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Original article

Posterior drawer after olecranization of the patella in posterior cruciate-injured knees: A cadaver study

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ABSTRACT

Introduction: Olecranization of the patella (OP) is a surgical technique that anchors the patella to the tibia using a Steinmann pin to reduce the posterior drawer in cases of acute posterior cruciate ligament (PCL) tears. The advantage of this procedure is that rehabilitation can start early with passive and active mobilization, all the while maintaining the reduced position. The primary objective of this cadaver study was to evaluate the reduction in the posterior drawer induced by OP. The hypothesis was that OP significantly reduces the posterior drawer at 0°, 45° and 90° flexion after isolated PCL transection.
Material and methods: A Steinman pin was inserted in 70° flexion on seven fresh cadaver knees. Changes in the posterior drawer were measured on radiographs at 0°, 45° and 90° flexion before and after adding a posterior load (150 N) in the following sequence: intact knee, after PCL transection, after OP. Posterior translation was measured in millimetres.
Results: In unloaded knees, the posterior drawer was significantly reduced after OP in 45° flexion (4.1 mm to −1.2 mm, $p < 0.05$) and 90° flexion (7.9 mm to 3.8 mm, $p < 0.05$). When a posterior load was applied, the posterior drawer was significantly reduced in 0° flexion (4.9 mm to 0.2 mm, $p < 0.05$), 45° flexion (6.7 mm to 0.6 mm, $p < 0.05$) and 90° flexion (11.8 mm to 7.6 mm, $p < 0.05$).
Discussion: Anchoring the patella to the tibia in 70° flexion led to a significant reduction in the posterior drawer after PCL transection in cadaver knees. Olecranization of the patella may help optimize the healing of an injured PCL treated conservatively.
Level of evidence: III, controlled laboratory study.

1. Introduction

Initially described by Grammont et al. [1], olecranization of the patella (OP) is used to stabilize the knee in a position that reduces the posterior translation force in the joint. A temporary Steinman pin crossing the patella and tibia prevents backward movement of the tibia under the femur in cases of severe posterior ligaments injuries, particularly in isolated posterior cruciate ligament (PCL) tears. This technique has only been featured in a few publications [2–5]. The strengths of this technique are that it allows early postoperative mobilization of the knee [4] and that it is a fast, simple percutaneous procedure [2–4,6] that can be used in polytrauma patients or those with concurrent vascular lesions. Holding a position in which the posterior drawer load is reduced may facilitate spontaneous healing of the PCL. The drawback is the potentially arthritic effect on the patellofemoral joint induced by temporary patello-tibial transfixation [3,6]. This risk must weigh against that of conservative treatments of isolated PCL injuries, which reportedly lead to a 46% rate of patellofemoral osteoarthritis 5 years later [7]. By anchoring the patella to the tibia in extension, Rungee [6] and Kambic [3] showed that OP induces a detrimental posterior drawer force. They denounced this surgical technique, which aimed to reduce the knee by patello-tibial transfixation in 70° flexion. The objective of our study on cadaver knees was to evaluate the reduction in the posterior drawer after OP performed in 70° flexion and not in extension. The hypothesis was that OP significantly reduces the posterior drawer at 0°, 45° and 90° flexion after isolated PCL transection.

2. Materials and methods

In this cadaver study performed at the Bordeaux 2 anatomy laboratory, ten fresh frozen, non-formalin fixed cadaver knees were

