistego oraz mięśnia prostego uda. Często stosowane autoprzeszczepy to: przeszczepy więzadła własnego rzepki z dwoma blokami kostnymi, złożone ścięgna mięśni smukłego i półścięgnistego oraz mięśnia prostego uda.
Zaletą alloprzeszczepów jest nie uszkadzanie chorej kończyny, znaczne rozmiary, wadami możliwość transmisji chorób (ostatnio praktycznie wyeliminowana), wysoki koszt, możliwość indukowania odpowiedzi immunologicznej. W rekonstrukcjach WKP bardzo dobre i dobre wyniki w autoprzeszczepach stwierdza się w około 94% przypadków, w alloprzeszczepach w 86%.
Przez całe lata za złoty standard uważana była artroskopowa technika operacyjna z użyciem pojedynczego pasma rekonstruująca jedynie pęczek przednio-boczny. Opisano technikę tego zabiegu ze szczególnym naciskiem podkreślając konieczność stałej kontroli zarówno artroskopowej jak i radiologicznej miejsca wyprowadzenia kanału piszczelowego w tylnym aspekcie kości piszczelowej, ze względu na możliwość uszkodzenia pęczka naczyniowo-nerwowego goleni. Ostatnio, coraz powszechniejsza staje się rekonstrukcja WKT z użyciem dwu pasm, odtwarzających dwa pęczki więzadła – przednio-boczny napinany w zgięciu 90° i tylno-przyśrodkowy napinany w zgięciu 30°, gdyż tylko takie postępowanie przybliża nas do biomechaniki oryginalnego więzadła.
W pracy omówiono szczegółowo technikę operacyjną artroskopowej rekonstrukcji WKT z użyciem uformowanego w literę „V” zdwojonego pasma ścięgna mięśnia prostego uda, która jest preferowana w CMC. Przedstawiono także możliwe, opisane w literaturze powikłania – takie jak ograniczenie zakresu ruchu, pooperacyjna niestabilność, przedni ból kolana, martwica kłykcia przyśrodkowego kości udowej, powikłania naczyniowe i nerwowe i pokrótce – ich przyczyny i możliwości leczenia.
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Słowa kluczowe: więzadło krzyżowe tylne stawu kolanowego, rekonstrukcja więzadła krzyżowego tylnego, artroskopia stawu kolanowego, technika „dwóch pęczków”

Summary

Posterior cruciate ligament is a main restraint of posterior translation of tibia. PCL acts primarily as two functional separate bundles, with anterolateral portion acting predominantly in flexion and a posteromedial acting predominantly in extension. The linear stiffness of the anterolateral bundle is 2,5 times greater than that of the posteromedial bundle and menisco-femoral ligaments. The strength and stiffness of the anterolateral component of PCL has significant implication for ligament reconstruction. PCL is a main component of functional entity of posterolateral anatomical structures of the knee joint composed of two parts: posterolateral complex of the knee in terms of the superficial lateral collateral ligament and „deep ligament complex”, which include the arcuate ligament, popliteus tendon, fabellofibular ligament and the posterolateral capsule – so called posterior complex ligaments. The main mechanisms are high velocity injuries, e.g. hyperextension or fall on flexed knee and direct trauma of proximal tibia. Incidence of PCL injury is reported to be from 1 – 40% of acute knee injuries, in 42% of patients with haemarthrosis occurs PCL lesion. A total of 45,9% of PCL injuries were combined ACL/PCL tears, 41,2 PCL/PLC tears and only 3% were isolated PCL tears. The base of diagnosis is a clinical investigation, and the most accurate clinical test to evaluate the PCL injury is the posterior drawer at 90° of flexion performed with the patient supine. Increased external rotation of 15° or more at 30° of knee injury is considered diagnostic for posterior lateral complex injury.
Main classification of PCL injury and simplified schema of decision-making used in CMC are presented. Graft selection options available are commented. Two basic operative techniques have been described in details: an arthroscopic single bundle (that might be simplified by a mini-open posterior approach inlay proposed by Clancy) and an arthroscopic double-bundle method with the use of „V” shaped rectus femoris ligament graft – preferred in CMC.
Complications and pitfalls were also commented, including loss of motion, persistent instability, anterior knee pain, osteonecrosis of medial femoral condyle, infection, vascular and neurological problems and a brief comment, how to avoid them was given.
[Acta Clinica 2002 2:62-76]

Key words: posterior cruciate ligament reconstruction, knee arthroscopy, double bundle technique

The posterior cruciate ligament (PCL) has been a subject of many controversies. Basic research and clinical studies have exploded in recent years, many new operative techniques have been described, followed by rehabilitation protocols and a basic question – whether and when we should reconstruct an injured PCL – has not been yet solved. Opinions differ from Hughston (1, 2), who found PCL „the fundamental stabilizer of the knee" to Shelbourne who stated, that „knee function is independent of the grade of PCL laxity". Probably the key is a careful clinical investigation, a good qualification based on both: degree of instability and a level of patients activity and expectations. Surgery should be reserved for active, young patients with a severe, III grade instability of a „posterior corner type" (PLC).

