Chronic anteromedial rotatory instability of the knee: technique and results of a near-anatomical reconstruction

Mohamed Aboelnour Badran, Abd Elrhman Elganiny

Department of Orthopedics and Traumatology, Knee Surgery Arthroscopy Sports Injury Unit, Faculty of Medicine, Mansoura University, Mansoura, Egypt

Correspondence to Mohamed Aboelnour Badran, MD, Department of Orthopedics and Traumatology, Faculty of Medicine, Mansoura University, 4 Elgomhoria Street Mansoura, Egypt. Tel: +20 122 236 0955; e-mail: maboelnour@gmail.com

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Background

Superficial and deep medial collateral ligament (MCL) together with the posterior oblique ligament (POL) works in harmony to control anteromedial rotatory instability (AMRI) throughout the knee range of motion (ROM). Associated anterior cruciate ligament (ACL) injury will accentuate the instability in all directions, adding more challenge to the management plan. This pattern of injury is a common type of combined ligamentous knee injury.

Hypothesis

Near-anatomical reconstruction of both ACL/MCL will restore knee AMRI to normal, with minimal ROM deficit.

Patients and methods

Twenty-five patients with chronic combined ACL and MCL injury (>3 months since injury) were included in this study. Anatomical ACL with percutaneous MCL–POL were performed and the patients were assessed at 2 years for knee stability, ROM, and complications.

Results

The mean subjective International Knee Documentation Committee scores for the patients were 43.32±7.58, range 28–60; at the end of follow-up, the mean was 94.76±3.7, range 89–100, *P* value less than 0.0001. The knee stability was restored to normal in 84% of patients and nearly normal in 16% of patients.

Conclusion

Anatomical ACL with percutaneous MCL–POL reconstruction yields very good results in cases of chronic AMRI. This technique is associated with little morbidity and can be done through minimally invasive incisions.

Keywords:
anterior cruciate ligament, combined reconstruction, medial collateral ligament, percutaneous

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Introduction

Rotational knee instability is a major challenge for knee surgeons; this is secondary to the multifactorial origin of such instability as well as the difficulty in diagnosis and quantification of the instability. Slocum and Larson [1] first described anteromedial rotatory instability (AMRI) of the knee as excessive valgus motion coupled with external rotation of the knee. This occurs when the anteromedial tibial plateau subluxates anterior to the corresponding femoral condyle. The posteromedial corner has been shown to act as an important restraint to AMRI throughout the normal range of motion (ROM) [2].

Superficial and deep medial collateral ligament (MCL) together with the posterior oblique ligament (POL) works in harmony to control AMRI throughout the knee ROM [3,4]. Associated anterior cruciate ligament (ACL) injury will accentuate the instability in all directions, adding more challenge to the management plan [5,6]. Being the most common type of combined ligamentous knee injury [7,8].

Successful management of chronic AMRI requires the reconstruction and elimination of all the elements of instability to restore knee stability and protect both ligament reconstructions from failure. MCL is anatomically and functionally composed of many parts with different functions at different knee flexion angles controlling both varus and rotatory stability of the knee [9]. To restore the function of the medial side of the knee, reconstruction must address all parts of the of medial ligament: superficial, deep medial ligament, and POL [10,11].

Many surgical techniques for the reconstruction of the MCL with POL have been published; however, there has been no consensus on the best technique because of the heterogeneous patient populations in the studies. In this study, we report on our case series of patients

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with chronic AMRI, with no other associated ligamentous injuries, treated by a near-anatomical reconstruction. Our hypothesis is that a near-anatomical reconstruction can restore the knee stability to normal, with minimal ROM deficit.

Patients and methods

This study was carried out after approval was obtained from the Medical Research Ethics Committee, in our University.

Twenty-five patients with chronic AMRI injury (>3 months since injury) were included in this study; all the patients were male and the average age was 27 years, range 23–47 years. Patients with other associated ligamentous injuries, previous surgery to the knee, and active and/or previous history of septic arthritis of the knee, ligamentous laxity, and bony malalignment were excluded from the study.

Preoperative assessment

For all patients detailed history including the mechanism of injury, clinical examination plan radiography and stress radiography for the medial instability and MRI was done. Lysholm and International Knee Documentation Committee (IKDC) scores were determined for all patients [12].

Anterior cruciate ligament reconstruction

The same surgeon performed all the surgeries. Anatomical single-bundle ACL reconstruction was carried out through the anteromedial portal using the hamstring tendons from the other side.