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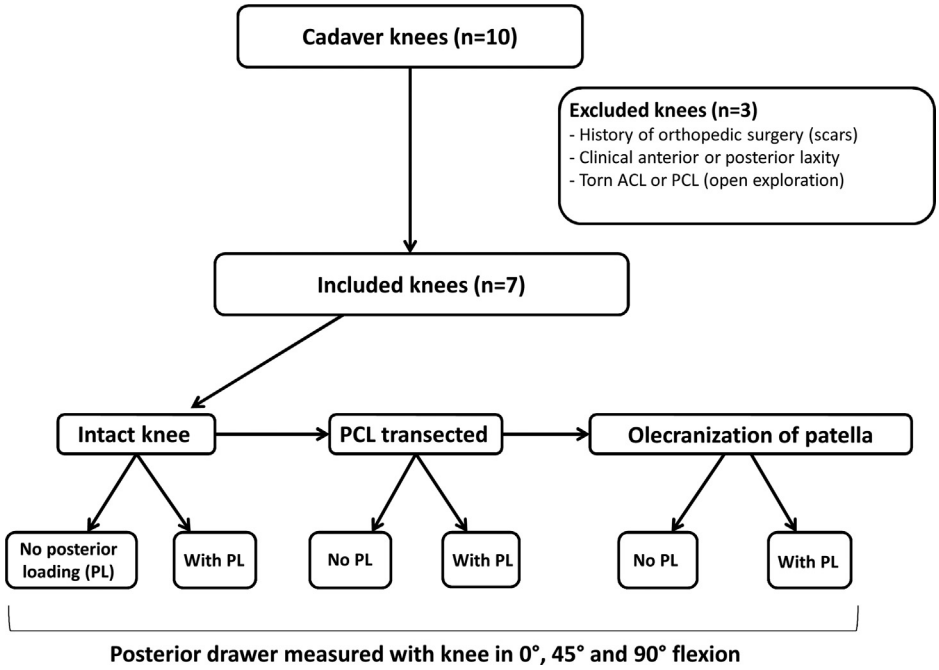

Fig. 1. Study flow chart (PL: Posterior Load).

used after being disarticulated at the hip. No information about the donor's age, medical history or cause of death was available. The knees were considered independent samples, as we had no way of knowing whether two knees came from the same subject. Knees were excluded if they had evidence of previous surgery (scar), clinical laxity, or torn anterior cruciate ligament or PCL found during exploration through an open medial parapatellar approach. Of the ten available knees, seven were included as they had not previously undergone surgery and had intact cruciate ligaments (Fig. 1).

2.1. Experimental set-up

After thawing at room temperature for 48 hours, the knees were placed on a wooden base, and the femur secured with two screws placed horizontally to let the knee move freely between 0° and 130° flexion and prevent rotational movements (Fig. 2). The knee was placed in the middle of a work area formed by two vertical boards with an opening used to reproducibly position and align the base of the image intensifier (OEC Brivo Plus®, GE Healthcare). An 8 kg weight was hooked on the quadriceps tendon and quadriceps muscle belly to prevent patella infera, while ensuring the tibia could not translate anteriorly or posteriorly during the X-rays.

A posterior traction force was applied by securing a circular strap 10 cm below the tibial tuberosity; the weight was hooked to a suture on the posterior side of the strap. Posterior traction was held perpendicular to the tibial axis using pulleys, independent of how much knee flexion was applied (0°, 45° or 90°). The posterior traction was controlled by a dynamometer to ensure that a consistent 150 N load was applied.

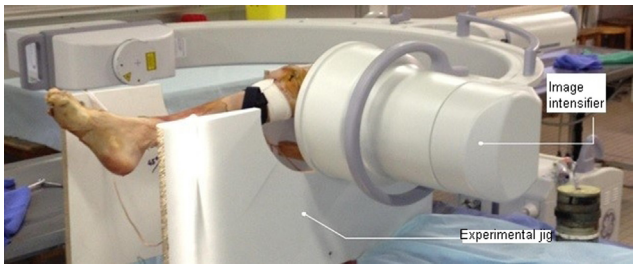

Fig. 2. Positioning of the limb during fluoroscopy with the knee extended and 150 N posterior load applied by a dynamometer.

2.2. Experimental protocol

The primary outcome measure was the variation in posterior drawer in millimeters, before and after applying the posterior load (150 N). A first set of strict lateral fluoroscopy images of the knee in 0°, 45° and 90° flexion was taken on intact knees, with and without the posterior load applied. The same set of images was taken again after having cut all the PCL's femoral attachments with a scalpel through an open medial parapatellar approach with the knee at 90°. We decided transect the PCL's femoral attachments only to simplify the procedure and reduce the risk of damaging the other posterior stabilizing elements [8,9]. The medial patellar retinaculum was sutured with absorbable suture (Vicryl® No. 2).