Functional anatomy

The posterior cruciate ligament originates from lateral aspect of the medial femoral condyle and passes posteriorly and laterally to the anterior cruciate ligament (ACL) to insertion on the posterior aspect of the tibia in posterior tibial fovea ~ 1 cm below the medial tibial condyle. PCL is intracapsular but extraarticular, because it reflects synovium from posterior capsule of the knee joint and it's anterior, medial and lateral aspects are covered by a synovial fold, and its posterior aspect connects with posterior capsule and periosteum distally (4,16). The synovial covering is evidently thicker and more complete than that of ACL, but there's no evidence that vascular supply of PCL is more effective than of ACL.

The average length of PCL is 38mm, width 13 mm (16). Cross sectional area of PCL increases from the tibial to femoral insertion and is approximately 1,5 times that of the ACL. The orientation of the ligament depends on the angle of the knee flexion – it is vertical in the frontal plane and angles forward 30 – 45° in the sagittal plane and is located just medial to the center of the knee near the longitudinal axis of tibial rotation. Fibers are more horizontal in flexion and more vertical with knee extension.

PCL consists of different functional regions of which the anterolateral and posteromedial bands are two of the largest (3, 4). The anterolateral component runs from the anterior aspect of the intercondylar surface of the medial femoral condyle posterolaterally to insert on the lateral aspect of the posterior tibial fossa. The posteromedial bundle arises from the posterior portion of the femoral insertion site and extends obliquely to insert on the medial aspect of the posterior tibial fossa. The anterolateral bundle tightens with a knee flexion, whereas the posteromedial component tightens with knee extension (3, 4, 16).

Meniscofemoral ligaments (MFLs).

MFLs represent accessory knee ligament that attach to the medial femoral condyle in the region of PCL, present in 71% to 100% of the dissected knees consist of the anterior ligament of Humphrey and the posterior ligament of Wrisberg (3, 19).

The posterior MFL of Wrisberg originates from the posterior horn of the lateral meniscus, posterior tibia or posterior capsule and crosses obliquely, posterior to the PL to a separated insertion site on the medial femoral condyle, maybe as large as 50% of diameter of the PCL (15, 18), and a dominant posterior MFL was found in 36% of specimens dissected by Heller and Langman (19), averaged 20% (7 – 35%) size of PCL (3).

The anterior MFL of Humphrey arises from the posterior horn of the lateral meniscus, passes along the anterior aspect of the PCL to insert on the medial femoral condyle.

MFLs serve as a minor restraint to posterior translation of the tibia when the PCL is cut, but they are believed to play an important role in meniscal kinematics.

Functional biomechamincs

Tensile properties are function of age, ligament orientation and the direction of applied load. For a long time after Kennedy's study (22) PCL was taught to be almost twice as strong as ACL and the tibial collateral ligaments (MCL) respectively at the same strain rates. Prieto (27) tested cadavers 19 – 25 years old with the knee 45° and obtained an ultimate load of1 627 ± 491 Newtons and linear stiffness of 204 ± 66 Newtons – similar to values of ACL. Harner (3) performed a more detailed study and has found that the ultimate load to failure of the anterolateral band was ~2,5 times greater than the posteromedial band and ~5 times greater than the MFL. The linear stiffness of the anterolateral bundle was ~2,5 times greater than that of the posteromedial bundle and MFL. The strength and stiffness of the anterolateral component of PCL has significant implication for ligament reconstruction.

Knee kinematics

Butler (7) assessed total restraining force in the stressed knee and then selective cutted individual ligaments and measured reduction in the restraining force, independently of ligament cutting order. He determinates, that the PCL provided 95% of the total restraining force to a straight posterior draw. Grood and Gollehon (17, 18) independently performed selective cutting studies of the PCL and posterolateral structures. Gollehon (17) defined the posterolateral complex of the knee in terms of the superficial lateral collateral ligament and „deep ligament complex", which include the arcuate ligament, popliteus tendon, fabellofibular ligament and the posterolateral capsule. As knee flexion increased from 0° to 90° isolated sectioning of PCL caused a progressive increase in posterior tibial translation which was greatest at 90° flexion. Isolated sectioning of lateral collateral ligament caused increased varus rotation at all angles of flexion, with relatively small increases in external rotation at 0°, 30° and 90° of knee flexion. Isolated sectioning of „deep ligament complex" produced increased external rotation at 90° of flexion with a concomitant increase in varus rotation.

Fig. 1 a, b. A drawer test

This findings suggested, that the posterior draw test at 75°-90° of flexion is the best way to asses stability of PCL. Combined injuries of PCL and PLC demonstrate significant increase in posterior translation, varus angulation and external rotation at all angles of the knee flexion when compared to the normal knee. Lesion of PCL severely disturbs a so-called „screw-home mechanism" of external rotation of the tibia as the limit of extension is approached.

Skyhar (29) measured articular contact pressure in cadaveric knees after sectioning ligaments and they have found, that contact pressures in the medial and patellofemoral compartments were significantly increased after isolated or combined sectioning of PCL, in lateral compartment pressure was increased only after combined PCL and PLC sectioning.

