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ORIGINAL STUDY

Anatomical superficial medial collateral ligament reconstruction with posteromedial capsule reefing successfully restores valgus knee laxity

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The goal of this study was to present the results of an anatomical superficial medial collateral ligament (sMCL) reconstruction combined with reefing of the posteromedial capsule in a series of 10 patients with symptomatic valgus instability complaints in combined injuries of the knee. All patients underwent an sMCL reconstruction with reefing of the posteromedial capsule. If cruciate ligament insufficiency was present, this was reconstructed as well. Pre- and postoperatively, multiple subjective knee outcome scores were obtained, and valgus stress radiographs objectively evaluated laxity. Median valgus laxity of the injured knee on valgus stress radiographs improved significantly. There was no statistically significant difference between postoperative valgus laxity of the injured knee and valgus laxity of the uninjured knee. All subjective knee outcome scores improved significantly compared with the preoperative situation. The described procedure restores valgus laxity to a level comparable to the uninjured knee.

Keywords : medial collateral ligament ; reconstruction ; multiligament ; knee ; stress radiographs ; valgus laxity.

INTRODUCTION

The medial collateral ligament (MCL) is the most frequently injured ligament in the knee. In most cases the MCL is partially injured (grade I and II). Most authors have suggested non-operative treatment for such injuries *(1,14)*. In addition, in many studies, non-operative treatment for an isolated complete MCL injury (grade III) showed good results *(7,19)*. There are different opinions about the optimal treatment strategy in knees with grade III MCL injury with combined (anterior) cruciate ligamentous injuries. Some studies advocate conservative treatment of the MCL with reconstruction of the anterior cruciate ligament (ACL) *(1,16)*. However, leaving the grade III injured MCL untreated may lead to chronic symptomatic valgus instability and may affect healing of the reconstructed ACL and lead to late graft failure *(3,21)*.

There is also debate regarding which surgical technique is most effective : MCL repair (17,18), isolated MCL reconstruction *(13,15,24)*, or MCL reconstruction combined with posterior oblique

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ligament (POL) reconstruction *(5,9,11,12)*. Furthermore, only few studies have used stress radiography in a reproducible manner to objectively document the results after MCL reconstruction *(13,25)*.

In this study, we describe our technique of reconstruction of the superficial MCL (sMCL) combined with reefing of the posteromedial capsule (PMC). We present the outcomes of this technique in a patient group with isolated and combined ligament injured knees. Our hypothesis was that this surgical technique would show an objective improvement in the stability of the medial side of the knee joint. Our second hypothesis was that patients would show improved knee function measured with multiple subjective knee outcome scores.

MATERIAL AND METHODS

Between 2004 and 2012, 10 patients underwent a reconstruction of the sMCL with reefing of the PMC and were included in this prospective cohort study. All patients had posttraumatic valgus instability of >10mm measured clinically, and an increase of minimal 3˚ of medial compartment opening during valgus stress radiographs when compared to the uninjured side.

The median age of the subjects (8 male, 2 female) was 31 (17-62) ; in seven cases the right knee was injured and in three cases the left. Nine patients had chronic medial instability complaints ; one patient underwent a reconstruction in the acute stage (within 6 weeks).

Nine of the 10 patients had concomitant cruciate ligamentous injury of the involved knee, with the anterior cruciate ligament being involved in 7 of 9 patients. One patient had an isolated complete tear of the MCL

Three patients had undergone a previous reconstruction of the ACL (which failed later) before referral to our hospital. In one of these three patients, a repair of the MCL also had failed before referral to our hospital. In another patient a MCL repair was done which failed before referral to our hospital (Table I).

For the MCL and cruciate reconstructions, an autograft or allograft tendon was used, depending on availability (Table I).

All patients except one were operated in one session (Table I). If insufficiency of the ACL or PCL was present this was anatomically reconstructed first. Meniscal tears were treated simultaneously. There were no chondral lesions that needed treatment.

