

**P o s t e r i o r
c r u c i a t e
r e c o n s t r u c t i o n**



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PC 60

Principles :

the concept of the use of synthetic ligament is a “ligament synthesis”

Classical P. C. L. reconstructions with autologous techniques are known to give inconstant results with regards to the complete correction of the posterior tibial displacement. It is therefore logical for some surgeons to think that a surgical reconstruction is not indicated, based on their opinion that the P. C. L. deficiency is well tolerated.

In fact, the data from literature as well as the experience of each of us are not so obviously in favour of this so called tolerance.

P. C. L. deficiency in fact disturbs the knee kinematics as much as does A. C. L. deficiency. The permanent traction of the hamstrings produces the posterior tibial subluxation. This subluxation is reduced by the pull of the quadriceps in the first phase of active extension. This mechanism leads to stresses on femoro-tibial surfaces and patello femoral cartilages as the patella must strongly press on the trochlea to bring the tibia forward.

Clancy (4) showed patello femoral cartilage damage 2 years after injury in 20 % of the cases and 70 % on femoro tibial joint. The reputation of good P. C. L. deficiency tolerance is more than questionable when reviewing the literature which shows pain, effusion, instability in many cases.

	Pain	Effusion	Instability
DANDY (6)	70 %	20 %	45 %
DEJOUR (7)	87 %	20 %	30 %
KENNEDY (11)	61 %	67 %	55 %
PAROLIE (13)	52 %	16 %	20 %

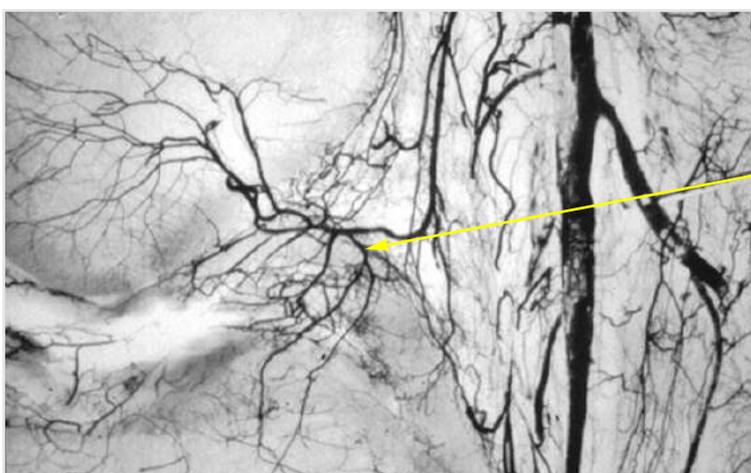
The evolution to osteoarthritis is confirmed by the same authors : 69 % grade III and IV after 15 years for Dejour (7). Keller et al (9) report a study of 40 non operated patients 6 years after injury. This study shows a lower activity level in 65 %, pain in 90 %. At 10 years, there was 60 % of grade II or III osteoarthritis, and 80 % at 15 years. P. C. L. injuries are far from being harmless.

If we judge the results of autografts on accurate radiographs, the mechanical efficiency of P. C. L. reconstruction is poor. Good mechanical objective results, as published by Bianchi (2), Bousquet (3), Kennedy (10), reach 50 % at best. These results would not be acceptable for A. C. L. reconstruction and would be considered a failure.

The results of allografts are also disappointing (Covey et al -5-, Harner et al -8-) with the additional risk of viral disease transmission which is not acceptable even though quite small.

Due to the collagen transformation which weakens them, autogenous transplants require a post operative period of rest. As opposed to what occurs in A. C. L., P. C. L. reconstructions must be resistant from the early post operative moments to resist to hamstring action. One can increase the size of the transplant or combine several of them, the same inevitable decrease of initial strength occurs and will end in elongation.

Scapinelli (14) has demonstrated the richness of P. C. L. vascularization. We learned a long time ago that the P. C. L. is able to heal and this has been recently confirmed by MRI studies which show a continuous but elongated P. C. L. (Shelbourne et al -15-, Akisue et al -16-). The P. C. L. heals, but with the tibia posteriorly displaced, it becomes too long. The healing potential makes the P. C. L. itself the best transplant, all the more so since it is the only one to have the mechanoreceptors for proprioception.



*The PCL is well vascularized by a postero superior pedicle (middle geniculate artery)
Scapinelli.*

Therefore, the goal is to obtain proper healing without elongation, primary healing in acute injuries, secondary healing in chronic lesions with the tibia recentered. This healing is always better in acute cases.

In chronic cases the tibial attachments have to be stired up widely as the vascular pedicles are proximal. The use of appropriate synthetics ligaments allows recentering of the knee and the healing with the knee and ligaments in an anatomic position.

A reconstruction with one bundle is enough in acute injuries (less than 3 weeks). In chronic injuries our experience of 2 bundles reconstruction started in 1978. Probably due to secondary global distensions in chronic cases, it is mandatory to have an anatomical and physiological 2 bundles reconstruction. This is the only way to stabilize the knee in all positions of flexion - extension - rotation. The antero lateral bundle is slack in extension, the postero medial is slack in flexion. The posterior displacement of the tibia is controlled by the anterior bundle when the knee is in flexion and the posterior bundle when the knee is in extension. Each bundle is progressively recruited during motion and it is impossible to reproduce this mechanism with a single bundle.

The LARS ligaments

The LARS ligaments show, in their functional median part, a structure made only of longitudinal, parallel and totally independent fibers. This structure has the advantage to avoid the cutting of the fibers crossing each other (the previous ligaments were all braided, woven or knitted).

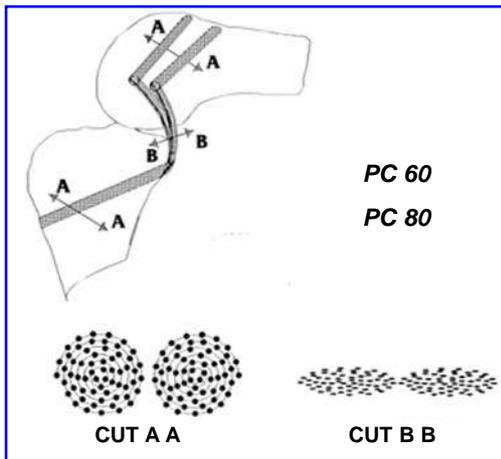
Another advantage of the " free fibers " design is a gain of volume and the use of less synthetic material for equivalent resistance, as well as offering a completely open structure for fibroblastic invasion. It gives also a flat structure behind the tibia which is much better than a cylindrical body for flexion - tension stresses.