The PCL is so complex structure, that is very difficult to define the points of isometric placement of the graft, hence tension on the ligament remains constant during range of motion of the knee. Isometric placement restores normal knee kinematics and minimizes stress on the graft. Only 5% of PCL is isometric (11). Ogata and McCarty (24) recommended anatomic guidelines for isometric placement of the PCL, the most isometric and isotonic position for the femoral insertion was at the intersection of a line, one third the distance between the distal articular surface and the proximal edge of the intercondylar notch, and the two or ten o'clock position on the notch for a right or left knee respectively.

Incidence

Incidence of PCL injury is reported to be from 1 – 40% of acute knee injuries, approximately 3% in general population and 38% in reports from regional trauma centers. Fanelli (13) reports in he's practice 38,3% incidence of PCL tears in acute knee injuries, 56,5% of these injuries occurs in patients wit multiple trauma. A total of 45,9% of PCL injuries were combined ACL/PCL tears, 41,2 PCL/PLC tears and only 3% were isolated PCL tears. He stated 42% of PCL injury in patients with haemarthrosis. Shelbourne and Jari (21) in a multicenter study estimated for 5164 isolated ACL injury 352 isolated PCL, 61 PCL/MCL, 49 ACL/PCL/MCL, 28PCL/PLC – but it is an extremely low ratio of combined injuries, that has been reported.

Mechanism

Most PCL injuries occurs secondarily to sports or motor vehicle trauma. A posteriorly directed force at the level of tibial tubercle is a common mechanism, e.g. fall on the flexed knee with a foot plantarflexed. Other mechanism is an external rotation of the tibia or posteromedial varus directed force. Other mechanism might be hyperextension.

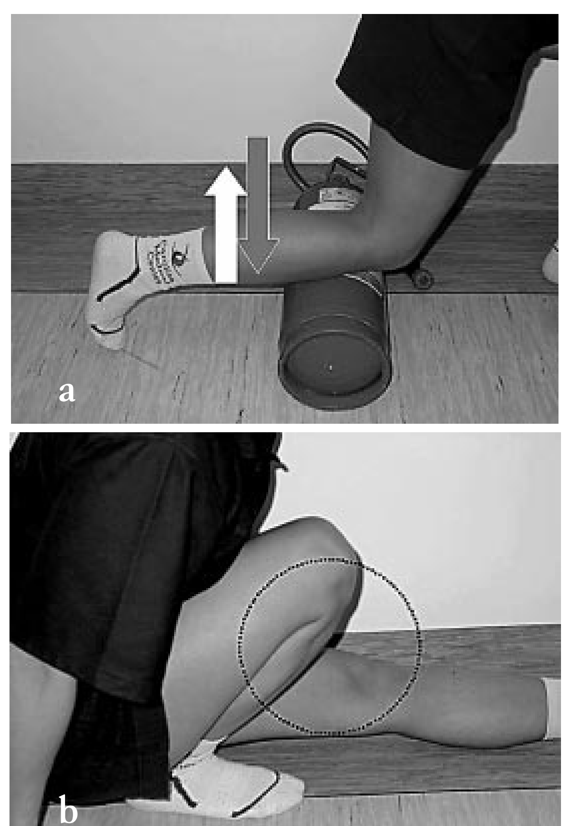


Fig. 2 a, b. Mechanism of injury

Patients experience severe pain and swelling and usually describe gross deformity of the knee, but majority of these dislocations spontaneously reduces and majority of victims present reduced.

Evaluation of PCL injuries

The most accurate clinical test to evaluate the PCL injury is the posterior drawer at 90° of flexion (1, 26), performed with the patient supine. Usually exist a 10 mm step off between the medial tibial plateau and the medial femoral condyle. One should always compare the contralateral leg. Fu, Harner and Kashiwagushi subdivided posterior drawer into III categories: Grade I injuries usually lose 0,5 cm of step off, Grade II injuries lose the entire step-off, but still cannot be subluxated beyond the condyle. In grade III injuries the proximal tibia could be subluxated posteriorly 10 mm beyond the medial femoral condyle, creating a reverse step off.

Fig. 3 a. A positive „step-off"

Fig. 3 b. „Step-off reduce

Fig. 3 c. „Negative step-off"

Because in Grade III injury tibia at 90° of flexion is always posteriorly subluxated, when testing PCL tibia should be reduced into „neutral position" with an anteriorly directed force. Testing should be performed in both 30° and 90°. This is the most easily performed with one hand behind the proximal tibia, reducing the joint, and the other at the ankle, creating an external rotation

Fig. 4 a. An external rotation assessment in prone position

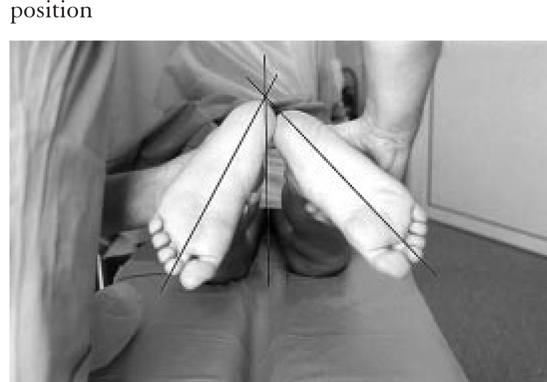


Fig. 4 b. A decrease external rotation

force. It should be always compared with an uninjured side. Increased external rotation of 15° or more at 30° of knee injury is considered diagnostic for PLC injury.

