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Posterolateral reconstruction combined with one-stage tibial valgus osteotomy: Technical considerations and functional results

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ABSTRACT

Background: To report the functional outcomes and complications from reconstructing the knee posterolateral complex (PLC), associated with one-stage opening-wedge tibial valgus osteotomy, and discuss the technical feasibility of this procedure.
Methods: Five patients with chronic PLC injuries and varus deviation of the mechanical axis, associated with central pivot injuries or not, underwent medial opening-wedge high tibial osteotomy combined with PLC reconstruction. The lateral collateral ligament, popliteal tendon, and popliteofibular ligament were reconstructed using a single femoral tunnel. Patients were assessed on physical examination, range-of-motion and functional scales, and radiographs. The International Knee Documentation Committee (IKDC) score, Lysholm score, and Knee Injury and Osteoarthritis Outcome score (KOOS) were determined.
Results: Five patients were evaluated: four presented with central pivot injury, and one had an isolated PLC injury. The mean time between injury and surgery was 40 ± 6.5 months (± is indicating standard deviation value). Four patients had minimal residual instability on physical examination, with a lateral opening at varus stress of ±3+ at 30° flexion. The means of the IKDC score, Lysholm score, and KOOS were 67.8 ± 9.2, 83.0 ± 9.3, and 79.2 ± 5.9, respectively. All patients showed satisfactory consolidation of osteotomy in 2.6 ± 0.9 months.
Conclusions: The results of this series indicate that one-stage PLC ligament reconstruction associated with medial opening-wedge valgus osteotomy is feasible and shows satisfactory functional results with a low rate of complications. A one-stage procedure might be indicated for young patients with high functionality and more pronounced posterolateral instabilities.

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1. Introduction

Posterolateral complex (PLC) injuries comprise approximately 16% of all knee ligament injuries, and most of these injuries affect the central pivot ligaments. Isolated injuries occur in two percent of all cases [1]. For grade I injuries or injuries without instability, conservative treatment progresses with satisfactory results [2]. However, more extensive injuries should be treated surgically. Regarding grade III injuries, persistent instability and degenerative changes can occur in cases of non-surgical treatment, with increased forces on the anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL), ultimately leading to failed reconstruction of these structures.

Surgical treatment during acute phases consists of performing repair, reconstruction, or both. Stannard et al. and Levy et al. recently reported better results with reconstruction compared to isolated repair [3,4]. Patients should ideally be operated on within the first three weeks after injury. After this period, postoperative functional results are similar to treatments for chronic injury [5,6]. In cases of chronic injury, assessment of the lower limb alignment is necessary. In the presence of axis deviation, especially an asymmetric varus, valgus osteotomy combined with ligament reconstruction should be performed [7].

Some authors recommend performing treatment over two stages, starting with an osteotomy and evaluating the need for reconstruction during the second stage. Savarese et al. suggested that reconstruction of PLC structures should be performed only in cases in which instability persists despite valgus osteotomy [8]. These authors recommend performing ligament reconstruction six to eight months after correcting the misalignment. Arthur et al. reported that approximately 62% of patients who underwent osteotomy required posterior ligament reconstruction [9]. Noyes et al. reviewed 41 patients with ACL deficiency and classified them as either double or triple varus. All of these patients underwent a lateral closing wedge high tibial osteotomy (HTO) and ACL reconstruction. A total of 18 patients who were triple varus had a subsequent PLC reconstruction due to residual instability [10]. The literature still lacks consensus regarding which patients need soft tissue reconstruction after osteotomy. Younger patients with greater posterolateral instability and higher functional demand have a greater tendency to need this procedure.

The potential advantage of performing osteotomy concomitantly with posterolateral ligament reconstruction is to eliminate the need for a second surgery, and reduction in total recovery time and costs. However, the combined procedure has longer duration and complexity. The literature lacks studies concerning the feasibility, safety, and technical aspects of this approach. Therefore, the two-stage procedure remains the routine of most hospitals.

The objective of this study was to report the safety and functional results of one-stage PLC reconstruction associated with opening-wedge tibial valgus osteotomy, and discuss the technical feasibility of this procedure. It was postulated that this procedure is safe, has a low rate of complications, and can effectively restore functional capacity in these patients.