There are 2 types of ligaments : PC 60 and PC 80. The resistance of the ligament depends on the number of fibers.

The size varies according to the patient's morphology :

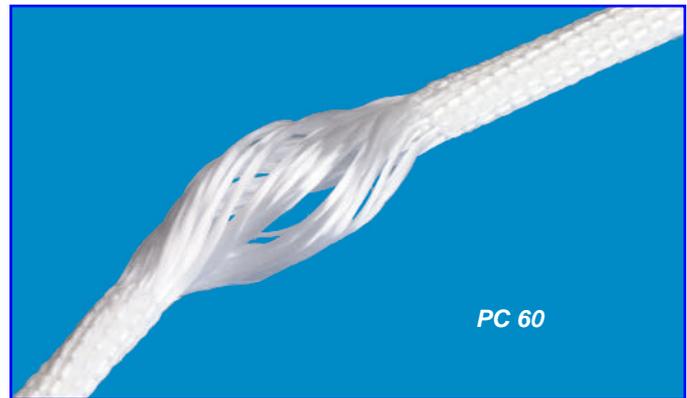
In a one bundle reconstruction (acute lesion only), the PC 80 is recommended,

In a two bundle reconstruction : the antero-external bundle uses a PC 80,
the postero-internal bundle uses a PC80 or PC 60.



		Tunnel	Resistance minima
LARS PC 60	60 fibers	6 mm	2 000 newtons
LARS PC 80	80 fibers	6 mm	2 800 newtons

References L010605 : PC 60
L010805 : PC 80



Fixations

The fixation of the synthetic ligaments is made with canulated interference screws, specially designed not to damage the ligament. The diameter of the screw must always be at least one millimeter greater than the diameter of the tunnel. (For example a 6 mm tunnel requires at least a 7 mm screw).

After the emergence of the tunnel the fixation of the ligament is completed, particularly on the tibial side, by a second transverse tunnel and another screw or at least a staple.



References

Interference canulated screws
 F110725 7 x 25
 F110730 7 x 30
 F110825 8 x 25
 F110830 8 x 30

Cobalt chromium staples
 G200620 6 x 20
 G200820 8 x 20

The instruments

The LARS instrument set comprises a tibial guide and different accessories to make the operation easy.

Tibial guide

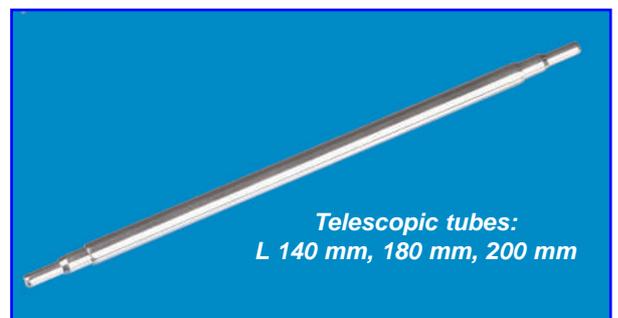
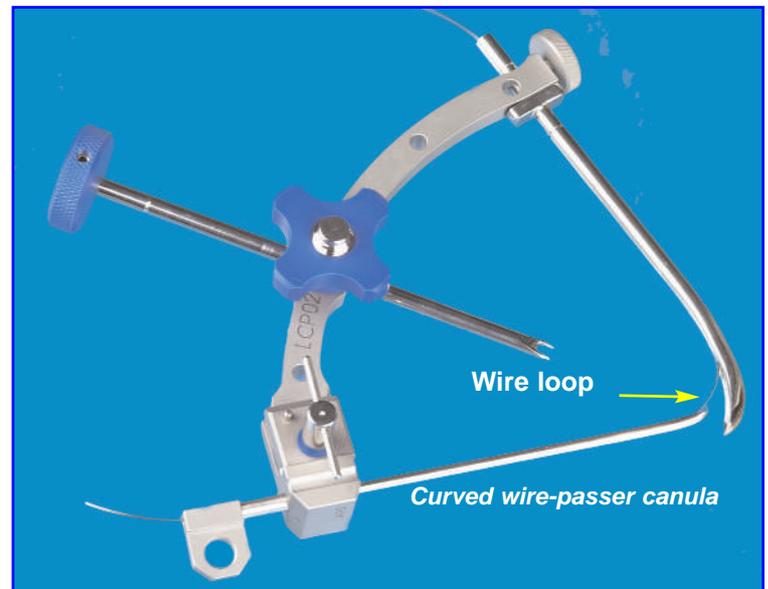
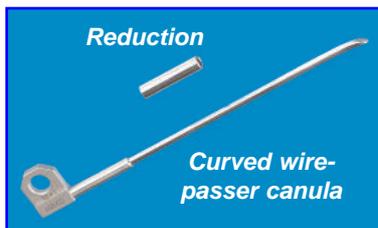
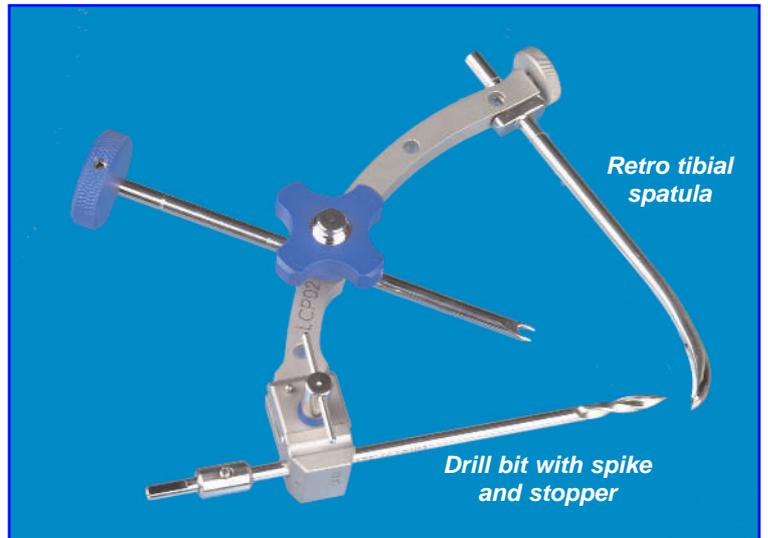
Allows the placement and the drilling of the tibial tunnels while ensuring the complete safety of the posterior nerves and vessels (without any posterior approach).