The „reverse pivot-shift" may also detect a PLC or PCL/PLC injury. Testing begins with the knee flexed at 90°, with tibia posteriorly flexed. As the knee is brought into extension, relocates.

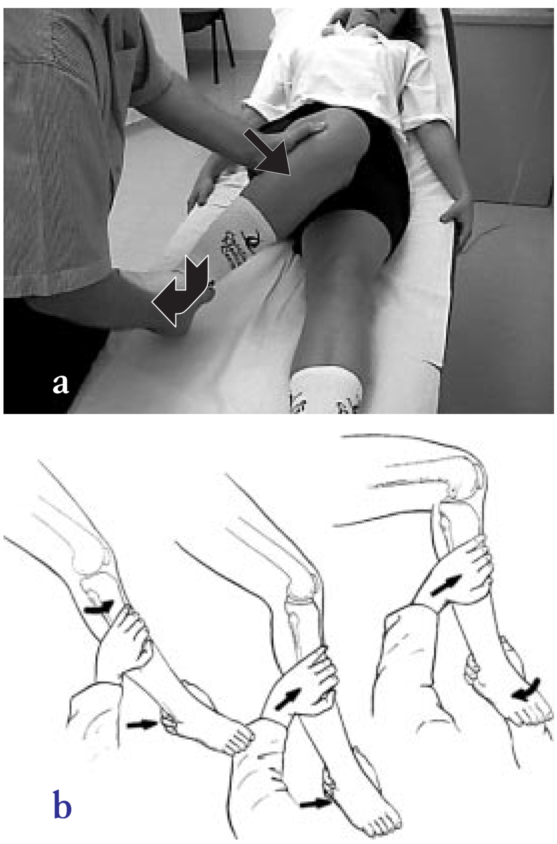


Fig. 5 a, b. Reversed „pivot-shift" phenomenon

PCL acts as an important secondary restraint to external rotation, more important at 90° than at 30° of knee flexion. Increased external rotation at 90° suggest a combined PCL/PLC (but not LCL) injury.

Classification of PCL injuries (after Cooper, 10)

Level I – isolated injuries to either the PCL or PLC, yields mm posterior drawer, trace asymmetry in external rotation and varus laxity at 30°.

Level II – 2-ligament injury, knee stable to varus and valgus at full extension by having ++ varus or valgus laxity at 30° of flexion, posterior drawer 11 – 15mm, with the PLC – extensive external rotation.

Level III – 3 ligament injury, varus-valgus unstable in full extension, always PCL and PLC, knee with severe hyperextension, drawer 15 mm, knee reduced.

Level IV – dislocation.

Subclassify: Acute or chronic (A or C). Full thickness chondral injury or meniscectomy.

Ligament healig potential of PCL

The PCL has an intrinsic ability to heal unlike the ACL – maybe due to better synovial coverage (17). In the acute setting MRI has been reported to be 99% sensitive and specific. With a chronic injury results of MRI studies suggest that torn PCL may heal and 77% of torn ligaments regain continuity although with an abnormal appearance. Often MRI show a „normal" PCL despite obvious clinical posterior laxity and so reduces the accuracy of this investigation as a predictor for treatment. Clinical decision should be than based on results of clinical investigation and patients complaints than on MRI studies.

Decision making

Natural history of a PCL deficient knee has been well described (12) and in a population of active patients less than 45 years of life it leads to a progressive knee deterioration and 5 years after an injury majority of PCL deficient patients complaints of instability and functional disability and presents signs of early degenerative changes on X-ray examination.

Patients with high-energy knee dislocation may have remote injuries that take precedent over the knee, but an immediate reduction of the joint is required to prevent amputation and to allow the best chance for functional recovery of the injured knee. Urgent reduction of dislocation should be performed once a neurovascular examination is documented. If a surgeon is unable to do it manually, a closed or open reduction under anesthesia should be performed as soon as possible in order to restore a blood flow within 6 – 8 hours of injury. Any suspicious leg compartments should have fasciotomies performed when indicated. Open injuries requires urgent irrigation and debridement. An external fixator in reduced position that spans the knee joint without distraction might be used in patients with polytrauma, vascular repair, open dislocation or dislocation highly unstable after reduction. The knee should be braced or splinted in 20° flexion.

In patients with less severe, isolated PCL or PCL/PLC injuries patient might be immobilized in extension to minimize posterior subluxation by the hamstrings (26). Quadriceps sets, straight leg raises and weight bearing are allowed.