The OP was done using a 4-mm diameter Steinmann pin with the knee flexed 70° in a position to reduce the posterior drawer. The fixation was done using a surgical drill after having confirmed no posterior drawer was present on fluoroscopy (Fig. 3). The entry point in the patella was centered in the frontal and sagittal planes using fluoroscopy. The pin was positioned exactly parallel to the patella's articular surface. It followed a mid-line trajectory and exited behind the tip of the patella, then passed behind the patellar tendon before entering the tibia over the prespinal surface. According to Grammont's original description [1], the OP pin was then inserted using a surgical drill into the tibial axis by the prespinal surface with the posterior drawer reduced and the knee in 70° flexion. Fluoroscopy was used to verify the pin's trajectory and to ensure over-correction did not induce an anterior drawer. The last step was to make sure patella infera was not present on lateral 30° views. A last set of lateral fluoroscopy views was taken after OP with the knee in 0°, 45° and 90° flexion, with and without posterior load application.

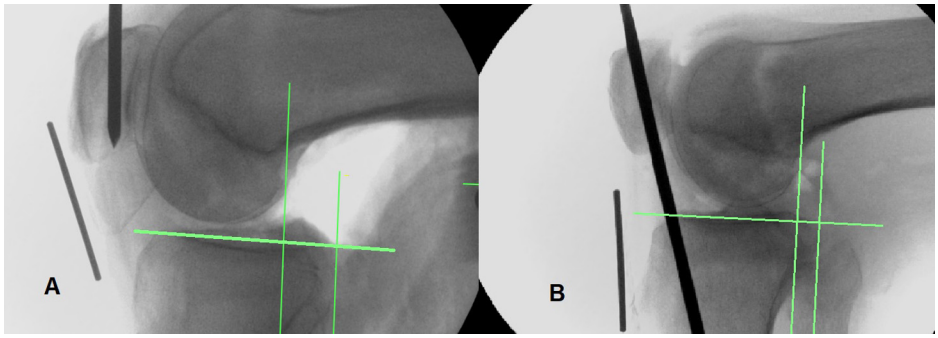

Fig. 3. Lateral view of knee in 90° flexion without loading showing a knee after PCL transection (A) and the same knee after olecranization of the patella to reduce the posterior drawer.

2.3. Radiographic measurements

The digital images were processed using the OSIRIX® 5.8.2 software (Copyright 2003–2013, Pixmeo) for reading DICOM images. A 5-cm long pin was placed vertically in the skin over the patellar tendon to serve as a length calibration guide. Since OSIRIX® provides distances in pixels, 5 cm corresponded on average to 280 pixels; thus a rule of three was used to convert the distances in millimetres.

Posterior translation was measured using the technique described by Jacobsen [10,11]. Two lines perpendicular to a line tangent to the medial tibial plateau were traced, one passing through the posterior edge of the medial tibial plateau and the other adjacent to the posterior edge of the medial condyle (Fig. 4). The gap measured in millimeters was positive when a posterior drawer was present and negative when an anterior drawer was present.

2.4. Statistical analysis

The statistical analysis was performed with IBM SPSS® Statistics software (version 19.0). Wilcoxon paired tests (non-parametric) were used to compare the distribution of each parameter and analyze the variations in the posterior drawer in the various experimental conditions. The significance threshold was set at $p < 0.05$.

3. Results

The results are shown in Tables 1 and 2.

3.1. Without posterior loading

The mean posterior drawer with the knee in 90° flexion was 3.3 mm for intact knees and 7.9 mm after PCL transection.

After OP, the posterior drawer was significantly reduced in 45° flexion (4.1 mm to −1.2 mm, $p < 0.05$) and 90° flexion (7.9 mm to 3.8 mm, $p < 0.05$), which corresponded to a mean reduction of 89%. At 0° flexion, the difference was not significant.

3.2. With posterior loading

After the PCL was transected, a posterior drawer was present in 45° and 90° flexion ($p < 0.05$) relative to an intact knee. After OP, the posterior drawer was significantly reduced in 0° flexion (4.9 mm to 0.2 mm, $p < 0.05$), 45° flexion (6.7 mm to 0.6 mm, $p < 0.05$) and 90° flexion (11.8 mm to 7.6 mm, $p < 0.05$).