For the MCL reconstruction, an incision was made 5cm above the joint space over the medial epicondyle and continued distally to just below the pes anserinus. After opening of the superficial fascia a reefing of the posteromedial capsule (including the posterior oblique ligament) was performed creating a tight posteromedial corner in extension as described by Wymenga et al *(22)*. Subsequently, for the reconstruction of the sMCL, the medial epicondyle was identified and the insertion of the sMCL was identified 3.2 mm proximal and 4.8 mm posterior to the medial epicondyle, as described by LaPrade et al *(10)*. Usually remnants of the sMCL can be found at the insertion site. An eyelet-passing pin was drilled at this location transversely across the femur. Then a reamer drilled the reconstruction tunnel according to the measured diameter of the graft that was used. Next, distally, the fascia of the sartorius muscle was incised and the gracilis and semitendinosis tendons were exposed (if present). The distal tibial attachment site was identified deep within the pes anserine bursa, approximately 6cm distal to the joint line. An eyelet-passing pin was drilled in the center of the distal attachment site transversely across the tibia. Then a reamer drilled the reconstruction tunnel with the same diameter as used in the femur. The graft was passed into the tibial tunnel below the pes tendons and fixed with a bioabsorbable screw (Biosure, Smith&Nephew, London, United Kingdom), and in a few cases with an Endobutton (Smith&Nephew, London, United Kingdom). An isometry test was performed by moving the leg after twisting the graft around a pin at the proximal graft site. Then the graft was passed into the femoral tunnel where it was fixed with a screw of the same type as used in the tibial tunnel, with the leg in 20 degrees of flexion and a slight varus reduction force. The fascia was closed over the reconstructed sMCL. The procedures were performed in a similar way by three experienced surgeons.

Table I. — Patient characteristics

Subject	Age at Injury	Mechanism	Grade	Acute / Chronic	Injuries*	Previous Surgery	Undergone procedure	MCL graft	ACL / PCL graft	Lachman test post-op	Posterior drawer test post-op
1	31	Sports injury	III	C	sMCL + ACL		sMCL + ACL reconstruction	Hamstring autograft	ACL: BPTB	Grade 1	Normal
2	47	Traffic accident	III	C	sMCL + PCL	Diagnostic arthroscopy	sMCL + PCL reconstruction	Achilles allograft	PCL: hamstrings autograft	Normal	Grade 1
3	49	Fall	III	C	sMCL		sMCL reconstruction	Hamstrings autograft		Normal	Normal
4	27	Traffic accident	III	C	sMCL + ACL + PCL	sMCL repair	sMCL + PCL + ACL reconstruction	Tibial posterior allograft	PCL: hamstrings autograft	Grade 1	Normal
5	29	Sports injury	III	A	sMCL + ACL		sMCL + ACL reconstruction	Achilles allograft	ACL: hamstrings autograft	Normal	Normal
6	21	Sports injury	III	C	sMCL + ACL + LCL	ACL reconstruction	sMCL reconstruction + ACL re-reconstruction	Tibial posterior allograft	ACL: tibial posterior allograft	Normal	Normal
7	62	Fall	III	C	sMCL + ACL		sMCL + ACL reconstruction	Tibial posterior allograft	ACL: hamstrings autograft		
8	17	Sports injury	III	C	sMCL + ACL	ACL reconstruction	sMCL reconstruction + ACL re-reconstruction	Tibial posterior allograft	ACL: BPTB autograft	Normal	Normal
9	18	Sports injury	III	C	sMCL + ACL	Arthroscopy ACL reconstruction sMCL repair	sMCL reconstruction + ACL re-reconstruction	Tibial posterior allograft	ACL: tibial posterior allograft	Grade 1	Normal
10	48	Sports injury	III	C	sMCL + ACL + PCL		sMCL + ACL + PCL reconstruction	Tibial posterior allograft	ACL: hamstrings autograft PCL: tibial posterior allograft	Grade 1	Normal

* sMCL superficial medial collateral ligament, ACL anterior cruciate ligament, PCL posterior cruciate ligament, LCL lateral collateral ligament

At the first post-operative day, a varus brace was applied (Mos-Genu, Bauerfeind, Zeulenroda – Triebes, Germany). Flexion and extension of the knee were limited during the first two post-operative months by the brace, with a flexion range from 0˚ extension to 90˚ flexion. On the second post-operative day, the patient was mobilised with crutches with partial weight bearing up to 50% for the next two months. The patient was instructed to wear the brace 24 hours a day. After that period, under supervision of a physiotherapist, the load was gradually increased to full weight bearing on the operated knee, and the patient was allowed to take off the brace at night. Also the range of motion was gradually increased.

Low-molecular-weight heparin was prescribed for a 2-month period to prevent deep venous thrombosis.