After the administration of spinal anesthesia, both lower limb were draped in a sterile manner, followed by clinical examination and diagnostic arthroscopy to confirm the diagnosis. The semitendinosus and gracilis tendons were then harvested from the other side through a minimal longitudinal skin incision. The tendons were prepared and tripled on a back table to achieve a length not less than 8 cm and the average tendon diameter was 9 mm for the femoral side and 10 mm for the tibial side.

During arthroscopy, meniscal injuries, if present, were treated by meniscectomy and/or repair according to the type of meniscal injury. The remnants of the torn ACL were preserved as much as possible and the notch was prepared to determine the anatomical footprint of the ACL. An ACL guide pin was introduced in the femoral footprint with the knee flexed to 120° and the femoral tunnel was drilled to the appropriate size and a shuttle suture was passed through the medial portal and femoral tunnel outside the skin on the lateral aspect of the thigh.

The tibial tunnel was drilled over a guide pin that was passed through the tibial footprint of the ACL using a C guide of smith and Nephew Company adjusted to an angle of 55°. The shuttle suture was the retrieved from the joint through the tibial tunnel.

The ACL graft prepared was then passed through the tibial tunnel to the joint and the femoral tunnel. The knee was kept near full extension to ease the passage of the graft. The ACL was fixed on the femoral side with bioabsorbable interference (Bio Sure Smith and Nephew Company, Memphis, Tennessee, USA). The tibial side fixation was deferred to the end of the surgery.

Medial collateral ligament reconstruction

The semitendinosus and gracilis tendons of the same side were then harvested from a longitudinal incision, cleaned from the attached muscle fibers, and sutured together. The anatomical footprint of the MCL on the femoral side was then identified by clinical palpation of the medial epicondyle and then confirmed by an image intensifier [13]. A small one incision was made on the proper site of the MCL femoral footprint, after which a drill pin was passed from medial to lateral, a 3 cm tunnel was drilled using a 7 mm drill, and a shuttle suture was passed through the tunnel. An arthroscopic grasper was then passed under the skin to retrieve the tendon out through the femoral incision of the MCL. After measuring the proper length of the first limb of the MCL was measured a 2 cm part of the graft is doubled over itself in a fashion that when this folded part is within the tunnel and fixed with an interference screw the vertical limb of the MCL is in a good tension at 30° flexion.

Another small incision was made on the posteromedial corner of the tibia and the remaining part of the tendon was then passed inferiorly under the skin. A drill pin was drilled from the posteromedial corner of the tibial in an inferior lateral and slight anterior direction, over which a 3 cm tunnel was drilled using a 6 mm drill. The oblique limb of the graft was passed through the tunnel using a shuttle suture, tensioned, and fixed by an interference screw at full extension. Finally, the tibial side of the ACL was fixed at 40° of knee flexion and posteriorly applied force to the tibia by interference screw (Figs 1 and 2).

Examination under anesthesia was performed at the end of the surgery to confirm achievement of proper knee stability for both the ACL and MCL.

Figure 1

Schematic drawing of the reconstruction technique; AB is the MCL limb and BC is the posteromedial limb of the ligament. The dashed line in the tibia and femur illustrates the tunnel drilling direction. MCL, medial collateral ligament.

Postoperative care

Prophylactic intravenous antibiotics were administered to all patients for 3 days, after which oral antibiotics were administered for another 5 days. The knee was immobilized in a hinged knee brace starting from full extension and range of flexion was increased gradually till according to pain. Partial weight bearing was allowed with crutches for the first 4 weeks, after which gradual weaning from crutches was performed to allow full weight bearing. The use of the knee brace was discontinued at 2 months, running in a straight line was allowed at 5 months, and return to full sports was delayed to 9 months after surgery [14].

Evaluation

All the patients were evaluated preoperatively and postoperatively by a single experienced surgeon not involved in the surgical procedure. The IKDC objective scores Lysholm score, ROM.

The degree of anterior translation was evaluated using a KT-1000 arthrometer (Medmetric, San Diego, California, USA); the side-to-side difference with the knee at 20° of flexion was also graded according to the IKDC criteria (134N, maximum manual; 0–2 mm=A; 3–5 mm=B; 6–10 mm=C; >10 mm=D) [15].

