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ORIGINAL STUDY

Valgus stress radiography following superficial medial collateral ligament reconstruction using a modified LaPrade technique with adjustable loop femoral fixation

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Purpose of this study was to assess postoperative laxity of MCL reconstructions utilizing a modified LaPrade superficial MCL reconstruction. We retrospectively reviewed post-operative valgus stress radiographs in 23 multiligament injured patients who underwent concurrent sMCL and cruciate ligament reconstruction by a single surgeon. Post-operatively, 23 patients underwent valgus stress radiographs that were assessed at a mean of 8.7 months (range: 4-13 months), and mean SSD was 0.64mm ± 0.42mm. Eight patients underwent both pre- and post-operative valgus stress radiographs. Post-operative (0.09mm ± 0.63mm) SSD was found to be significantly reduced compared to pre-operative (2.07mm ± 0.44mm) SSD (mean diff. = 1.98mm, 95% CI = 0.72-3.24, P=0.007). Inter-observer reliability value for medial compartment gap measurement was 0.91 with a 95% confidence interval of 0.34-0.97. In conclusion, presented technique results in excellent static stability of the knee as measured by valgus stress radiography at a minimum of 6 months postoperative.

Level of Evidence: IV

Keywords : Valgus Stress Radiography ; MCL reconstruction ; knee ; adjustable loop.

INTRODUCTION

The medial collateral ligament (MCL) is an important static stabilizing structure of the knee, originating posterior and proximal to the medial femoral condyle and inserting on the proximal medial tibia. It is a primary stabilizer of valgus rotation of the knee, as well as providing secondary control of internal and external rotation *(8)*. The medial knee anatomy literature has described a proximal and distal division of the superficial medial collateral ligament (sMCL), meniscofemoral and meniscotibial divisions of the deep medial collateral ligament (dMCL), and the capsular arm of the posterior oblique ligament (POL) as the main medial knee structures *(12,23)*. Previous research has

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described the individual biomechanical functions of these divisions and structures as well as the load-sharing relationships between these structures *(8,9,39)*. This has led to a greater understanding of the role of the MCL in providing stability in both the coronal and axial planes.

MCL injuries occur frequently with most of them amenable to non-operative treatment (Hughston grade I or II) (Table I) leading to satisfactory outcomes *(5,7,13,19,21,26)*. Surgical management of MCL lesions has previously been suggested for severe valgus laxity (Hughston grade III) in extension, with concurrent ligament injuries or chronic lesions *(1,21,38)*. However, this fails to identify isolated complete sMCL injuries, or laxity in the axial plane, which may be of particular importance when combined with ACL injuries.

Table I. – Clinical and radiographical MCL grading system

Type of MCL Lesion	Clinical gapping	Radiographical gapping
Grade 1	0-5 mm	Less than 2 mm
Grade 2	6-10 mm	2 - 3.2 mm
Grade 3	More than 10 mm	More than 3.2 mm

The initial diagnostic method of choice for MCL injuries is an accurate physical examination by applying valgus stress in full extension and at 30° of knee flexion *(11,13)*. Grading by physical examination depends on the ability of the patient to relax and also on the clinician's capacity to determine an end point during valgus stress at 30° of knee flexion *(22)*. However, any existing concomitant lesions can obscure the physical examination, such as cruciate ligament injury *(31)*. Therefore, too much confidence on physical examination can potentially lead to error in the diagnosis and grading of the MCL lesion, certainly in the context of combined ligament injuries, and can therefore potentially influence outcome *(10,20,30)*. Other diagnostic tools to evaluate medial knee lesions are magnetic resonance imaging and valgus stress radiographs *(25,32,33)*. When performing valgus stress radiography, a comparison with the normal contralateral knee can be made allowing the extent of gapping of the medial compartment to be measured, resulting in a more objective grading of the MCL injury *(16-18,33,36)*. LaPrade et al have validated the use of physician applied valgus stress radiography, the results of which are summarized in Table I. This can be an effective tool to help objectively understand the extent of the injury. Furthermore, management effectiveness can be monitored with measuring the gaps after non-operative or surgical treatments *(10,18,21,35)*. In this way, valgus stress radiographs cannot only be used to diagnose medial knee injuries, but also be a potential quantitative indicator for the return of medial stability after treatment *(22)*.