Preoperative valgus stress radiographs were performed as a standard diagnostic tool in the evaluation of the MCL injury. The method provides an objective and reproducible measure of medial compartment opening. The radiographs were obtained using the Telos device (Fa Telos, Medizinisch-Technische GmbH, Griesheim, Germany) with the subject lying in a supine position with the leg in 0 of extension, while a 15-Nm load was applied at the level of the joint line. Using the measurement tool included in the radiographic database program, the medial compartment opening was determined as the angle between the tangent to the femoral condyles and the line through the deepest tibial joint surfaces. Measurements were made at the nearest 0.1 degree (Figure 1). A detailed description of the measurement technique and its accuracy was previously published by Heesterbeek et al *(6)*. One clinician who was trained by the senior author of this article performed the measurements.

To test our hypothesis, at 2 years after surgery, the medial compartment opening was again measured on the stress radiographs and compared with the medial compartment opening in the uninjured knee.

Several subjective clinical score forms (VAS satisfaction score, Lysholm, the IKDC subjective form and the Noyes and Tegner activity scores) were completed preoperatively and 1 and 2 years after surgery.

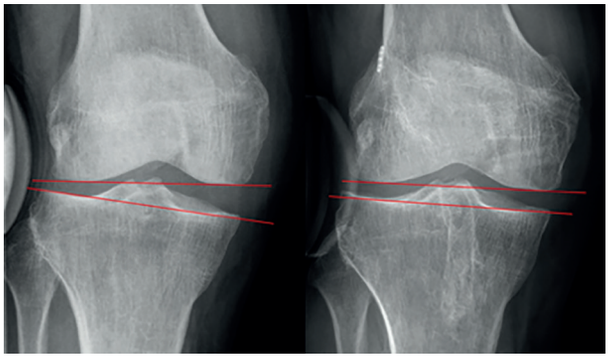

Figure 1. — Medial compartment opening on stress X-ray before and after surgery.

All patients were followed up prospectively. One patient sustained a fall in the early follow-up period and the reconstructed MCL failed. There were no other intra- or postoperative complications.

In two patients the stress X-ray of the 12-month follow-up visit was used because the ones of the 24-months follow-up were missing ; in one patient because of a technical issue, and one patient moved abroad.

The results were evaluated with version 13 of STATA (College Station, Texas, USA). The data obtained at the final follow-up were compared with the preoperative data using Wilcoxon signed-rank tests. *p*-values smaller than 0.05 were considered statistically significant.

The accredited ethics committee (Dutch acronym : METC, English : IRB) Slotervaartziekenhuis and Reade reviewed this study, registered under number P1312, by expedited review and determined, based on the Dutch Medical Research Involving Human Subjects Act (Dutch acronym : WMO), that the research activities described meet the requirements for exemption from METC review under the WMO.

RESULTS

Median follow-up was 2.4 years (1.0-6.0), excluding the patient who had a failed reconstruction and dropped out.

The median opening of the medial compartment on the stress radiograph decreased significantly from 5.6˚ (3.3-11.1) to 2.6˚ (0.1-2.8), (p = 0.015). There was no statistically significant difference

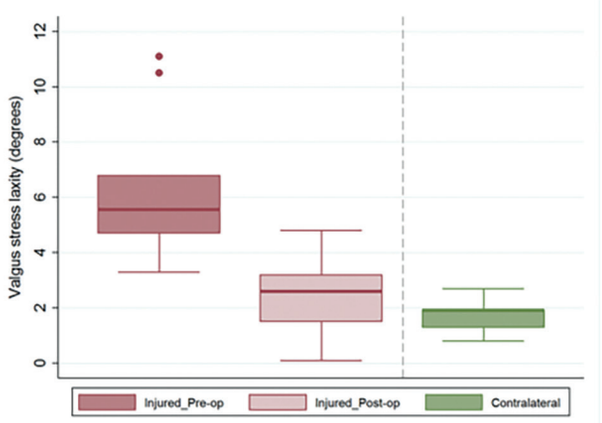

Figure 2. — Box plot showing valgus laxity of the injured (pre-operative and post-operative) and contralateral knee. Boxes show the 25th and 75th percentiles and the median (horizontal line within the box), the dots represent outliers.