The drill bit guides allow drilling through a small anterior incision at an angle of about 45° until the drills reach the spatula placed behind the tibia. The contact between the drill bit and the spatula must be confirmed.

The drill bit must be pulled out and then passed again several times to remove all the bony debris at the posterior aspect of the tunnel.

The drill bit is then replaced by the curved wire-passer canula.

A wire loop passes into the curved wire passer canula and pushed through it. This wire loop exits out of the base of the retro tibial spatula.



Telescopic tubes

They allow the passage of the drill bits through a micro-incision on the femoral side (specially when using an arthroscopic procedure) as well as the passage of the wire loops and the interference screw, without damaging the soft tissues



Surgical Technique

For severe chronic or combined instabilities, or revisions, this technique should not be performed under arthroscopy unless the surgeon has a great experience. A well done open surgery will always be better than an uncertain and lengthy arthroscopic procedure. Therefore the 2 techniques will be described.

Open surgery

◆ Step 1 - Installation and approach

Supine position. The thigh lies on a knee holder which is placed with the tourniquet as proximal as possible. The knee must be able to be positioned in full extension and a 100 to 110 degrees of flexion. The incision is medial para patellar from the tibial plateau up to the quad tendon and passing laterally to the vastus medialis tendon. The patella must be laterally retracted.

The first step consists in dissecting the remaining P. C. L. from the A. C. L. to which it is often adherent. Following the anterior aspect of the P. C. L., scissors cut all adherences and tibial attachments along the midline and 2 or 3 cm on each side.

This step is most important in chronic cases and is the most difficult step to be completed under arthroscopy. This "reviving" will allow the reattachment of the P. C. L. and adjacent structures when the tibia is reduced forward (with a shortening effect on the P. C. L.)

◆ Step 2 - Drilling of tibial tunnels

➤ 1 - Tunnel for postero medial bundle

The spatula of the guide is introduced through the notch, after removal of osteophytes if any. The spatula passes on the medial side of the A. C. L., and is pushed backward until its stem lies on the roof of the notch, the knee being flexed at 90°.

The canulated fixation stem must be parallel to the tibial plateau. The spatula is oriented medial to the midline, such that the entrance point of the drill bit is at the mid part of the medial metaphyseal aspect of the tibia. When this proper orientation is obtained the guide is fixed by the mean of the canulated fixation stem and a 2.5 mm k-wire. (Fig 1)

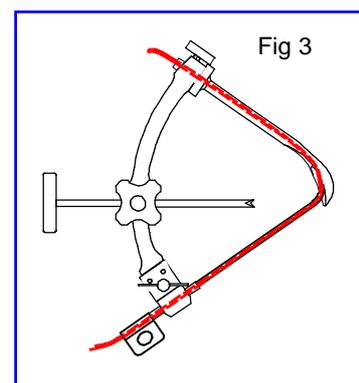
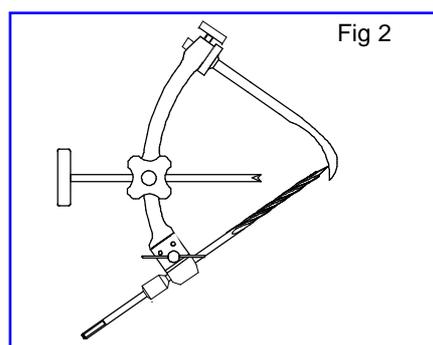
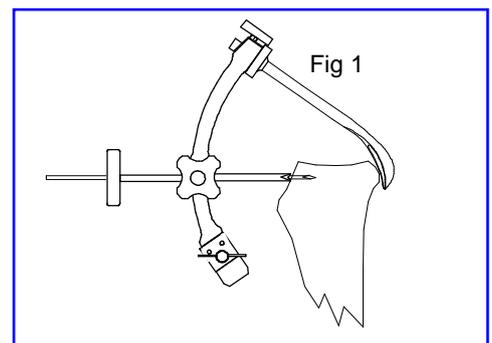
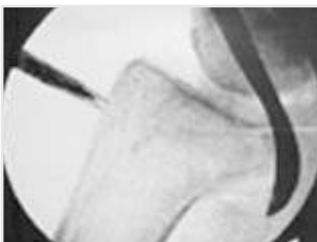
A small incision is made vertically, centred by the position of the drill bit. The soft tissues are retracted from the cortex. By the way there is a cutaneous bridge between the lower incision and the para patellar approach. This bridge has to be respected to preserve the branches of the saphenous nerve (sensibility and proprioception).

The 6 mm drill bit guide is afixed on the movable jaws of the guide. The sharp 6 mm drill bit is first used to obliquely enter the cortex, and is pushed until it bumps against the spatula.

This first drill bit is replaced by the flat ended drill bit which is pushed and pulled back and forth to remove all the bony chips.

The drill bit is then replaced by the curved wire-passer canula. (Fig 2) A wire loop passes into the curved wire passer canula and pushed throught it. This wire loop exits out of the base of the retro tibial spatula. (Fig 3)

The guide is dismantled.