2. Methods

Patients with chronic PLC injuries and varus deviation of the mechanical axis, associated or not with central pivot injuries, received medial opening-wedge HTO combined with PLC reconstruction at the current institution between 2014 and 2016. Varus malalignment was defined when the mechanical axis of the inferior limb passed medial to the tip of the medial tibial spine, and when it was also asymmetrical in relation to the contralateral side. Patients with degenerative arthrosis with a Kellgren–Lawrence radiological index >2 and a related medial collateral ligament injury were excluded from this analysis. Patients without complete pre-operative radiographic evaluation and those who could not be contacted for outpatient follow-up visits were also excluded. Patients were evaluated pre-operatively based on a physical examination that included weight-bearing frontal and lateral radiographs of the knee, panoramic radiography of the lower limbs, and magnetic resonance imaging.

2.1. Surgical procedure

2.1.1. Patient preparation

To enable a fluoroscopic view of the region from hip to ankle, patients were placed in the supine position on a radiolucent table. A pneumatic tourniquet was positioned at the thigh root. All patients were operated on under spinal anaesthesia.

2.1.2. Medial opening-wedge high tibial osteotomy

The surgical procedure starts with the osteotomy. All patients were operated on using the medial opening-wedge osteotomy technique. Tibial osteotomy was chosen instead of femoral osteotomy because femoral osteotomy is only used for varus deformity when the deformity is located at the femur, and this was not the case in any patient. Previous planning was performed via trigonometric calculation of the wedge size to determine the mechanical axis of the lower limb passing through the centre of the knee (Figure 1). When the expected wedges were ≥10 mm, the patient was prepared and the autologous bone graft was removed from the anterior iliac crest. The tibial cut was planned so that it would be located at least five millimetres distal to the most distal portion of the posterolateral tibial tunnel (Figure 2), and directed towards the apex of the fibular head or immediately distal to it, depending on the space required for the popliteal graft tunnel. When a lower osteotomy was required, attention was paid during opening of the osteotomy because the risk of lateral cortex fracture is increased in this region with more rigid bone [11]. Tunnels were created after securing the osteotomy plate, and the

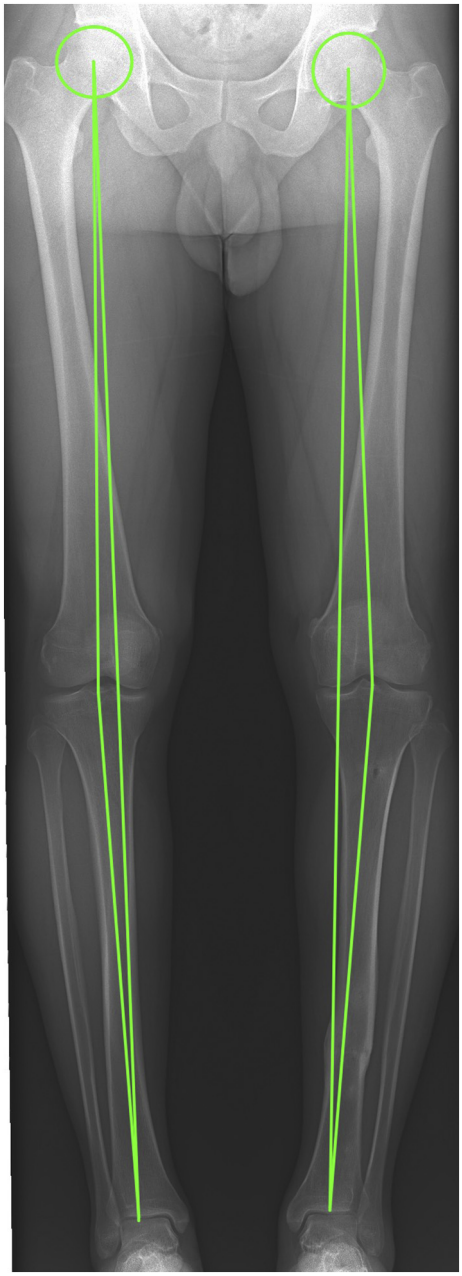

Figure 1. Pre-operative panoramic weight-bearing radiograph of the lower limbs of a patient undergoing valgus osteotomy and multiligament reconstruction.

ligament grafts were passed and fixed with interference screws (Figure 3). In some situations, shorter screws for plate fixation were used to avoid a confluence between the ACL and PCL tunnels.