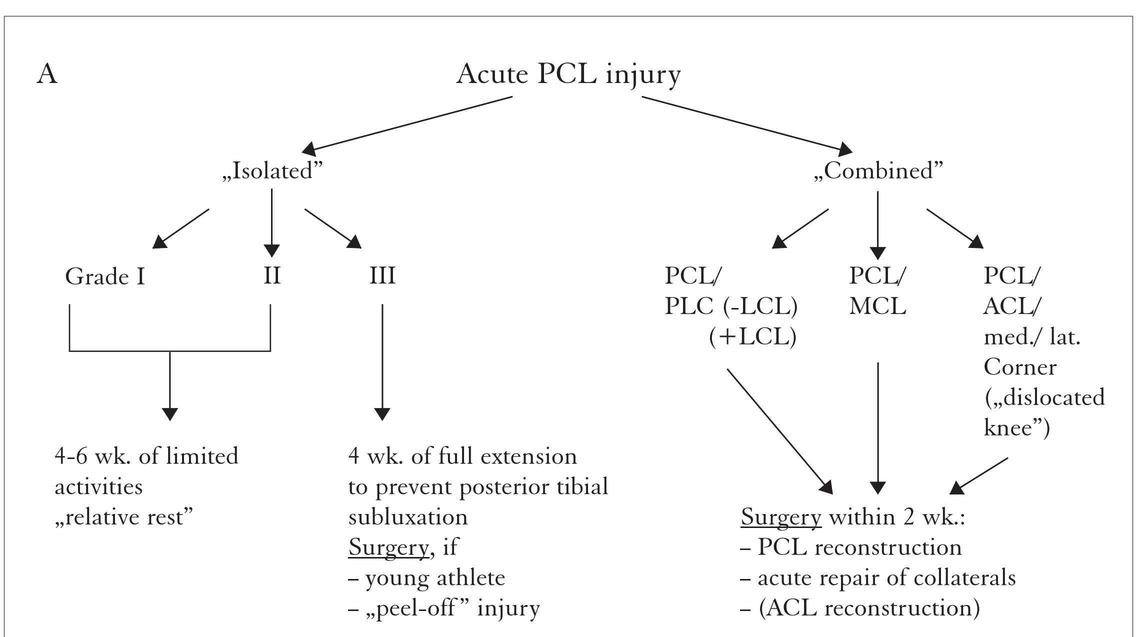
An acute surgery is rather not indicated for isolated PCL injury. This is primarily due to of the high incidence of stiffness and arthrofibrosis if acute reconstructions are performed within first six weeks. On the other hand the PCL could heal and for patient with less than ++ posterior drawer laxity, the PCL injury might be managed conservatively.

There's a doubt considering PLC injury – these structures are often amendable to primary repair, because scar formation occurs quickly, obscuring details and making primary repair and anatomical positioning nearly impossible. According to Harner and Petrie (26) it may indicate a „subacute" repair within 2 – 3 weeks.

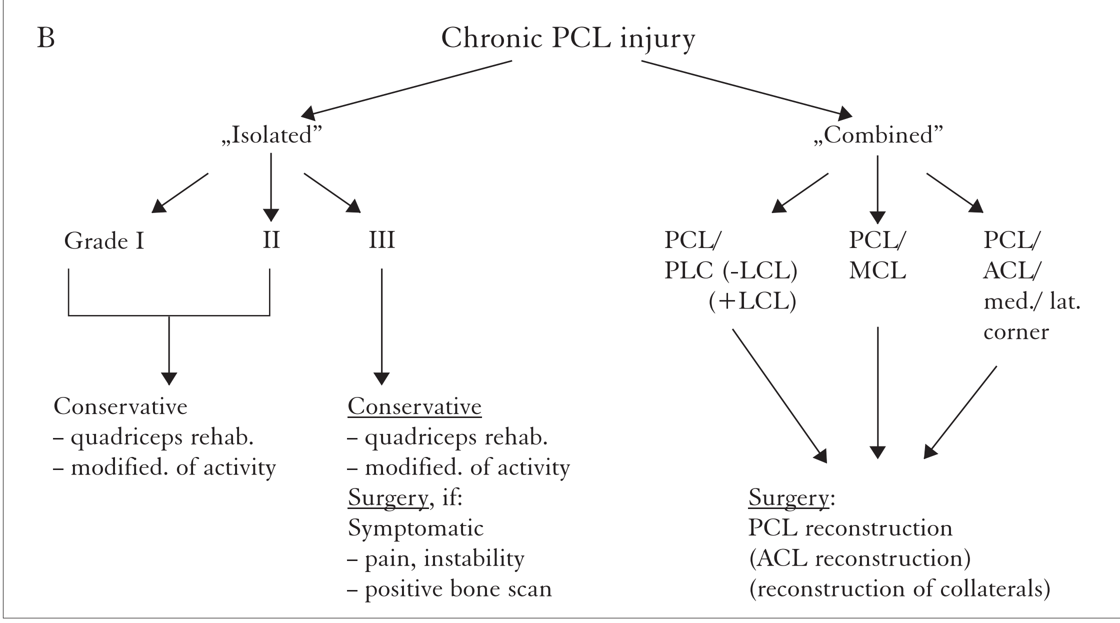
If a diagnostic arthroscopy is performed, a very careful attention should be paid to pressure of a fluid in order to avoid a liquid leakage through torn capsule to popliteal fossa and possible venous compression and complications.

Surgery should be performed on elective basis, once the knee is fully rehabilitated

Tab. 1. Schema of decision



Tab. 2. Schema of decision



to include full range of motion, minimal swelling, good leg control. The patient should be educated regarding rehabilitation goals like proprioception, cocontraction, quadriceps strengthening and surgical procedure.

In chronic PCL injuries surgery should be carefully indicated and any effort to improve joint function and stability by a proper rehabilitation program should be made.

So a simplified schema (Tab. 1 and 2) of decision might be proposed (acc. to Harner and Petrie, 26).