The principles of surgical management of MCL injuries include repair and reconstruction techniques *(3,14,15,26,29,40)*. Reconstruction techniques can be used to address the superficial medial collateral ligament (sMCL) only or in combination with the posteromedial structures, such as the central arm of the posterior oblique ligament (POL) within the posteromedial capsule *(2,21)*. LaPrade et al. recently described an anatomic reconstruction technique of both sMCL and POL, utilizing semitendinosus autograft or allograft. Other techniques by Lind and Marx utilizing semitendinosous autogaft and Achilles tendon allografts respectively have also been applied for complete MCL reconstructions *(27)*.

Recently, a modified LaPrade sMCL reconstruction utilizing an adjustable loop device (ACL Tightrope RT, Arthrex, Naples, FL) for the femoral fixation of a double looped semitendinosus tendon was described *(4)*. This technique gives the advantage of the ability to re-tension the graft following tensioning and fixation of one or both cruciate ligaments during multiligament knee surgery, potentially allowing the fine tuning and optimization of knee kinematics.

The purpose of this study was to assess the postoperative laxity of sMCL reconstructions utilizing this technique via stress radiography in the treatment of the multiple ligament injured knee. We hypothesized that valgus laxity was adequately restored by the proposed sMCL reconstruction technique.

METHODS

We retrospectively reviewed postoperative valgus stress radiographs in patients who underwent a concurrent sMCL and cruciate ligament reconstruction by a single surgeon from April 2013 to July 2016. The study was approved by the author's institution ethics board and informed consent to participate in the study and to comply with the postoperative regimen was obtained form all patients.

Superficial MCL reconstruction was performed in cases where the SSD was greater than 2mm and/or significant anteromedial rotatory laxity existed in combination with an anterior cruciate ligament injury.

Twenty-three patients (16 male and 7 female) were included in the study with a mean age of 29.3 years old (range: 18-55 years). The ratio of right side to left side was 13:10. Fifteen patients (65.2%) underwent cruciate plus MCL reconstructions on the same knee (Schenk Classification KDI), seven patients (30.4%) had three ligament reconstructions (Schenk Classification KDIIIM) and one patient (4.4%) had a four ligament reconstruction (Schenk Classification KDIV) *(34)*. The median time from injury to surgical intervention was 26 weeks (range: 1-886 weeks) and the mean time lapse from surgery to valgus stress radiography was 35 weeks post-operatively (range: 24-52 weeks).

A modified LaPrade technique was used to reconstruct the superficial MCL *(4)*. This method uses an adjustable-loop suspensory fixation device for graft fixation. Briefly, after tibial fixation with either a standard interference screw or staple, femoral fixation of the semitendinosus autograft tendon is performed with the adjustable-loop suspensory fixation device (ACL Tightrope RT, Arthrex, Naples, FL), which allows for both initial graft tensioning and re-tensioning after cyclical knee range of motion. This provides the ability for the graft to accommodate for resultant soft-tissue creep and stress relaxation, thereby allowing for optimal soft-tissue tension and reduction in laxity at the end of the procedure. A suture anchor is added to the anterior limb of the graft at the proximal tibial insertion of the sMCL, with the posterior limb of the graft remaining in continuity with the distal tibial insertion of the sMCL to attempt to control external rotation in extension. In the event where the posterior oblique ligament was injured as well, signified by the knee opening in extension, the central arm of the posteromedial capsule was repaired and augmented with a synthetic graft (Fibretape, Arthrex, Naples, FL) secured in place with two knotless anchors *(4)*.

Rehabilitation: Postoperatively, the knee is kept in a hinged brace with 0 to 90 degrees of motion for 2 weeks and then allowed full range thereafter. Flat foot toe-touch weight bearing is recommended for 6 weeks postoperatively, with weight bearing as tolerated thereafter. The brace should be worn for 3 months and then exchanged for an ACL brace used for sports and recreational activities for at least 1 year postoperatively *(4)*.