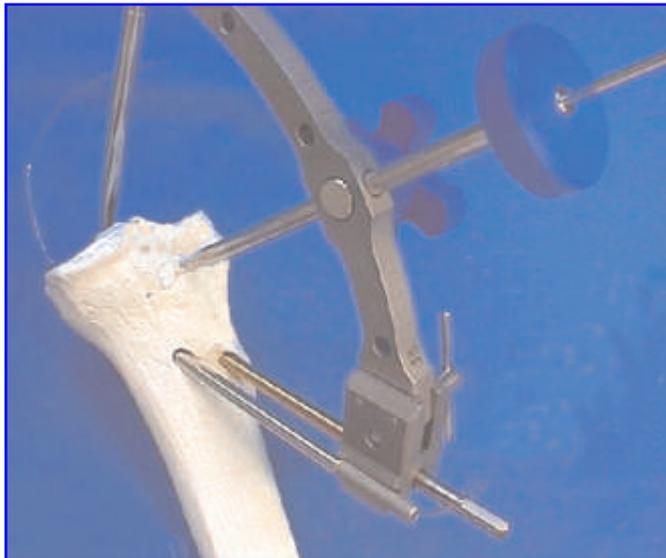
➤ 2 - Tunnel for antero lateral bundle

A tube is placed in the first medial tunnel to protect the wire loop, and ensure that the second tunnel will not cross the first one.

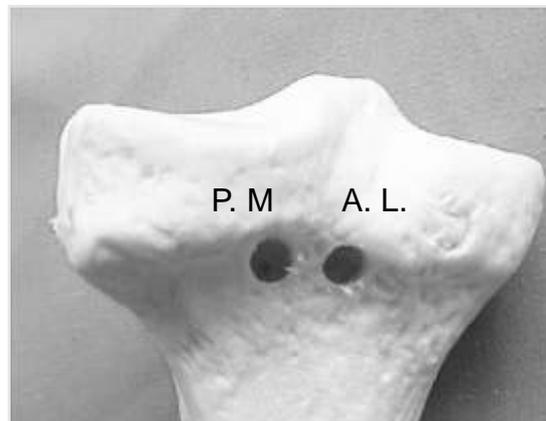
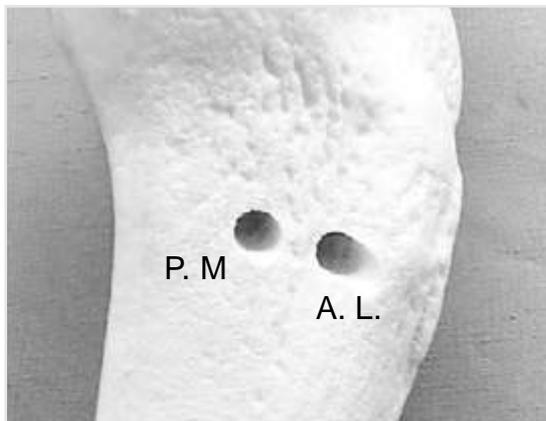
The guide and the spatula are put back in place. The tube of the first tunnel lies on the groove of the medial face of the drill guide. The spatula is oriented lateral to the midline and the guide afixed in that position.

Note : depending on the size of the bone, the entrance of the second tunnel can be on the medial slope of the tibial tubercle on more distant on its lateral slope.

Same procedure as above will bring the wire loop outside the knee.



Antero lateral tunnel drilling



Location of tibial tunnels entrances and exits

◆ Step 3

A good positioning of femoral tunnels is fundamental.

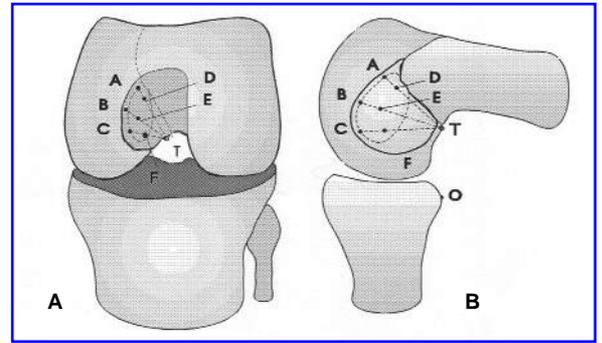
The center of the anatomical P. C. L. insertion corresponds to a point that can be geometrically defined for each knee. This point is at 40 % of a line drawn parallel to the Blumensat line and passing by the most prominent point of the posterior condyle on an X-Ray where the 2 condyles are superimposed. This point corresponds also to the so called isometric point as described by Ogata et al (12). This point can be determined on a preop X-Ray and found intra operatively by any graduated device or with the help of the image intensifier which is highly recommended.

A one bundle reconstruction (acute cases) must be centered at this point.

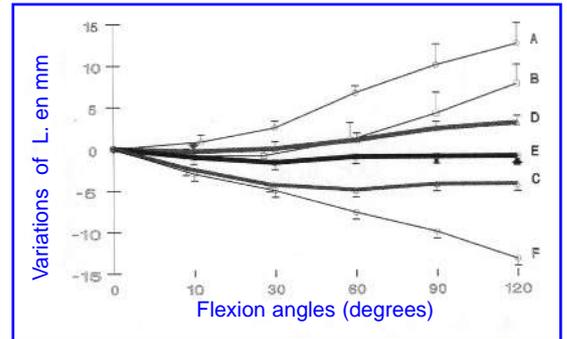
The tunnels of a 2 bundles reconstruction must be located on each side of this point : anterior and proximal for the antero lateral bundle, posterior and distal for the postero medial bundle. These points correspond to Ogata's points D and C and each bundle will have a limited non isometry.

The drilling is directly made inside - out from the intra articular aspect of the medial condyle. Directions of tunnels are most important to avoid any sharp angle of the implant and any risk of osteonecrosis and collapse of the condyle. The anterior tunnel is directed anteriorly, proximally and medially to exit at the junction of the medial and anterior aspect of the femoral metaphysis. The posterior tunnel will exit more distally and medially just in the middle of the medial aspect. These exits are both extra articular.

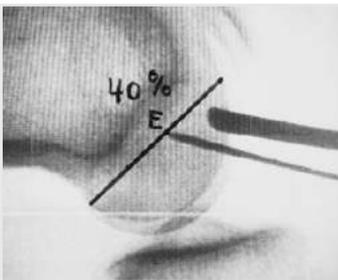
The less transverse and the closer to the axis of the femur the tunnels will be, the less will be the risk of osteonecrosis and the stresses given to the ligament in flexion and torsion will be minimized .