4. Discussion

Our hypothesis is confirmed since we found that OP significantly reduces the posterior drawer in PCL-deficient knees at 45° and 90° flexion when unloaded and at 0°, 45° and 90° flexion when loaded.

The largest changes were found in 45° and 90° flexion with and without posterior loading. Clinically, Li [12] and Pearsall [13] found significant changes in the posterior drawer in knees starting at 60° flexion when the PCL is injured. Full knee extension is not a relevant position in which to measure the posterior drawer [14].

Our findings contradict those of the 1995 study by Rungee [6] in which a larger posterior drawer was reported after OP starting at 30° flexion, with values reaching 10 mm posterior translation in 90° flexion versus 1 to 3 mm before OP. However, these authors did not perform the OP technique as initially described by Grammont, and instead chose to insert the pin with the knee in full extension [6]. Biomechanically, it is known that the patella follows the femur's posterior translation during flexion (i.e. roll back). When the transfixation pin joining the patella to the tibia is inserted with the knee extended, it moves the latter backward when flexion starts, which progressively increases the posterior drawer. By inserting the pin with the knee in 70° flexion and the posterior drawer reduced, the tibia cannot slide backward; the pin prevents this posterior translation and actually contributes to anterior translation near full extension. In our study, the posterior drawer was reduced from 3.2 mm to 0.2 mm after OP in unloaded knees in 0° flexion, and from 4.1 mm to 0.2 mm in loaded knees.

Several anatomical studies have described the two bundles of the PCL [15], with the anterolateral bundle taut during flexion and the posteromedial bundle taut during extension [16] and also 90° flexion [14]. By inserting the olecranization pin with the knee extended, the PCL is slack due to release of its anterolateral bundle, Rungee et al. [6] consequently observed resistance to flexion in intact knees and after PCL reconstruction.

While OP does not stop the tibia from moving backward slightly during flexion [4], the posterior drawer is still less than the one of PCL-injured knees before OP. Our study supports this observation with and without loading, no matter the knee flexion angle. In 90° flexion, the reduction in the posterior drawer after OP on PCL-injured knees was 89% in unloaded knees and 51.8% after a posterior load was applied. This is comparable to the Badet study [17] evaluating the effectiveness of PCL reconstruction which was 6 mm (50%) in 90° flexion and to the Quelard study [18] in which laxity decreased from 11.9 mm to 3.8 mm.

Our study has certain limitations. By definition, the knee flexion angle during the OP procedure is 70°. According to Grammont, inserting the pin with the knee in 70° flexion instead of 90° flexion helps to limit the tibia's dynamic anterior translation due to forward recoil during full extension. Moreover, excessive flexion of the patella on its olecranization axis creates a non-anatomical load on it and may contribute in vivo to arthritis developing in the patellofemoral joint [4]. A study comparing patello-tibial transfixation at various knee flexion angles may find a better compromise between reducing the posterior drawer and applying excessive pressure in the patellofemoral joint.