2.1.3. PLC reconstruction

The PLC was reconstructed using autologous hamstring tendons. A single tunnel was drilled in the femur between the origins of the lateral collateral ligament (LCL) and the popliteal tendon [12]. The PLC reconstruction was performed with reconstruction of the LCL, popliteal tendon, and popliteofibular ligament. Surgical restoration was always preceded by dissection, isolation, and protection of the fibular nerve. The LCL was reconstructed by drilling a tunnel into the fibular head in an anterolateral to posteromedial direction, seeking the longest length of the tunnel approximately five to 10 mm from the apex of the fibular head. The tibial tunnel of the popliteal tendon was drilled from in an anterior to posterior direction, with entry at Gerdy's tubercle

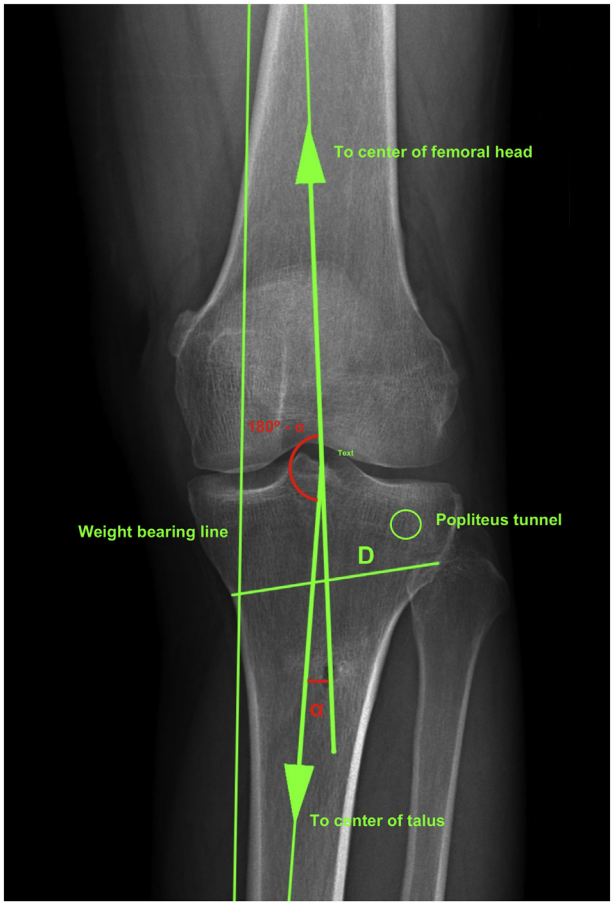

Figure 2. Planning the location of the medial opening-wedge valgus osteotomy combined with posterolateral ligament reconstruction (the circle indicates the tibial tunnel for reconstructing the popliteal tendon). Angle α represents the predicted magnitude of correction.

and exit at the posterolateral aspect of the tibia, slightly proximal and medial to the apex of the fibular head. Care should be taken during positioning of this tunnel to ensure that it is located proximal enough to avoid interference with the planned path of the tibial osteotomy. A technical alternative is positioning the guidewire of this tunnel and the guidewires of the valgus osteotomy so that the tunnel is only drilled after confirming non-interference between the guidewires on radioscopy.

The gracilis and semitendinosus tendon grafts were positioned and fixed in the same femoral tunnel. For LCL reconstruction, one graft was initially passed deeply to the iliotibial tract and then through the fibular tunnel in an anterior to posterior direction. The same graft was passed from the posterior exit of the fibular tunnel to the posterolateral tunnel of the tibia to reconstruct the popliteofibular ligament. The second graft was passed under the iliotibial tract and introduced into the posterior entrance of the tibial tunnel, along with the popliteofibular ligament graft, to reconstruct the popliteal tendon.