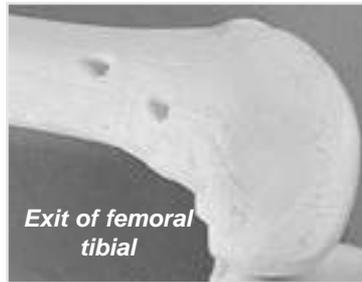
A. P. and lateral views of Ogata's points for femoral insertion



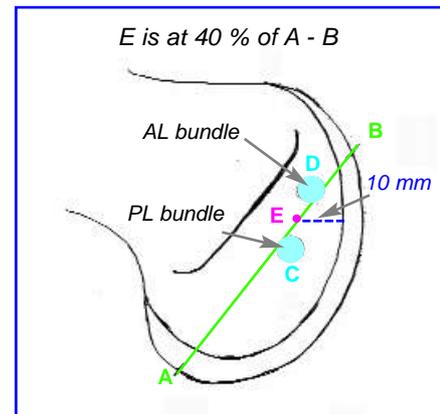
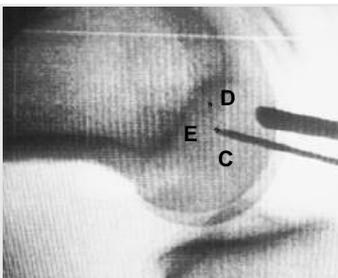
Change in length related to the different points (Ogata et all.)



Geometrical definition of points E, C, D



Exit of femoral tibial



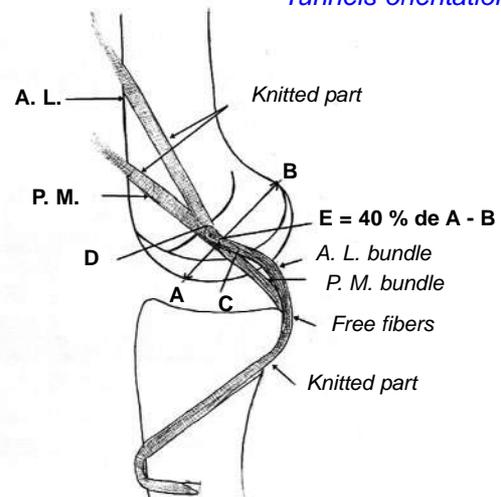
E is at 40 % of A - B

AL bundle

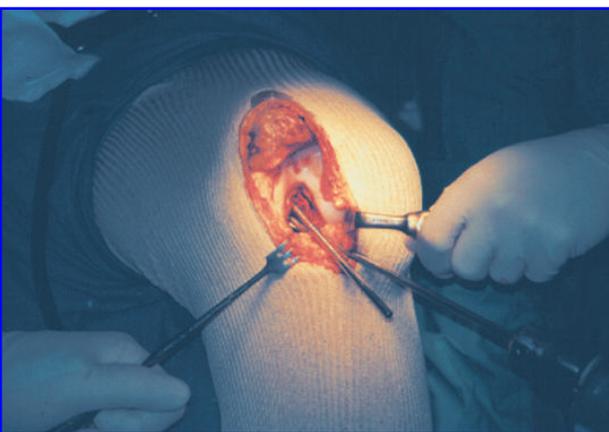
PL bundle

10 mm

Tunnels orientation



E - D - C = OGATA'S POINTS



Position of the drill bits for drilling anterior and posterior femoral tunnels

◆ Step 4 - Passage of the ligament and femoral fixation

Wire passer tubes are placed in femoral tunnels. The wire loop and a blunt K-wire that will lead the interference screws are introduced outside in.

Each bundle is pulled through the corresponding tunnel inside out. The junction of the free fibers and the knitted portion must be adjusted one millimeter inside the tunnel.

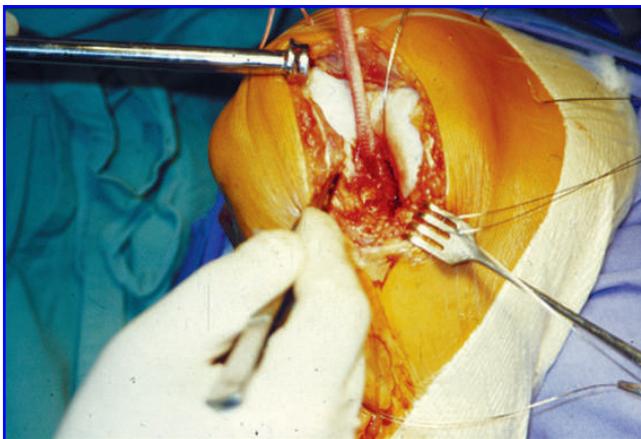
Then by the mean of the tibial wire loops each bundle is pulled through the corresponding tibial tunnel anterior femoral bundle in the lateral tibial tunnel, posterior femoral bundle in the medial tibial tunnel.

The femoral fixation is immediately performed with the interferences screws (8 x 30 or 7 x 30) which are placed outside in with the help of the guiding K-wire and the telescopic tubes.

The length of the bigger tube and the length of the canulated screw driver are adapted to allow the placement of the screw flush to the bone. It is even recommended to give another turn to the screw after removal of the bigger tube when the screwdriver has been stopped by the tube.



Femoral fixation through telescopic tube



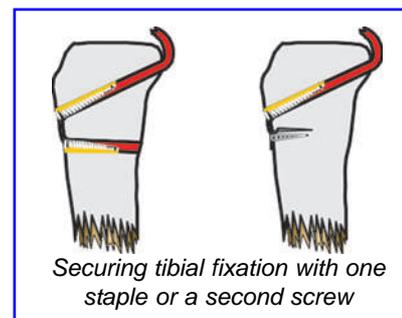
Passage of the ligament

◆ Step 5 - Tensioning and tibial fixation

The antero lateral bundle must be tightened in flexion. This tensioning must be performed manually and must be limited to placing the ligament rectilinear and correcting the tibial posterior displacement. This is achieved when the A. C. L. is back to its normal tensioning and obliquity. The ligament is then blocked in this position and **one makes sure that complete extension can be obtained.**

Tibial fixation is performed with an interference screw (7 x 30 or 8 x 30). The screw must be placed at the upper face of the ligament and guided by a K-wire all the way up into the tunnel.