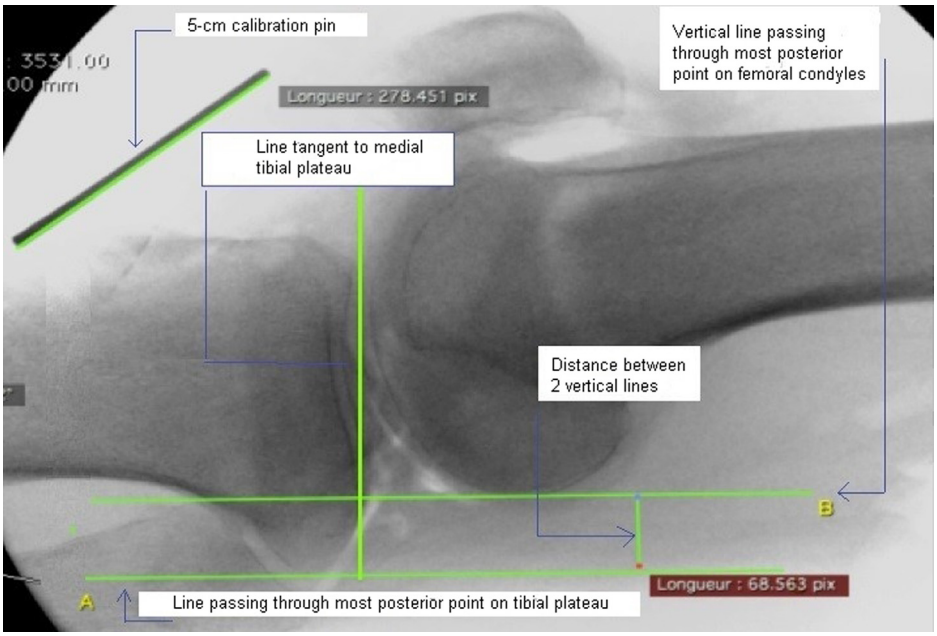

Fig. 4. Digital fluoroscopy image of the knee in full extension with a 150 N posterior load applied. The posterior drawer was measured as described by Jacobsen [10,11].

Table 1
Changes in the posterior drawer (mean, standard deviation values) at 0°, 45° and 90° flexion on an intact knee, after PCL transection and after olecranization of the patella.

Posterior drawer(in mm)	Intact knee		PCL transection		Olecranization after PCL transection	
	No PL (Mean ± SD)	With PL (Mean ± SD)	No PL (Mean ± SD)	With PL (Mean ± SD)	No PL (Mean ± SD)	With PL (Mean ± SD)
0° flexion	3.2 ± 5.4	4.1 ± 6.5	2.8 ± 6.3	4.9 ± 4.5	0.2 ± 3.6	0.2 ± 3.5
45° flexion	3.6 ± 2.1	4.4 ± 2.7	4.1 ± 2.2	6.7 ± 3	−1.2 ± 5.4	0.6 ± 2.8
90° flexion	3.3 ± 2.5	3.7 ± 2.8	7.9 ± 2	11.8 ± 3.7	3.8 ± 3.2	7.6 ± 3.3

PCL: Posterior Cruciate Ligament; PL: Posterior Load.

Table 2
Wilcoxon test used to analyze the changes in the posterior drawer under the various experimental conditions.

Comparison of posterior drawer	(*p*-value)	0° (mm)	45° (mm)	90° (mm)
State of PCL(Intact knee vs. PCL transected)	With PL	NS	0.04	0.03
Loading condition	Intact knee	NS	NS	NS
(with PL vs. without PL)	After PCL transection	NS	0.02	0.03

PCL: Posterior Cruciate Ligament; PL: Posterior Load.

Since all the cadaver knees were disarticulated, standard knee laxity measurements devices could not be used. A pulley system was used to ensure the pressure was applied perpendicular to the leg axis. In clinical knee laxity measurement studies [19–22], the minimum load needed to induce posterior translation is 80 N, while the maximum load inducing pain and reflex contraction is 180 N. We chose to apply a posterior load of 150 N.

The cadaver specimens were left at room temperature for 48 hours to thaw them out before the experiment. We sought to combine the optimal conditions for measuring knee laxity with the elasticity/solidity relationship being close to clinical practice on a living patient, all the while getting around any bias associated with reflex contractions. Nevertheless, performing this study on fresh cadaver knees would allow us to come even closer to reproducing the knee laxity measurement conditions in living patients. Finally, our study did not determine the patellofemoral loads induced by this technique.

5. Conclusion

Olecranization of the patella significantly reduces the posterior drawer in PCL-injured knees when the transfixation pin is inserted with the knee in 70° flexion. This technique, which allows postoperative joint mobility to be maintained, could help optimize PCL healing in the context of conservative treatment.

Disclosure of interest

A. Benzakour, G. Odri, G. Renard, S. Pesenti, and M. Severyns declare that they have no competing interest.

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Authors' contributions

J.L. Rouvillain and M. Severyns: writing of article.

A. Benzakour, G. Renard and M. Severyns: experimental procedures.

G. Odri and S. Pesenti: statistics, writing assistance.

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