2.1.4. Central pivot reconstruction

In the presence of ACL or PCL injury associated with PLC injury, reconstructions were performed arthroscopically at the same time. The femoral tunnels for both ligaments were drilled using the outside-in technique. The tibial tunnels were drilled to not interfere with the proximal screws of the osteotomy fixation. When required, contralateral limb hamstring tendons were harvested for ACL, and contralateral quadriceps tendons with bone plug were used for PCL reconstruction.

2.2. Postoperative care

Patients were allowed proprioceptive weight-bearing with only ground touch after three weeks, with gradual progression after this period as tolerated. Full weight-bearing without the use of supports was allowed after six weeks. A knee brace was used for six weeks, but range-of-motion exercises were encouraged during the initial postoperative period at physical therapy sessions.

All patients were assessed based on a physical examination that included range-of-motion and functional scales, and radiographs. The International Knee Documentation Committee (IKDC) score, Lysholm score, and Knee Injury and Osteoarthritis Outcome score (KOOS) were determined at the last follow-up visit.

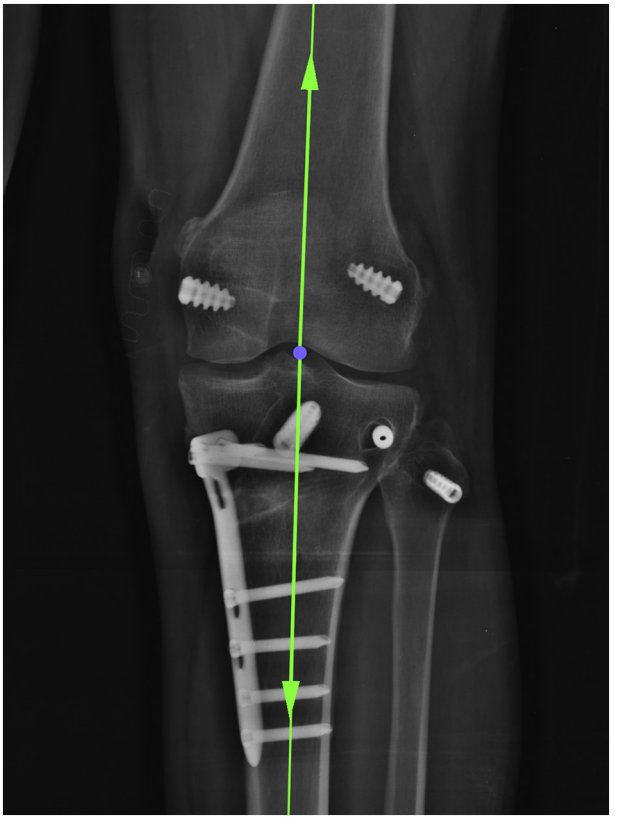

Figure 3. Radiograph showing fixation of the osteotomy with a medial plate, and posterior cruciate ligament and posterolateral complex reconstruction, without conflict between the tunnels and opening wedge.

3. Results

Five patients who underwent the described procedure were evaluated, including four with associated central pivot injuries and one with an isolated PLC injury. The epidemiological data are shown in Table 1. The mean time between injury and surgery was 40 ± 6.5 months.

One patient presented with postoperative complications related to the surgical procedure (a superficial infection in the access for the lateral reconstruction). This complication was treated with oral antibiotics and did not impair rehabilitation. One patient had a chronic injury in the fibular nerve before surgery, which was treated with posterior tibial transfer to correct the foot. None of the other patients developed nerve damage after surgery. All returned to work and none required additional surgeries.

With regard to range of motion, one patient showed hyperextension of five degrees relative to the contralateral side, and two had a loss of flexion of 10° relative to the contralateral side. Four patients had minimal residual instability on physical examination, with a grade 1 lateral opening at varus stress at 30° flexion without opening at full extension; however, they did not complain of instability. The results of the evaluation according to the functional scales are described in Table 2.