Graft selection:

Many materials have been proposed, because the ideal graft should be strong, provide secure fixation, be easy to pass, be readily available and have low donor site morbidity. On the other hand there should be some technical opportunities, because many of these patients have been previously operated or have a multiligamental injury and many sources of graft materials might be needed at the time of operation.

The available options are autografts and allograft sources: Achilles tendon allograft, autograft bone-patellar tendon-bone (BPTB), split quadriceps tendon autograft, quadruple semitendinosus and gracilis au-

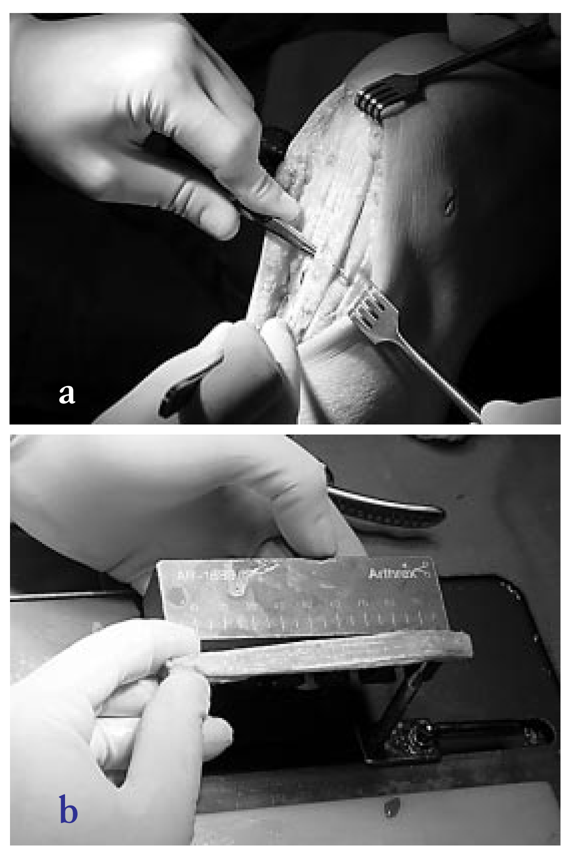


Fig. 6 a, b. Graft sources: central part of patellar tendon

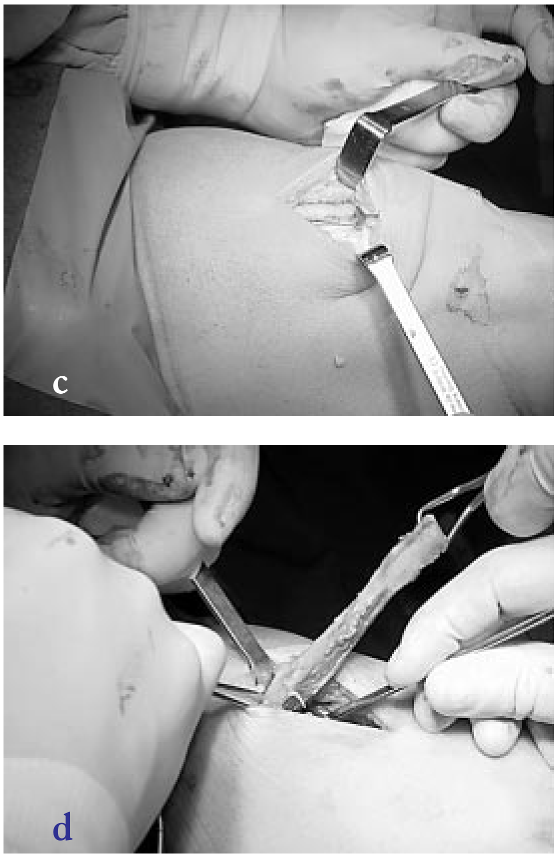


Fig. 6 c, d. Graft sources: a rectus femoris graft

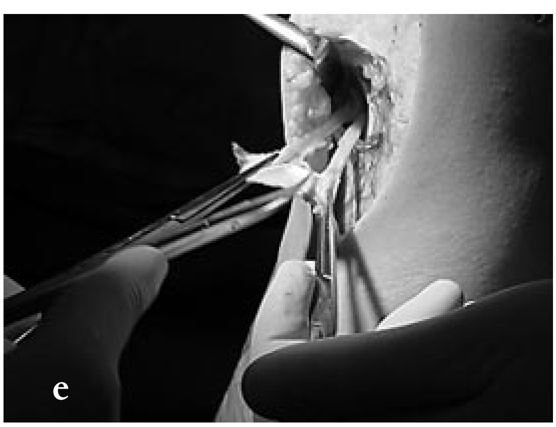


Fig. 6 e. Graft sources: hamstrings gracillis and semitendinosus graft

to- and allografts, autograft BPTB and split biceps tendon autograft. Synthetics are not approved by the Food and Drug Administration (10), but in Europe still are used so called „hot-dog" combined autografts and synthetic augmentation (15).

Allograft tissues have well-known advantages – no morbidity, significant bulk, disadvantages are: expense, the possibility of disease transmission, histocompatibility mismatch with immune response (present in up to 60% of patients) and even a slight risk of acute rejection or failure to incorporate. The risk of viral transmission has been currently so reduced, that is nearly negligible, there were no such a studies performed in PCL surgery, but in ACL reconstruction an overall success ratio is 86%, when compared with 94% in autografting.