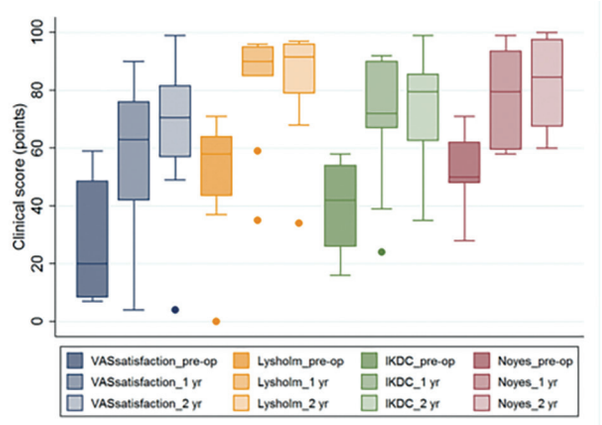

Figure 3. — Box plot of preoperative, 1-year, and 2-year postoperative VAS satisfaction, Lysholm, IKDC and Noyes scores. Boxes show the 25th and 75th percentiles and the median (horizontal line within the box), the dots represent outliers.

between postoperative valgus laxity of the injured knee and valgus laxity of the uninjured knee : 1.9° (0.8-2.7), $p = 0.19$ (Fig 2).

All clinical scores increased significantly both 2 years after surgery. The VAS satisfaction score 2 years after surgey improved from 20 (7-59) to 71 (4-99), ($p = 0.028$). The Lysholm score improved from 58 (0-71) to 92 (34-97), ($p = 0.028$). The IKDC subjective knee score showed an increase from 42 (16-58) to 80 (35-99), ($p = 0.028$). The Noyes score improved from 50 (28-71) to 85 (60-100), ($p = 0.028$) (Fig 3).

There was a statistically significant improvement of the VAS satisfaction score and the Noyes score in between the first and second year after surgery. The Lysholm and IKDC subjective knee scores were comparable one year and two years postoperatively (Fig 3).

The median Tegner score did not improve significantly : from 2 (0-5) to 4 (1-7), ($p = 0.21$)

When a concomitant rupture of the ACL or PCL was addressed with a reconstruction, this led to a stable or grade 1 Lachman test, and a stable or grade 1 posterior drawer test (Table I).

DISCUSSION

The most important finding of the present study was that good results could be achieved with the described sMCL reconstruction technique combined with reefing of the PMC with a significantly decreased median opening of the medial compartment on stress radiographs at a median follow-up of 2.4 years. The operated knees became as stable as the uninjured knees. The VAS satisfaction score, the Lysholm, IKDC subjective knee form and the Noyes score all improved significantly.

In the studied group, the associated injuries are comparable to patient series described in other studies *(20)*.

An interesting finding was that 3 patients in the studied group had already undergone an ACL reconstruction elsewhere. In 2 of these 3 patients the MCL was not treated operatively and in 1 patient only a reefing of the MCL was done. In all 3 patients the ACL reconstruction had failed and a re-reconstruction was done in our center together with a MCL reconstruction. Other studies had similar findings and showed that when only the ACL was treated in ACL-MCL injured knees, this could lead to higher stresses on the reconstructed ACL, which could affect its healing and lead to graft failure *(3,21)*.

There is debate however about the optimal treatment strategy in knees with grade III MCL injury with combined cruciate ligamentous injuries and some studies advocate conservative treatment of the MCL with reconstruction of the anterior cruciate ligament *(2,16)*. When operative treatment of the MCL is chosen, there is ongoing debate about what