The postero medial bundle must be tightened in extension and one makes sure that complete flexion can be obtained.



Securing tibial fixation with one staple or a second screw



Femoral fixation with screw and staple

Complete correction of the posterior sag and full motion must be again controled and the tensioning of each bundle again readjusted if necessary. This step is fundamental and one must take the necessary time until a perfect result is obtained.

The stress on the ligaments being high, it is mandatory, specially on the tibial side, to complete the primary fixation with at least a staple or better with a second screw placed in a transverse lower tunnel.

The parts of the ligaments which are preserved outside the main tunnels will eventually allow a revision if needed for retightening, new injury or other indication.

The operation is ended by a careful lavage, and closure is performed layer by layer over a vacuum drain. No splint. A compression machine can be successfully used to reduce patient's discomfort and swelling.

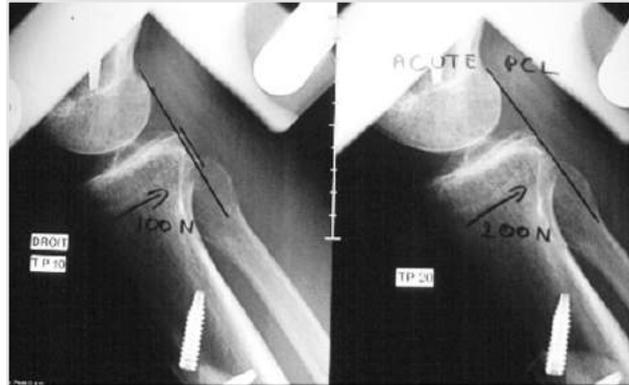
Arthroscopic procedure

“It is a mini invasive "ligament synthesis”

This procedure is recommended in mild isolated posterior laxities and mainly in acute injuries where a one bundle "internal fixation" is enough. This "internal fixation" is a simple procedure which does not add any new damages to those of the injury itself.

Technical principles are the same as for open procedure. Particular points are :

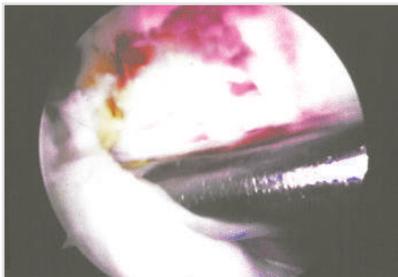
- Do not use an arthroscopic pump in acute cases.
- If there is an important leak, which is rare, one must give up with the scope and do a mini arthrotomy (watch the calf).
- The portal for the spatula of the guide is medial parapatellar 1 or 2 centimeters above the lower pole of the patella. The wire loop will exit from the same portal. The spatula must be placed behind the tibia on the midline.
- Femoral tunnel : with a one bundle reconstruction the femoral tunnel must be located at the "isometric" point described above (point E). The use of the fluoroscope is highly recommended. This point is marked by a k-wire which is introduced into the notch through the skin at the lateral edge of the patellar tendon, at the level of the joint-line. The k-wire is directed obliquely through the medial condyle to exit through the skin of the lower and antero medial aspect of the thigh. A micro incision allows the passage of the telescopic tubes guided by the k-wire. The canulated drill bit is introduced through the bigger tube and will drill the tunnel from outside in.



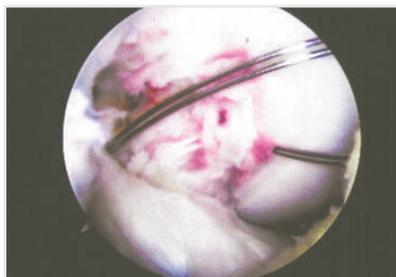
Acute P.C.L. - Perfect mechanical result at 3 Y under 100 and 200 newtons

A wire loop is passed outside in through the canulated drill bit and will be caught by a small arthroscopic forceps. This forceps is introduced through the medial portal from which is already exiting the tibial wire loop. With the help of those 2 wire loops the ligament (PC 80) is passed first through the femur, then through the tibia. The scope controls the proper position of the free fibers in the joint.

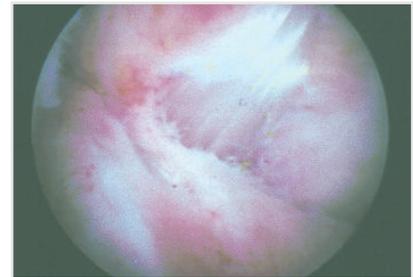
Tensioning and fixation are performed just like in the open procedure. As being supposed to be isometric the single bundle can be tightened in flexion which is easier to control the aspect of the A. C. L. But one must make sure that full extension is still easily obtained and adjust the tension accordingly.



Spatula on the medial edge of the



Femoral and tibial wire loops



PC 80 in place

Autogenous option

For all the previously given reasons (vascularization, proprioception, real ligamentous structure) the P. C. L. itself seems to us the best material. However in some cases, the P. C. L. is totally absent (revisions) or poor.

In these cases in our opinion the P. C. L. must be reconstructed with an autogenous transplant reinforced with a synthetic ligament, as no fibroblastic ingrowth can be expected from nothing. At the beginning of our experience in P. C. L. with synthetic we used to combine autogenous and synthetic even if P. C. L. was looking elongated but strong and thick. We made 2 groups with or without autogenous transplant. After 2 years there was not difference between these 2 groups. So we actually think there is no need to harvest any structure except if there is no valuable P. C. L. remaining structure.

But some still prefer whatever the P. C. L. looks like, the classical use of an autogenous transplant.

When using autogenous we prefer the quadriceps tendon or gracilis - semi tendinous which seem less damaging than the patellar tendon for the extensor apparatus. And the extensor apparatus should be a main concern in P. C. L. deficiency.

Specific LARS ligaments have been designed for autogenous reinforcement, to prevent post operative elongation :

- **ACTOR 10** : it is a cylindrical tube, comprising also free fibers in its intra articular part. The autogenous transplant is placed inside the tube with the help of built in leaders. The synthetic structure is very porous, specially in the intra articular part, which permits biological exchanges between transplant and environment. The transplant must be positioned and centered in the free fibers intra articular part.