Operative techniques:

There are in general two methods: a single bundle and a double bundle one and three techniques: by an open approach, arthroscopically assisted and a true arthroscopic technique.

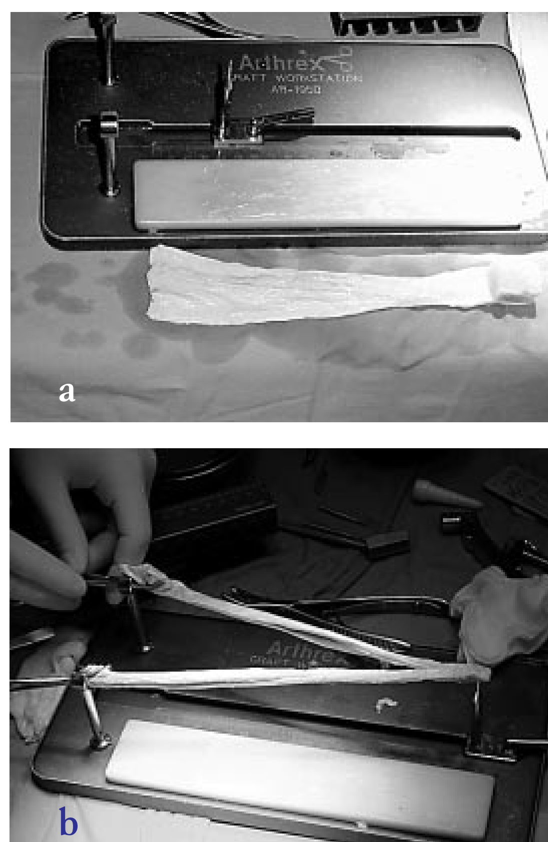


Fig. 7 a, b. Allograft of Achilles tendon

Single bundle technique

Traditionally, reconstruction involved replacing only the anterolateral bundle of the posterior cruciate ligament. This type of reconstruction has been termed „single bundle reconstruction" and persist low-grade posterior cruciate graft laxity. Clancy operated PCL with a BPTB with a two incision approach (8), Fulkerson (14) added an ipsilateral autogenous central quadriceps tendon with proximal patellar bone plug, to avoid a disruption of an extensor mechanism. Nowadays a pure arthroscopic technique, e.g. a so-called Pittsburgh approach has been widely accepted (23).

Patient positioning: Patient is positioned supine with a tourniquet over the upper thigh. Flexion of the knee should be maintained 90° without assistance throughout the entire procedure. The dorsal pedis and posterior tibial pulses should be checked before and after the procedure. Antibiotics are given routinely.

Examination under anesthesia and diagnostic arthroscopy are carried out in a systematic manner, tourniquet use is avoided if possible. The arthroscope is placed through a lateral, a motorized shaver through medial.

Debridement of the PCL femoral and tibial insertion: The intercondylar notch is debrided of the remnant PCL, sometimes is good to leave some fibers of femoral attachment to serve as a landmark for femoral tunnel pins placement. The 30° arthroscope is passed through the notch and a posteromedial portal is made under direct visualisation. A shaver is placed through the posteromedial portal with the mouth pointed anteriorly to avoid inadvertent injury to the neurovascular bundle and tibial insertion is debrided under vision. It is facilitated by use of 70° scope. Debridement is performed to 1,5 cm below the joint line.

Fig. 8. An X-ray intraoperative control of a tibial tunnel positioning

Tibial tunnel: The PCL tibial guide is placed through the medial portal and its an set is an orientation parallel to the proximal tibiofibular joint. A 2 cm longitudinal incision is made to periosteum on the anteromedial aspect of the tibia 1 fingertip below the level of tibial tubercle and it's position should be checked by intraoperative X-ray before drilling. Guide pin should exit on the distal third of the PCL foot print seen on X-ray as a posteriorly sloped cortical shadow just anterior to the medial tibial plateau shadow. When pin or drill are drilled a special curette is placed over the guide to prevent pin migration. 11 mm PCL tibial tunnel is made, great attention is paid when exciting the posterior cortex, last step might be done by hand drilling.

Femoral tunnel – should be centered 8 – 9 mm proximal to the articular surface of the medial femoral condyle in the anterior half of the native femoral insertion site (approximately 2 o'clock for the right knee). Through a anterolateral portal a 35 mm blind femoral tunnel is the created with a cannulated drill.

Graft preparation – a bone plug is shaped a round 11 mm plug corresponding to the femoral tunnel and one 5# Suture is placed through the bone. The tendinous portion of graft is trimmed, tubulerized using a baseball type stitch to correspond with the 10 mm tibial tunnel.

Graft passage is facilitated by use of looped, 18-gauge wire that is inserted through the tibial tunnel, great care is exercised when passing wire posteriorly around the tibial insertion to prevent a vascular injury. When the looped wire is visible inside the joint, the suture attached to the soft tissue end of Achilles allograft is threaded through the loop. The wire is then pulled out the distal end of the tunnel carrying the suture with it. The entire graft is pulled into the joint. The suture attached to the bone block is then threaded through the eye of the needle and pulled out of the anteromedial thigh allowing placement of bony plug into the femoral tunnel from within the joint. We fix it with a bioresorbable interference screw or through a separate incision anteromedially, midway between the medial patellar facet and the medial epicondyle through the vastus medialis oblique muscle.