Valgus rotational instability was assessed both clinically and by stress radiography at 20° of flexion for both the injured and the sound knee. Medial stability was graded according to the IKDC knee examination criteria on the basis of the medial joint opening compared with the uninjured knee (0–2 mm=A or normal; 3–5 mm=B or near normal; 6–10 mm=C or abnormal >10 mm=D or severely abnormal). The AMRI of the knee was assessed clinically by the Slocum test and evidence of anterior subluxation of the medial tibial plateau with an anterior drawer with the foot in external rotation was documented.

Statistical analysis

Statistical analysis was carried out using SPSS 13.0 (SPSS, Chicago, Illinois, USA). The preoperative results of the anterior translation, valgus rotation and, ROM, and IKDC scores were compared with the final follow-up result using a paired *t* test, analysis of variance with Tukey's test for nonadditivity, and a nonparametric one-sample test.

Results

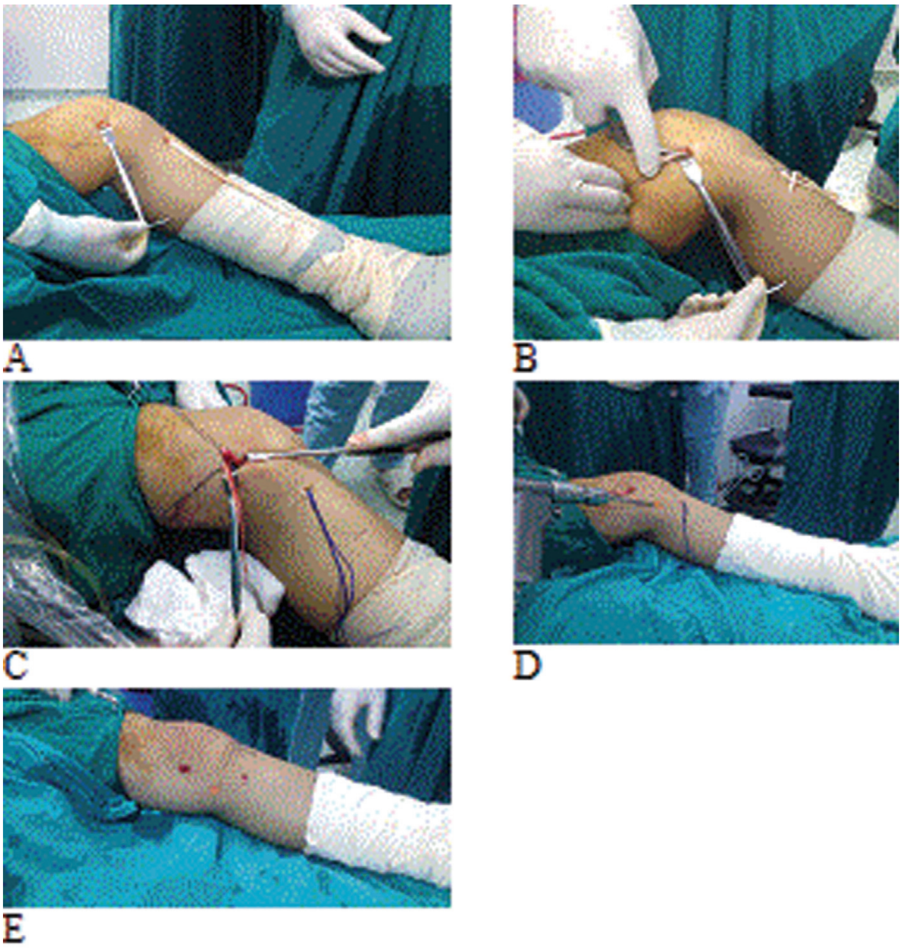
All 25 patients completed at least 24 months of follow-up, 18 patients had meniscal injuries, 11 patients had medial meniscus injuries, five patients had lateral meniscus injuries, and two patients had combined medial and lateral meniscal injury. Medial meniscal repair was performed in eight patients with three out in sutures and one all inside suture by fast fix (Smith and Nephew Company).

Knee stability results

Valgus stability showed statistically significant improvement at the end of follow-up, with the mean valgus stress radiography reduced from 7.01±1.04 mm (range, 5.7–9.5 mm) preoperatively to 1.6±0.3 mm (range, 1.3–0.8 mm) at the end of follow-up ($P<0.0001$). Anteroposterior instability improved significantly at the end of follow up, the mean side-to-side difference was reduced from 9.040±2.67 mm (range, 5.4–13.2 mm) to 1.98±0.68 mm (range, 1–3.1 mm). With the examination, we found The AMRI has been positive in all patients preoperatively and was controlled with negative Slocum test results in all patients at the end of follow-up. The overall knee stability was normal according to IKDC in 21 patients and nearly normal in four patients in contrast to 18 patients with abnormal knee and seven patients with severely abnormal knee preoperatively.