Table II. — Comparison of current study results to other studies

Study	Number of Patients	Follow-up (Months)	Isolated sMCL / Combined injuries	Technique	Stress X-rays	Result Pre- / Postoperative	Lysholm Pre- / Postoperative	IKDC Pre- / Postoperative
Current	10	28	1 Isolated 9 Combined	Anatomic sMCL reconstruction + reefing PMC	Telos device	Medial opening 5.6 to 2.6 degrees	58 / 92	42 / 80
Yoshiya et al	24	27	2 Isolated 22 Combined	Anatomic sMCL reconstruction	Manual valgus stress	Side to side difference 4.1 to 0.2mm		
Kim et al	24	53	6 Isolated 18 Combined	sMCL and POL reconstruction with preservation of tibial semi-t attachment	Manual valgus stress	Medial joint opening 7.8 to less then 2mm in 22 patients	? / 91.9	
Koga et al	7	26	7 Combined	Proximal advancement + semitendinosus augmentation	According to IKDC form	Unknown for this subset of 7 patients	81 / 91	
LaPrade et al	28	18	2 Isolated 26 Combined	Anatomic sMCL and POL reconstruction	Manual valgus stress	Side to side difference 6.2 to 1.3mm		43.5 / 76.2
Liu et al	16	34	2 Isolated 14 Combined	Anatomic sMCL reconstruction	Telos device	Side to side difference 8.9 to 1.1 mm	69.3 / 88.6	49.8 / 84.3
Kitamura et al	30	At least 24	30 Combined	Anatomic sMCL reconstruction	Manual valgus stress	Medial opening 8.5 mm vs 8.0 uninjured side	? / 94.8	
Zhang et al	21	40	21 Combined	Tibial inlay technique	Telos device	Medial opening 8.0 to 0.8 mm		45.3 / 87.7

sMCL superficial medial collateral ligament, PMC posteromedial capsule, POL posterior oblique ligament, IKDC International Knee Documentation Committee.

surgical technique is most effective. Our proposed technique is a reefing of the posteromedial capsule including the POL *(22)*, combined with anatomic reconstruction of the sMCL. The goal of MCL-PMC reconstruction should be functional anatomical recovery of the pathology and retention of the meniscus. The PMC-meniscus-semimembranosus complex should be refixated at the posteromedial corner of the tibia if it is loose. The reefing of the posteromedial capsule is a simple technique and for the reconstruction of the sMCL only 2 tunnels need to be drilled. The technique as described by Coobs et al *(4)* with reconstruction of the POL and sMCL using 2 separate grafts is a more extensive and complex procedure in which 4 tunnels need to be drilled. We believe that from a theoretical point of view a reconstruction of the POL is necessary to gain stability in extension. However, in this study we have shown that with our more simple technique comparable results can be reached compared to anatomical reconstruction of the POL and sMCL as presented by LaPrade et al *(11)*. This implicates that reefing of the PMC is as effective for stability in extension as anatomic reconstruction of the POL. To our opinion the anatomical reconstruction of the sMCL using the landmarks as described by Coobs et al *(4)* is the best technique and is therefore the used technique in our center. Furthermore, cruciate ligament injuries should be treated in the same session.

By using a Telos device, an objective and reproducible measurement of medial compartment opening could be achieved. This method is objective and the preferred method compared to valgus stress given manually, with which the results could be influenced by variations in degree of force applied, knee flexion angle, limb rotation and measurement method.

Valgus laxity was measured in degrees on stress radiographs to prevent any discrepancies due to

the magnification factor *(6)*. As a consequence, the results are difficult to compare with other studies. When considering a medial opening of <3° as being successful (surgeon's opinion), then all patients (except the patient with a failed reconstruction after a fall) can be considered a success. Other studies using different techniques also reported high success rates with comparable results *(8-13,15,23,25)* (Table II). This shows that different studies describing different MCL reconstruction techniques show satisfactory results. Often the stress X-rays were not done in a standardized way using a Telos or comparable device. Future objective outcome-based studies are needed to further evaluate the optimal treatment strategy.

There are limitations in the present study. It is a single cohort study and no comparison has been made with an alternative treatment. Instead, the result of the used technique was compared with the non-injured side. Furthermore, the size and the variety of the cohort can be considered as limitations of the present study, although this is inherent to the fact that most MCL injuries can be treated conservatively and the indications for this type of surgery are uncommon. Most patients had combined ligament ruptures making it more difficult to determine the clinical outcomes of only the MCL procedure. However, this is the clinical practice in these types of injuries. The anterior and posterior stability was tested clinically to analyze the result of a reconstructed ACL and / or PCL. Ideally, stress X-rays should have been done for a standardized analysis.

The most important strength of this prospective study is that the patients underwent standard quantitative assessments of medial laxity based on stress X-rays with a Telos device both pre- and postoperatively. Furthermore five different knee score forms were used for the assessment, comparing preoperative values to postoperative values and confirming clinical improvement of the patients.

In conclusion, in a small patient group with multiligament knee injuries, surgical management with reconstruction of the sMCL combined with reefing of the PMC restored valgus laxity to a level comparable to the uninjured knee. Functional knee scores improved significantly.

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