Tibial fixation is performed with the knee in 90° of flexion. The normal 1 cm tibial step-off of the medial tibial plateau in relation to femoral condyle should be restored and another interference screw installed. The graft should be pretensioned before installation.

Immediately after surgery the patient is placed in a hinged knee brace that is locked into extension with a particular care to ensure that no posterior translation occurs while putting on the brace.

Tibial fixation may by facilitated and secured by a tibial inlay procedure with on mini-open approach described by Berg (6), with the posterior opening of knee joint and a direct fixation of a bony plug into posterior proximal tibia, however it needs a two-stage procedure.

Our preferred method are double tunnel, because PCL acts primarily as two functional separate bundles, with anterolateral and anterocentral portion acting predominantly in flexion and a posteromedial acting predominantly in extension. As it was mentioned, single bundle graft represents only the anterolateral part and is tensioned at 90° of flexion. Because majority of functional activities are performed at less than 70° of flexion, the graft is subjected to posterior stresses at flexion angles that are significantly less those at which it was tensioned what results in a cyclic fatigue and lengthening of the graft.

Double tunnel technique

Positioning of the patient, examination of the knee under anesthesia and systematic arthroscopic of the knee without a tourniquet, debridement of the PCL femoral and tibial insertions, tibial tunnel creation as mentioned above. Differences begin when drilling the femoral tunnels. To facilitate that procedure a lateral portal is enlarged, arthroscope switched to medial portal and irrigation stopped. The anterolateral bundle origin an the medial femoral condyle is seen inside the PCL footprint, guide wire is placed approximately 9 – 10 mm from articular surface and advanced. 11mm tunnel, 25 – 30 mm of depth is drilled, bone debris removed. Posteromedial bundle femoral tunnel size is smaller, about 6 – 8 mm in diameter according to the graft size a minimum 3 – 4 mm bony bridge should separate these tunnels. An anterior proximal guide pin should enter an intercondylar notch at 10.30 position in a left knee or 1.30 position in a right, approximately 6mm posterior to the articular surface of the medial femoral condyle. The posterior-distal tunnel is drilled 5 mm posterior and 5 mm distal to the anterior, still within the anatomic site of origin of PCL.

Next steps depends on the graft choice – if a rectus femoris graft is chosen – massive Ethibond sutures are installed on three ends of a V-shaped graft – 5# on bony block from patella and a 2# baseball stitches placed on tendinous endings.

Graft passage through a tibial tunnel is facilitated by an elastic curved device, tunnel is large enough for a bony block. The entire graft is pulled into the joint. The suture attached to tendinous endings separately are then threaded through the eye of the needle and pulled out of the anteromedial thigh allowing placement of prepared tendons into the femoral tunnels from within the joint. We fix it with a bioresorbable interference screw or through a separate incision anteromedially, midway between the medial patellar facet and the medial epicondyle through the vastus medialis oblique muscle.

An anterolateral bundle is tensioned at 90° of flexion with an anterior drawer test, a posteromedial at 30° of flexion.

Immediately after surgery the patient is placed in a hinged knee brace that is locked into extension with a particular careto ensure that no posterior translation occurs while putting on the brace.

Complications

The most common is persistent laxity as noted by a positive posterior drawer test. This is mainly due to not sufficient correction of other accompanying ligamentous injuries or underestimation of malalignement of a limb axis and might need a revision surgery among symptomatic patients. Loss of range of motion may also occur and often of some degree of flexion. Loss of extension is minimized by avoiding immobilization in flexion immediately after a surgery. It maybe treated arthroscopically by debridement of medial and lateral parapatellar gutters and retinacular release. Neurologic injuries can be present in a form of neurapraxia if the tourniquet is prolonged. Due to a fear of vascular, thrombotic or neurologic problems an use of tourniquet should be strictly limited and controlled. Many surgeons (25) use a posteromedial safety incision – 2 cm incision made just inferior to the posterior joint line. The crural fascia is carefully incised, the interval developed between the posterior capsule of the tibio-femoral joint anteriorly and to medial head of gastrocnemius muscle and neurovascular structures posteriorly. The surgeon can place his fingertip in this extracapsular position to monitor the position of tools, thus protecting the neurovascular structures. It has an additional advantage as a way to escape pathway for extravasating arthroscopic irrigation fluid if a capsular tear occurs.

Infection after PCL reconstruction is unusual, there are no reported series in literature, a risk factor might be a previous surgery and meniscal repair (9, 25).

An osteonecrosis of the medial femoral condyle has been reported (5, 25) and might occur from increased pressure in the bone causing a vascular insufficiency. It might be also due to drilling a femoral tunnel too close to the articular surface, which might disturb the single nutrient vessel providing the intraosseus blood supply to femoral condyle.

Anterior knee pain due to synovitis, harvest of bone-patellar tendon-bone grafts, prominent hardware and degenerative patello-femoral joint disease has been reported.

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