All patients showed satisfactory consolidation of osteotomy 2.6 ± 0.9 months after the procedure. The mechanical axis of the knee was corrected from 9.6 ± 1.81° varus to 1.2 ± 1.9° valgus after a two-year follow-up period (Figure 4). The mean wedge size was 9.8 ± 1.8 mm.

Table 1
Patient epidemiological data.

Sex	Postoperative period (months)	Trauma mechanism	Age	Time between injury and surgery (months)	Injured ligaments
Male	41	Automobile accident	26	39	ACL + PLC
Male	25	Fall from height	41	54	PLC
Male	24	Automobile accident	23	36	ACL + PCL + PLC
Female	30	Sports practice	23	40	ACL + PLC
Male	27	Automobile accident	36	47	PCL + PLC
Mean	29.4		26	40	
Standard deviation	6.9		7.3	6.5	

Table 2
Functional evaluation ≥2 years after surgery.

	KOOS	Lysholm	IKDC
Patient 1	86.3	90	75.8
Patient 2	79.2	83	70.1
Patient 3	72	86	56.3
Patient 4[a]	77.4	63	58.6
Patient 5	88.4	78	78.2
Mean ± standard deviation	79.2 ± 5.9	83.0 ± 9.3	67.8 ± 9.2

IKDC, International Knee Documentation Committee; KOOS, Knee Injury and Osteoarthritis Outcome score.
[a] Fibular nerve injury at the time of trauma.

4. Discussion

This series demonstrates the possibility of reconstructing PLC structures associated with one-stage tibial valgus osteotomy to treat chronic posterolateral instabilities. The procedure was safe, considering that the patients developed minor complications related to it. These complications did not cause sequelae or impair rehabilitation, and there were satisfactory functional results.

Although some studies have shown that certain patients with varus posterolateral instability present with satisfactory functional results after osteotomy without the need for ligament reconstruction, others have shown that most patients undergo knee stabilisation at a later stage. Arthur et al. reported a case series of 21 patients with chronic PLC injuries who were treated with a two-stage approach, with an HTO being the first stage. The second-stage PLC reconstruction was performed a minimum of three months after the osteotomy if subjective instability was present at that time. Thirteen (62%) of the 21 patients had residual instability and needed the second-stage procedure. They reported average modified Cincinnati scores of 47.8 (range, 16–77) for patients who had a subsequent PLC reconstruction, which is comparable to the present results [9]. Noyes et al. investigated causes of failure in 57 cases of PLC reconstructions and found that untreated varus malalignment was a factor in 37% of them [13].

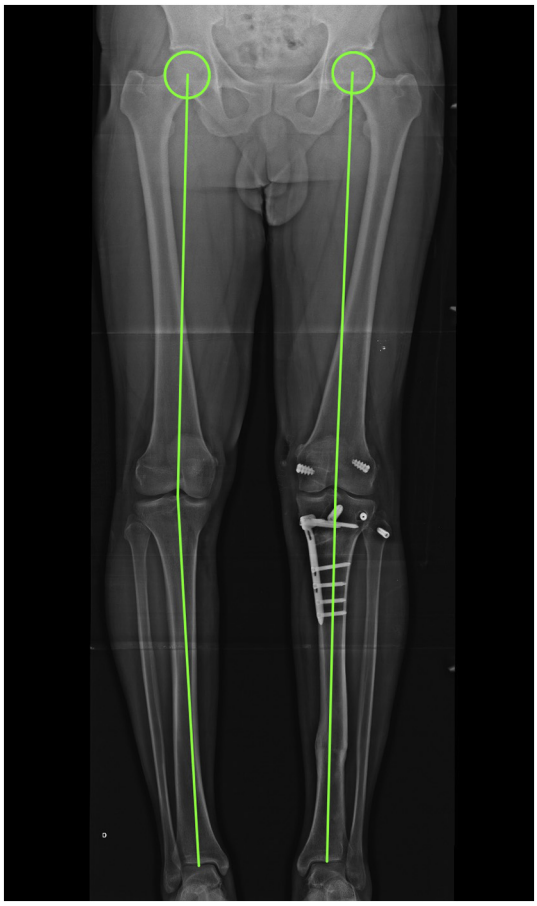

Figure 4. Final correction of the mechanical axis of the lower limb after a 30-month follow-up period to one degree of valgus with satisfactory consolidation of the osteotomy.