- **AC 30 RA** : it is a small ligament, with the usual LARS structure which is designed to be placed inside the autogenous transplant with a canula or after opening the transplant as a "hot dog". AC 30 RA is cylindrical in both bony part.

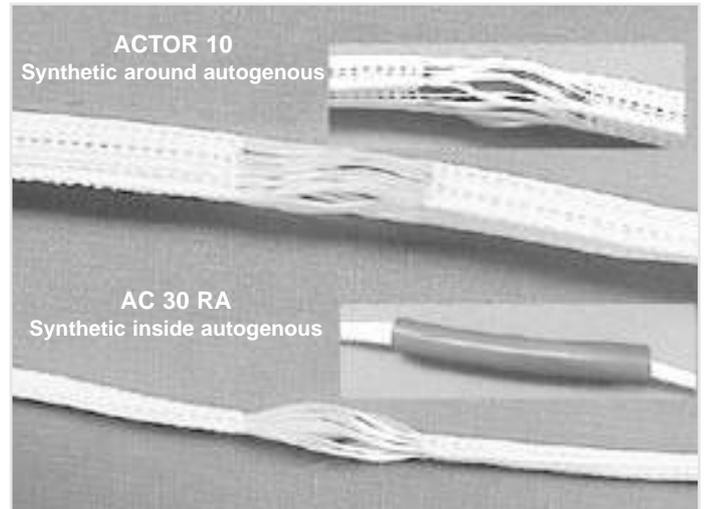
The tibial guide comprises drilling guides of 8 to 12 mm drill bits.

For the passage of the wire lopp, the wire passer tube must be centered by using the 6 mm drill guide. The autogenous transplant and the synthetic scaffold are fixed together in the femoral tunnel with an interference screw.

On the tibial side, the autogenous transplant must be tightened while the synthetic scaffold should not.

The synthetic reinforcement must not avoid any work given to the transplant, but is there to limit the elongation. Therefore at the end of the operation one must get a one to two millimeters of laxity with a firm end point.

It is the condition to obtain a new ligamentous structure with collagenic and vascularization ingrowth.



References L030407 : ACTOR 10
L030305 : AC 30 RA

Post operative care

The LARS techniques allow full and immediate mobilization and weight-bearing.

Days 1 - 2 : Passive motion with C. P. M.,
Active motion as allowed by patient's pain,
Isometric contractions of the quadriceps.

Days 2 - 3 : Weight-bearing with crutches,
Quad exercises. Mobilization,
Removal of the drainage.

Physical therapy is then carried on every day for each muscular group. Active dynamic contractions of the quadriceps against resistance and in open chain must be prohibited.

Isokinetic rehabilitation in closed chain follows isometric contractions.

Rehabilitation of proprioception at 4-5 weeks.

Resuming to sports activities must be progressive as soon as proprioception is satisfactory.

Full sports are generally authorized after 3-4 months for all synthetic reconstructions and about 7 month when combined autogenous synthetic have been used.

The use of synthetic ligaments allows to avoid the use of a brace.



Evaluation of objective results.

Pré and at review radio laximetry with Telos at 150 and 200 N.



NOTES

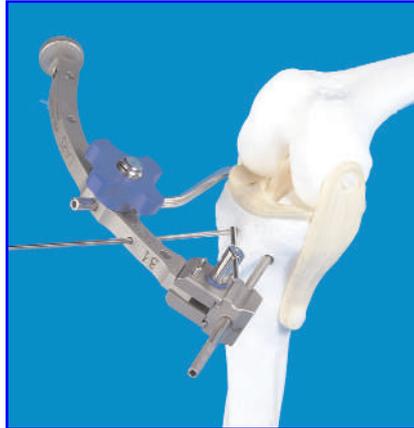
Isolated P. C. L. injuries represent about only 30 % of the cases. More often they are combined with other ligaments injuries, meniscal tears and cartilage damages.

◆ Postero lateral laxities

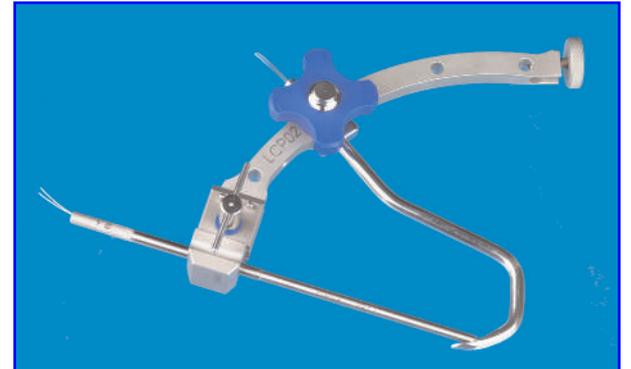
They are quite frequent and must be diagnosed and treated simultaneously.



LARS guide features a special harm for post-lat. reconstruction



Harm for drilling and passage of a wire loop for postero lateral reconstruction.
Hook wire-passer to bring the lateral branch of the PPLY 100 outside the notch.



In acute cases : by a selective approach crossing the middle of the lateral collateral ligament incising the fascia lata and passing in front of the lateral gastrocnemius.

One must :

- Suture what can be sutured.
- Reinforce with a PC 60 or PC 80 reproducing the path of the popliteus tendon, to immediately avoid the hyper external rotation of the tibial plateau and resist to the action of the biceps. Thus one can expect a proper healing in good position.

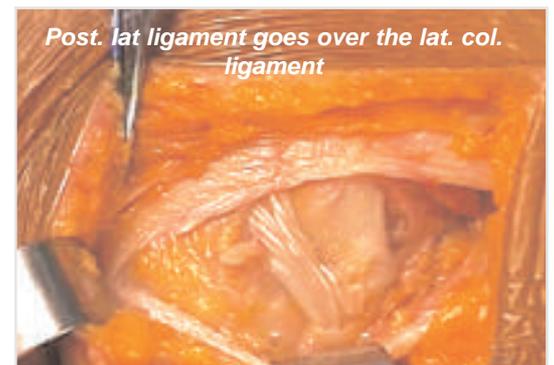
The P. C. L. guide features a specific device for positioning and drilling the tibial tunnel for postero lateral complex reinforcement.