Valgus stress radiographs: Physician applied valgus stress radiography was performed on both operative and contralateral knees to measure side to side difference for comparison. Valgus stress radiographs were taken in 20 degrees of flexion and were captured at a minimum of 24 weeks post-operatively *(22)*. All stress radiographs were performed by a single blinded fellowship-trained sports orthopaedic surgeon. All radiographs were stored and analyzed on our institution's Picture Archiving and Communication System (PACS). Medial compartment measurements were calculated as described previously *(22)*. The PACS measurement tool was used to determine the closest perpendicular distance between the centre of the medial femoral condyle and the adjacent medial tibial plateau. Two independent orthopaedic surgeons reviewed all radiographs and an inter-observer reproducibility was calculated.

Statistical Analysis: Statistical analyses were performed using SPSS Statistics version 21 (SPSS Inc). A P value of less than 0.05 was accepted as a statistically significant difference. Mean and standard error of the mean (SE) were reported for pre-operative and post-operative side-to-side difference (SSD) using the medial compartment distance difference between the affected and contralateral sides. A two-tailed paired t-test was used to compare pre-operative and post-operative SSD in patients who underwent both pre and post-op stress radiographs. A two-way random single measures intraclass correlation coefficient [ICC (2,1)] was calculated to determine the inter-observer reproducibility of the medial gap measurements on the valgus stress radiographs.

RESULTS

Nine patients underwent pre-operative valgus stress radiographs. The mean SSD was 2.07mm ± 0.44mm. All the other patients had obvious medial gapping in either an acute knee that was too painful to stress, or in a chronic knee where there was no diagnostic uncertainty. The smaller pre-operative SSD was indicative of both coronal plane laxity and anteromedial rotational laxity, forming the basis of the decision to treat with sMCL reconstruction. Post-operatively, twenty-three patients underwent valgus stress radiographs that were assessed at a mean of 8.7 months (range: 4-13 months). The mean SSD difference post-operatively was 0.64mm ± 0.42mm. Eight patients underwent both pre and post-operative valgus stress radiographs. Post-operative (0.09mm ± 0.63mm) SSD was found to be significantly reduced compared to pre-operative SSD (2.07mm ± 0.44mm) (mean diff. = 1.98mm, 95% CI = 0.72-3.24, p=0.007) (Figure 1). The interobserver reliability value for medial compartment gap measurement was 0.91 with a 95% confidence interval of 0.34-0.97.

DISCUSSION

The results from this study demonstrate that the modified LaPrade sMCL reconstruction technique can adequately restore valgus stability as shown by static physician applied valgus stress radiography. The mean side-to-side difference in medial joint gapping was found to be 0.64 ± 0.41mm at a minimum of 6 months postoperatively following multiliagment reconstruction.

Several types of reconstructions have been developed for medial instability of the knee, including single-bundle and double-bundle sMCL reconstructions and sMCL combined with POL reconstruction. All of these techniques aim to reproduce the different medial anatomic insertions of the femoral and tibial attachments of the medial collateral ligament complex *(27)*.

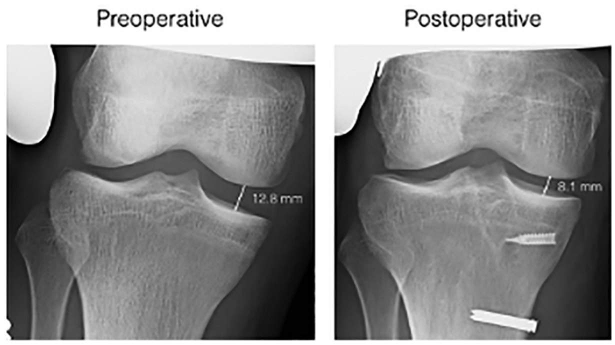

Figure 1. – Valgus stress radiographs showing a medial gap opening of 12.8 mm preoperative and 8.1 mm postoperative.

The modified LaPrade technique uses the same anatomical principles of graft placement to reconstruct the sMCL as the original technique; however, the fixation techniques are slightly different and graft consists of two limbs as opposed to one *(24,34)*. The technique uses an adjustable-loop suspensory fixation device (ACL Tightrope RT; Arthrex Inc., Naples, FL) for the femoral graft fixation. It has been demonstrated that cortical suspensory fixation provides a superior fixation of soft-tissue grafts than interference screw fixation alone *(37)*. A particular advantage of the adjustable loop is the ability to re-tension the graft after cycling the knee through a range of motion. Re-tensioning enables removal of creep from the graft, potentially providing a more secure final construct *(4)*. Furthermore, tensioning on the femoral side with the tibial graft already fixed pulls the knee into varus, as opposed to tensioning on the tibial side which can have the affect of applying valgus to the joint, the actual rotational moment that the reconstruction is trying to control.