The mean subjective IKDC scores for the patients was 43.32±7.58 (range, 28–60) at the end of follow-up; the mean was 94.76±3.7 (range, 89–100), *P* value less than 0.0001. The Lysholm score also showed a significant improvement from 32.4±5.7 (range, 26–44) to 96.9 ±3.09 (range, 89–100) at the end of follow-up, *P* value

Figure 2



Surgical technique: (a) Harvest of the tendon and small incision on the medial epicondyle. (b) Passing the tendon percutaneous to form the MCL Limb. (c) Suture of 2 cm tendon to be inserted into the femoral tunnel. (d) Drilling the tunnel for the tibial insertion of POL. (e) Final view of ACL/MCL/POL reconstruction with minimal skin incision. ACL, anterior cruciate ligament; MCL, medial collateral ligament; POL, posterior oblique ligament.

less than 0.0001. Medial side knee pain is of great value during subjective evaluation, in our results there was no or very mild pain in 92% of our patients and moderate pain in 8% of patients.

The ROM was full in 80% of our patients preoperatively; deep flexion and the ability to pray on ground were lost in four patients, whereas one patient showed incomplete extension with a locked bucket handle tear of the medial meniscus. At the end of follow-up, all our patients had full extension and all except one had complete knee flexion, and could pray normally on the ground. Ninety two percent of patients in this study returned back to their preinjury level of activity with recreational sport participation. Eight percent of our patients had to decrease their activity level.

Complications

Superficial Saphenous nerve injury occurred in five patients, 25%, in this study, with a small area of hypothesis on the anteromedial aspect of the leg. One patient had developed a noninfective inflammation at the site of the ACL tibial tunnel opening, which resolved completely after debridement of the wound.

Discussion

Our study showed that the near-anatomical reconstruction of AMRI in the chronic setting is an easy and effective technique to restore knee laxity to a near-normal situation. Anatomical reconstruction of both the superficial MCL and the POL restored the valgus laxity as well as the AMRI of the knee. Both the ACL and MCL reconstructions act in a synergistic way to protect each other and restore the rotatory stability of the knee [16–18].

Although true anatomical reconstruction of MCL and POL as proposed by LaPrade and Wijdicks [19] is more anatomical than our technique, the patient cohort in their study was heterogeneous, with different associated ligamentous injuries, and they included both acute and chronic patients. Moreover, they drilled four tunnels in the medial compartment (two femoral and two tibial), which increased the morbidity, cost, and time of surgery. However, this technique is simpler and still yields good results, with minimal complications. The ROM at the end of the study was full in most of the patients, which is a major issue in the surgery of medial ligament reconstruction.

There is a considerable amount of debate in the literature on the proper management of the combined ACL and MCL injury; in the acute setting, most of the reports recommend conservative treatment for grades I and II MCL with ACL reconstruction [20,21]. Grade III MCL associated with ACL is a very controversial issue, with most of the authors recommending acute repair for grade III MCL and others reporting better results with acute anatomical reconstruction for better control of rotational instability of the knee [22–24]. The associated ACL is treated with reconstruction mostly after the knee has passed the acute phase; however, ACL reconstruction in the acute phase has been reported to yield good results.

Owing to the good healing power of the MCL with either conservative or operative repair chronic, MCL/ACL instability of the knee is a rather uncommon scenario; however [25,26], the causes of failure of healing of the MCL leading to a chronic MCL are not well studied, with no definite criteria on which injury will lead to chronic instability. In these cases with grade III MCL, reconstruction of both ligaments is the only way to achieve knee stability [27]. Secondary to the small number of cases, only case reports with limited numbers are present in the literature.

In patients with complete ACL–MCL tears, leaving the MCL untreated may lead to chronic symptomatic valgus instability [28]. In some cases, we may encounter failure associated with nonoperative treatment, which leads to chronic medial instability [29]. If the ACL is treated alone in patients with ACL–MCL lesions, undue stress may be placed on the reconstructed ACL, which may affect healing of the reconstructed ACL and lead to late graft failure. Decrease patient satisfaction with continued sense of instability.