In chronics : if the patient is not involved in strenuous sports activities and the postero lateral laxity is moderate, a reconstruction using the PPLY 100 ligament is used. As described par J. Beaon (1) one branch of the Y reconstructs the anterior bundle of the P. C. L., the other branch reconstructs the path of the popliteus tendon. If it is a major postero lateral laxity on a high sports level patient, a two bundle reconstruction of the P. C. L. and a separate reconstruction of the postero lateral structure using a PC 80 must be performed.

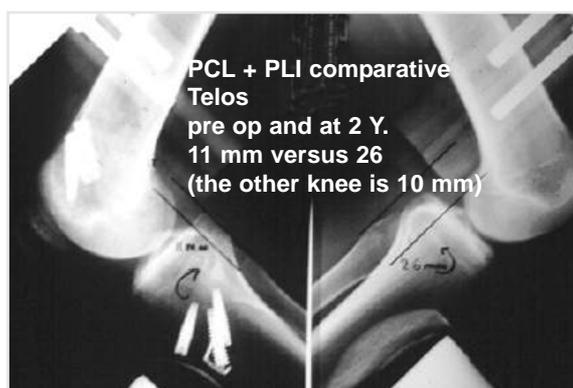
The tibial tunnel is 3 cm below the tibial plateau and 1 cm medial to fibular head. The postero lateral reconstruction crosses over the L. C. L. and enters the lateral condyle just in front and below its attachment.



Reference L041005 : PPLY 100



Post. lat ligament goes over the lat. col. ligament



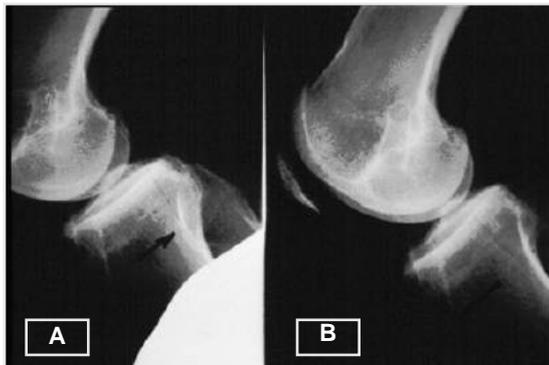
PCL + PLI comparative
Telos
pre op and at 2 Y.
11 mm versus 26
(the other knee is 10 mm)

◆ Simultaneous reconstruction of P. C. L. and A. C. L.

The P. C. L. reconstruction must always be performed first. The tensioning of the P. C. L. cannot be adjusted on the A. C. L. Therefore any hypercorrection of the posterior tibial displacement must be carefully avoided. Before fixation of the P. C. L. tibial side, one must make sure that the posterior border of the condyle is not in front of the posterior edge of the tibial plateau when the knee is at 90° of flexion.

The use of a fuoscope or intra operative X-Ray with the 2 condyles superimposed is very useful. A line is drawn down from the posterior edge of the condyle parallel to the posterior cortex of the tibia. If the tibial plateau is in front of this line, the tensioning of the P. C. L. must be released. This line must be adjusted flush with the posterior border of the tibial plateau. Then the fixation is achieved.

The A. C. L. reconstruction can be performed only when the knee has been recentered, by P. C. L. and / or postero lateral reconstruction.



Revision of a combined PCL + ACL
(Note that ACL tibial tunnel was too anterior)
A - Posterior sag
B - Recentering the tibia for PCL before ACL reconstruction



Laximetry + 1 Y

◆ P. C. L. and knee replacement

Some uni medial compartment osteo arthritis are related to P. C. L. deficiency. In that case it is much more conservative, instead of a total postero stabilized knee replacement, to perform an unicompartmental prosthesis combined with a P. C. L. synthetic reconstruction.

Sometimes in old chronic cases there are severe damages of the patella femoral joint. But total knee replacement is not justified by other compartments. An isolated patello femoral replacement can be performed in association with P. C. L. reconstruction with good results.

Medial O. A. on chronic PCL :
unicompartmental replacement
+ double bundle PCL

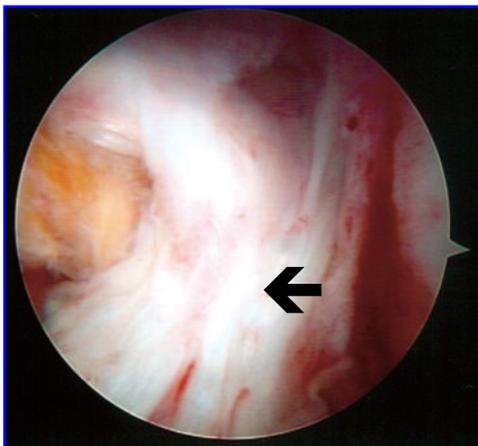


Conclusion

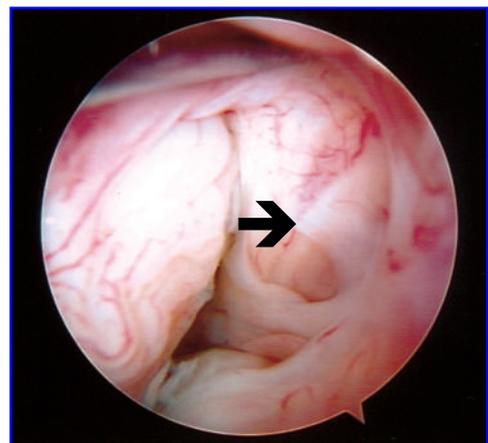
Functional disabilities and the high potential for severe osteoarthritis as a result of P. C. L. deficiencies suggest the need for early restoration of normal knee kinematics. None of the classic techniques give predictably good mechanical results. The LARS technique uses synthetic ligaments as a ligamento synthesis to get proper healing of the P. C. L. just like a plate or a nail is used to get good bony union.

This technique is now based on a 10 year international experience. It is quite a simple procedure for the patient, avoiding more or less severe harvesting around the knee and which does not "burn bridges".

With the help of the specific LARS guide, the procedure is made easy and safe and is now considered a first choice for many surgeons.



PCL at 4 years



PCL at 5 years

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