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

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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, the most common type of combined ligamentous knee injury, will worsen the instability in all directions, greatly compounding the challenge to the management plan.
Hypothesis
Near-anatomical reconstruction of both the ACL and the 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 was performed and the patients were assessed at 2 years for knee stability, ROM, and complications.
Results
The mean subjective International Knee Documentation Committee score among 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) ($P < 0.0001$). Knee stability was restored to normal in 84% and to nearly normal in 16%.
Conclusion
Anatomical ACL with percutaneous MCL-POL reconstruction gives very good results in cases of chronic AMRI. This technique is associated with little morbidity and can be achieved through minimally invasive incisions.

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

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Introduction

Rotational knee instability is a big challenge for knee surgeons, being secondary to the multifactorial origin of such instability as well as the difficulty in diagnosis and quantification of the instability. Slcoum 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 serve 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, the most common type of combined ligamentous knee injury, will accentuate the instability in all directions, greatly compounding the challenge to the management plan [5–8].

Successful management of chronic AMRI requires 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 formed of many parts, with different functions at different knee flexion angles controlling both the varus and rotatory stability of the knee [9]. To restore function of the medial side of the knee, reconstruction must address all parts of the 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 is no consensus on the best technique due to the heterogeneity of the patient population across the studies. In this study we present our case series of patients 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 approved by the Ethical committee of Mansoura University, El-Mansoura, Egypt. From March 2011 to September 2013, 25 patients admitted to the Knee Surgery Arthroscopy Sports Injury Unit, Mansoura University Hospital, with chronic AMRI injury (>3 months since injury) were included in this study. All patients were male; 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

All patients were subjected to detailed history taking, which included the mechanism of injury, as well as to clinical examination, plain radiography, stress radiography for the medial instability, and MRI. Lysholm and International Knee Documentation Committee (IKDC) scores were reported for all patients [12].

ACL reconstruction

Anatomical single-bundle ACL reconstruction was performed through the anteromedial portal using the hamstring tendons from the other side.

After spinal anesthesia both lower limbs 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. 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 menisectomy 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 from Smith and Nephew Company adjusted to an angle of 55°. The shuttle suture was then retrieved from the joint through the tibial tunnel.

The prepared ACL graft 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; Smith & Nephew: British-based multinational medical equipment manufacturing company headquartered in London, United Kingdom. 1856, Kingston upon Hull, United Kingdom Profiles). The tibial side fixation was delayed to the end of the surgery.

MCL reconstruction

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

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

Figure 1

Schematic drawing of the reconstruction technique; (a, b) the MCL limb and (b, c) the posteromedial limb of the ligament. The dashed line in the tibia and femur illustrate the tunnel drilling direction.

The patients were examined under anesthesia at the end of the surgery to confirm achievement of proper knee stability for both the ACL and the MCL.

Postoperative care

Prophylactic intravenous antibiotics were given to all patients for 3 days, after which oral antibiotics were administered for another 5 days. The knee was kept in a hinged knee brace starting from full extension and range of flexion was increased gradually as tolerated. Partial weight-bearing was allowed with crutches for the first 4 weeks after which the patients were gradually weaned off crutches 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 patients were evaluated preoperatively and postoperatively using The IKDC objective scores, Lysholm score, and ROM.

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 in 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.

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° flexion was also graded according to the IKDC criteria (134 N, 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 means of 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 AMRL of the knee was assessed clinically by means of the Slocum test and evidence of anterior subluxation of the medial tibial plateau with anterior drawer while the foot in external rotation was documented.

Statistical analysis

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

Results

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

Knee stability results

The 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) at the end of follow-up ($P <$ 0.0001). The 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). The AMRL had been positive in all patients preoperatively and was controlled with negative Slocum test results in all patients until 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) ($P < 0.0001$). The Lysholm score also showed significant improvement from 32.4 ± 5.7 (range 26–44) to 96.9 ± 3.09 (range 89–100) at the end of follow-up ($P <$ 0.0001). Medial side pain received special attention during subjective evaluation and our results showed the there was no or very mild pain in 92% of our patients and moderate pain in 8% of patients.

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

Complications

Superficial saphenous nerve injury occurred in five patients (25%) in this study with a small area of hypothesia on the anteromedial aspect of the leg. One patient had 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 for restoring the 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 AMRL 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 the MCL and POL as proposed by LaPrade *et al.*[19] is more anatomical than our used technique, the patient cohort in their study was heterogeneous, with different associated ligamentous injuries, and 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 gives 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 for medial ligament reconstruction.

There is a considerable amount of debate in the literature about the proper management of the combined ACL and MCL injury. In the acute setting most of the reports recommend conservative treatment for grade I and II MCL with ACL reconstruction [20,21]. Grade III MCL associated with ACL is highly controversial, 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 [25,26]. However, the causes of healing failure of the MCL leading to a chronic state of MCL is not well studied, with no definite criteria for 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 a 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 can see 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, and of course 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 medial stability, with a mean side-to-side difference of 0.2 mm. Although these procedures resulted in good valgus stability at 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 the rotational stability. Moreover, the study population was not homogenous as some cases were associated with ACL and others were 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 technique could be the same technique we are reporting in our study, which is triangular reconstruction with the hamstring tendon lift attached to their insertion and reconstructing both the MCL and POL. 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 are not superior to our technique's.

This triangular reconstruction technique has been described in a review article by DeLong and Waterman [33] as a tendon transfer procedure. However, we disagree with this definition as the tendon transfer procedures means keeping the origin of the tendon intact with its muscle and transferring the distal insertion to do an active function in another place; however in our technique the tendon is stripped from the muscle and we take advantage of the natural attachment to the tibia, while the other part is fixed on the femoral side to do a static function of the medial ligament.

Many researchers believe that MCL-POL reconstruction can better resist rotatory instability compared with isolated MCL reconstruction. After reconstruction of the ACL for a combined ACL-MCL injury, residual rotatory stability is also an important aspect of 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 recovery. Moreover, in many places where allograft is not available, as in our country, multiligament reconstruction requiring many grafts is an important matter 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 decreases the morbidity and facilitates 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]. Our patient population was 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 a single surgeon performing all the operations.

Reported complications with ACL-MCL reconstruction includes residual laxity especially rotational instability, motion loss, and medial side pain. As regard the residual laxity of the MCL-POL reconstruction Associated With anatomical ACL reconstruction; to address all the elements of instability either anteroposterior, valgus instability and, rotational instability. Our results showed that all the elements of instability are restored similar to that of the other normal side with good subjective results of stability. One weak point of our study is that the rotational instability measurement is not instrumented, which is not very accurate.

Motion loss after surgery is a greater concern 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 we did not have motion loss except in two patients with minimal loss of normal extension as those patients had a contralateral 5° of recurvatum. Our explanation for normal ROM at the end of follow-up was that doing anatomical ACL with correct tibial tunnel placement and anatomical MCL-POL reconstruction which is done percutaneous decreasing pain postoperative and subsequent inflammation associated 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 this secondary to percutaneous reconstruction and also avoiding over tension of the MCL-POL reconstruction which can lead to over constraining of the medial side and subsequent pain.

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

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Conflicts of interest
There are no conflicts of interest.

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