The two limbs of the graft allow for placement of an anchor at the proximal tibial insertion of the sMCL into one limb only. This allows for graft continuity between both the femoral insertion and proximal and distal tibial insertions. This may play a role in improving control of tibial external rotation in flexion (role of distal fibres of sMCL); however this was not measured in this study. In a number of cases the POL was also addressed. In a circumstance where the posteromedial capsule was present, albeit stretched or torn, a primary repair was performed and augmented with a synthetic graft representing the central arm of the POL. If the POL was absent biological tissue in the form of a gracilis autograft was used instead. Both of these reconstruction techniques lead to satisfactory stability as assessed by stress X-ray. A criticism of the technique may be that an ipsilateral hamstring graft was used to reconstruct the sMCL. We are unaware of any evidence to suggest that using the ipsilateral hamstring has any adverse effects on static or dynamic medial stability after a sMCL reconstruction.

Several articles have been published concerning sMCL reconstruction techniques and their outcomes *(6,15,27,28,40)*. However, the comparison of these papers has been complicated for mainly two reasons. Firstly, due to the usage of different classifications to describe the severity of the lesions, it is difficult to find out both the severity and the exact structures of the MCL that were affected. Secondly, there is a lack of data on the exact measurement of medial joint gapping at both 0° and 30° of knee flexion pre- and postoperatively *(27)*.

LaPrade et al. found that valgus stress radiographs can accurately and reliably measure the amount of medial compartment knee gapping due to medial structure injury *(22)*. They demonstrated that a simulated grade III sMCL injury torn off either its femoral or distal tibial attachment required only 3.2 mm of increased medial compartment gapping at 20° of knee flexion versus the intact state *(22)*.

In the existing literature, very few studies concerning sMCL reconstruction used stress radiography to obtain a quantitative assessment of medial laxity. Yoshiya et al. published their results concerning 34 patients who underwent a sMCL reconstruction using autograft semitendinosus/gracilis tendins *(40)*. In this study, medial instability was evaluated with a stress radiograph examination in which the medial joint opening under valgus stress was measured with the knee in 20° of flexion. Postoperatively, they found an average side-to-side difference of 2 mm or less in all cases, with an average value of 0.2 mm (range : –1-2 mm) *(40)*. Fanelli et al. published a procedure to reconstruct the sMCL in patients with severe lesions using an Achilles tendon allograft or semitendinosus tendon autograft *(6)*. The millimeters of increased medial joint space width at 0°and 30° of flexion were not described. They only stated that 30° valgus stress testing was normal in 7 of 7 (100%) surgically treated MCL tears *(6)*.

Liu et al. used a Telos device to perform valgus stress and then evaluated the medial joint space with radiographs. The knee was kept in 20° of flexion during this process. They found a mean side-to-side difference of 1.1 mm (range, –1.1 to 3.2 mm) after surgery *(27)*. Again, a comparison with the findings of the present study is compromised due to the difference in methods to measure the medial joint space opening.

Limitations of this study include that only a relatively small number of study patients were presented and that the follow-up period was limited. Another drawback of this study is that patients with valgus laxity and/or anteromedial rotatory laxity were included. The effect of the procdure on anteromedial rotatory laxity was not addressed with the valgus stress radiographs. Furthermore, no patient reported outcomes are presented. However, the study population was heterogeneous with combined muliligament lesions and therefore it would be difficult to determine the outcomes of the isolated MCL procedures. Longer-term follow up will be helpful to confirm the initial results and the reliability of the sMCL reconstruction technique used in this study.

CONCLUSION

A modified LaPrade superficial MCL reconstruction utilizing a doubled semitendinosus tendon with suspensory loop femoral fixation in the setting of the multiligament knee injury results in excellent static stability of the knee as measured by valgus stress radiography at a minimum of 6 months post operative. These results indicate that valgus instability can be effectively treated by the presented technique.

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