Yoshiya *et al*. [30] introduced single-bundle MCL reconstruction with an autograft of the semitendinosus and gracilis tendons. At follow-up, all 24 patients had achieved medial stability, with a mean side-to-side difference of 0.2 mm. Although these procedures resulted in good valgus stability at the short-term follow-up, the study did not pay much attention to the rotational stability and they did not reconstruct the POL, which is an important component of the MCL responsible for the control of rotational stability. Moreover, the study population was not homogenous as some cases were associated with ACL while others did not.

Many surgical techniques have been proposed with good results for the management of the medial side instability; whether to perform only MCL reconstruction or combined MCL/POL reconstruction for better rotational stability is a matter of debate. The MCL/POL [11,31] reconstruction techniques could be the same technique as that we are reporting in our study, which is triangular reconstruction, with the hamstring tendon lift attached to their insertion and reconstruction of both the MCL and POL, and our results were very good, with rotational and valgus stability comparable to the other normal side [32]. Other authors recommend a more anatomical reconstruction with two separate ligaments and four tunnels, one for the MCL and other for the POL [31]. Drilling four tunnels on the medial side other than the two tunnels for the ACL can increase the morbidity and time of surgery, with more postoperative pain and slower recovery; moreover, the clinical results of are not superior to our technique.

This triangular reconstruction technique has been described in a review article [33] as a tendon transfer procedure; however, we disagree with this definition as the tendon transfer procedures involve keeping the origin of the tendon intact with its muscle and the distal insertion is transferred for an active function in other place. However, in our technique, the tendon is stripped from the muscle and we make benefit of the natural attachment to the tibia, whereas the other part is fixed on the femoral side for a static function of the medial ligament.

Many researchers believe that MCL–POL reconstruction can better resist rotatory instability than isolated MCL reconstruction. After reconstruction of the ACL for a combined ACL–MCL injury, residual rotatory stability is also an important issue for knee stability [34]. Zaffagnini *et al.* [35] proved that chronic medial instability significantly increased rotatory instability in patients with ACL–MCL injuries, although the ACL was reconstructed.

To our knowledge, this is the first report of percutaneous MCL–POL reconstruction with minimal skin incisions [36], which decreases pain postoperatively and improves the recovery. Moreover, in many places where allograft is not available, as in our country, the multiligament reconstruction requiring many grafts is an important issue where the graft stock of the patient has to be managed wisely preoperatively.

In our study, harvesting the hamstring tendon and using the graft for the MCL–POL reconstruction while keeping the tendon attached decreased the morbidity and allowed for better vascularity. Contralateral hamstring tendon for the ACL reconstruction is a good option with very good results and decreases the morbidity of harvesting more than one graft from the same side and is our routine option for multiligament reconstruction of the knee [37]. All our patients' had been strictly selected to have a homogenous group of patients with only ACL–MCL insufficiency with no other associated ligament injuries. The surgical procedure was standardized, with one surgeon performing all the operations.Reported complications with ACL/MCL reconstruction include residual laxity, especially rotational instability, motion loss, and medial side pain. This technique addressed all the elements of the instability in all planes, thus eliminating any residual laxity. Our results showed that all the elements of instability are restored similar to the other normal side with good subjective results of stability. One limitation of our study is that the rotational instability measurement is not instrumented which is not very accurate.

Motion loss after surgery is a concern more with acute knee injuries, but with chronic instability, regaining the ROM preoperatively and early postoperative motion with good pain control can lead to a normal ROM postoperatively. In our study, there was no motion loss, except in two patients with minimal loss of normal extension, as these patients had contralateral 5° of recurvatum. Our explanation for the normal ROM at the end of follow-up was that anatomical ACL with correct tibial tunnel placement and anatomical MCL–POL reconstruction percutaneously decreased pain postoperatively and the associated subsequent inflammation with, a rehabilitation protocol that allows early knee motion [38].

Medial joint pain has been reported after medial ligament repair and reconstruction. In this study, the subjective evaluation of pain was very good, secondary to percutaneous reconstruction, and also avoiding overtension of the MCL–POL reconstruction, which can lead to overconstraining of the medial side and subsequent pain.

In summary, this technique is an easy and effective way for reconstruction of ACL–MCL-deficient knees; it can address all the elements of instability, especially rotational instability, and it has minimal complications. Further studies are needed to determine the causes of chronic medial instability and the causes of failure of healing in these cases.

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Conflicts of interest
There are no conflicts of interest.

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