It is believed that young patients with significant varus knee instability should be eligible for combined reconstruction. No studies to date have demonstrated superiority or recommended performance of a two-stage procedure for cases in which ligament reconstruction combined with valgus osteotomy is indicated. Despite the need for caution regarding surgical technique, the combination of ligament reconstruction and osteotomy does not require greater care during postoperative rehabilitation compared with isolated osteotomy. Therefore, total recovery time is potentially much lower using one-stage surgery. A lower recovery time would improve the level of satisfaction and probability of favourable outcomes, and decrease the direct and social costs related to absenteeism of young and economically active patients. Nonetheless, future comparative studies are necessary to test this hypothesis. At present, considering the experience of the current institution in treating these injuries, one-stage valgus osteotomy and ligament reconstruction is suggested for cases of chronic posterolateral grade III injuries associated with varus.

The greatest limitation of this procedure – other than its longer surgical time, increased number of incisions, and higher morbidity – is drilling the tibial tunnel for the popliteal tendon through the lateral aspect of the tibia. The potential intraoperative risk involves positioning the tibial tunnel close to the osteotomy cut, which creates a zone of weakness in this region that might cause tunnel fracture, thereby preventing fixation with interference screws or damaging the articular surface of the tibial plateau. The possibility of this complication can be reduced by drilling the tunnel at a safe distance from the osteotomy (at least five millimetres) and, if necessary, performing the osteotomy more distal than usual, directed slightly below the tip of the fibular head. It is useful to confirm the positioning of the guidewires of the osteotomy and the posterolateral tibial tunnel before making it. Respecting these considerations prevented occurrence of complications related to osteotomy interference in the tunnels. It is important to emphasize that this is a technically challenging procedure in a small series of patients, and may not be readily extrapolated to all patients.

With respect to the functional results, Zorzi et al. showed that patients with chronic PLC injuries associated with the central pivot were able to adequately perform their daily activities but usually presented with a limited range of motion and residual laxity, indicating that it was not possible to achieve normal knee biomechanics [14]. Therefore, the current results were considered satisfactory, with Lysholm and IKDC scores similar to those found in recent studies evaluating posterolateral reconstructions [15,16]. However, the current results were inferior to those of recent series that considered only cases of PLC injury associated with ACL injury [17,18].

The main limitation of this study was the small number of cases, which is explained by the small number of injuries of this type. The tendency for acute ligament injuries is to perform the surgery earlier, and just a few operations are performed in a chronic manner. The mean time between injury and surgery in this study was 40 months, which is not typical for treatment of these injuries at many centres. Another limitation was the heterogeneity of the associated injuries; however, the focus of this study was to assess the PLC injuries that were present in all patients. In addition, this study did not evaluate a control group that underwent a staged procedure or isolated ligament reconstruction, which was another limitation. Nonetheless, the initial objective was to assess the safety and reproducibility of one-stage treatment, and reasonable justification now exists for comparing one-stage with two-stage procedures.

Although the described procedure can be considered successful in this series, there are multiple possible complications throughout the several reported steps. Most common complications that can occur and potentially undermine surgery and rehabilitation are: deep venous thrombosis, non-union, peroneal nerve injury, tibial plateau fracture, infection, and, more rarely, compartment syndrome. A two-staged procedure is advised for surgeons that are not used to frequently performing multiple knee ligament reconstructions and osteotomy.

5. Conclusion

Ligament reconstruction combined with one-stage osteotomy is technically feasible, with satisfactory functional results and a low rate of complications. Few studies to date have evaluated the best approach for these cases; therefore, one-stage surgery is recommended for young and highly functional patients with more pronounced posterolateral instabilities because these patients might not progress satisfactorily with osteotomy in isolation. For patients with moderate or mild instability, an osteotomy can be performed initially, and reconstruction may occur at a second stage, if necessary, as recommended by Arthur et al.

Conflict of interest

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. To the best of our knowledge, no conflict of interest, financial or other, exists.

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