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Original Research

Complete Release of the Superficial Medial Collateral Ligament in Total Knee Arthroplasty

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A B S T R A C T

Background: Proper soft-tissue balance was essential in total knee arthroplasty (TKA). Superficial medial collateral ligament (sMCL) release has been recommended in correction of severe varus knee. However, it has concerns of overcorrection. This study aimed to analyze coronal plane laxity in sMCL-released TKA patients.

Methods: We prospectively collected data from TKA patients who were operated from January 2015 to November 2018. All patients went through the same surgical steps; however, sMCL was left intact in mild-to-moderate deformity (sMCL-intact), while it was completely released in patients with severe deformity (sMCL-released). All patients went through the same postoperative protocol. We used stress radiograph with 90 N force to evaluate coronal plane laxity and recorded modified Western Ontario and McMaster Universities Osteoarthritis Index score at 3- to 6-year postoperative appointments.

Results: There were 46 patients (59 knees) included with an average follow-up time of 48.3 months. The sMCL-intact group consisted of 14 patients (16 knees) with average preoperative mechanical axis (MA) varus of 4.84 degrees exhibited 1.64 mm (0.6-3.6 mm) laxity on medial side and 1.01 mm (0-3.1 mm) on lateral side. The sMCL-released group consisted of 32 patients (43 knees) with average preoperative MA varus of 14.74 degree exhibited 1.96 mm (0.4-4.8 mm) laxity on medial side and 1.57 mm (0.1-5.9 mm) on lateral side. At the time of follow-up, the mean modified Western Ontario and McMaster Universities Osteoarthritis Index in the sMCL-intact and sMCL-released groups were 14.8 and 13.5 (*P* value .79), respectively. There was no clinical laxity or reoperation of any causes in either groups.

Conclusions: Complete release of sMCL in severe varus knee does not result in overcorrection after TKA at the midterm follow-up period. Thus, sMCL release technique could be an effective and safe option for correction of severe varus deformity.

Introduction

Background

Soft-tissue balancing is essential to good clinical and radiographic outcomes in total knee arthroplasty (TKA) [1]. Varus deformity of the knee was commonly found as a result of soft-tissue contraction combined with erosion of distal femoral bone and cartilage. The degree of varus deformity in knee osteoarthritis can vary widely. Several surgical techniques have been proposed for the correction of varus deformity, including posteromedial capsule release [2], superficial medial collateral ligament (sMCL) release [3], and proximal tibia reduction osteotomy [4–6]. The value and efficacy of sMCL release for the correction of varus deformity have been debated for decades. Originally, the surgical technique consisted of the subperiosteal release of the sMCL from the proximal attachment at proximal tibia to the distal attachment at 6-8 centimeters below tibial articular surface. The process is subperiosteal elevation of soft-tissue sleeve rather than transection. This is performed from the anterior to the posteromedial edge of proximal tibia, beginning at the anterior insertion of the pes anserine and including the distal attachment of the sMCL in this flap. Therefore, the anterior insertion of the pes anserine is released together with

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the sMCL [7]. Although a cadaveric study found sMCL release to produce the largest increase in valgus rotation [8], it was later shown that the technique can result in over-release and eventual valgus instability [9]. Moreover, knee instability can occur when total sMCL release is combined with posterior cruciate ligament resection [10].

Rationale

Concerns about the instability of the knee joint after sMCL release have led to the development of several new techniques, such as sliding medial condylar osteotomy [4–6] and the pie crusting with blade or needle puncture technique [11–15]. However, these newer techniques have their own complication risks. There are reports of instability after pie crusting [11,13] and a high incidence of nonunion or fibrous union after sliding medial condylar osteotomy [16].

Less-invasive modifications to the sMCL release technique have been suggested [17]. Instead of releasing the pes anserine attachment with the sMCL, the anterior attachment of the pes anserine insertion is preserved and a medial soft-tissue sleeve is created. Preserving the pes anserine insertion could help maintain knee stability after sMCL release. An evaluation of this technique found no significant differences in medial laxity or clinical outcomes between patients with completely released sMCL and those with partially released sMCL either 6 months or 1 year postoperatively [18]. A case series reported good knee stability at midterm follow-ups after sMCL release in patients with TKA using this modified technique [19,20]. We have utilized the modified sMCL release technique in our practice since 2007 and found high satisfaction results without increasing incidence of revision due to instability. Using this modified sMCL release technique, we studied the effect after sequential release of posteromedial capsule and sMCL in a varus osteoarthritic patient who underwent TKA using computer-assisted surgery and found sMCL release resulted in mean varus correction of $3.4^\circ \pm 1.7^\circ$ without over-release or valgus instability [21]. We hypothesized that complete release of sMCL during TKA does not result in intraoperative and postoperative instability of knee. Therefore, we designed this study to compare knee laxity between sMCL-intact TKA patients and completely released sMCL TKA patients. The evaluation of laxity consisted of clinical and stress radiographic examination at midterm follow-up.

Material and methods

We prospectively collected data from patients with varus osteoarthritis who underwent TKA between February 2015-November 2018. Age, gender, and body mass index were recorded for demographic data. Preoperative long film standing hip–knee–ankle (HKA) angles were recorded to evaluate mechanical alignment. All radiographic studies were performed using a picture archiving and communication system. All patients underwent TKA by 1 senior surgeon and followed the same perioperative and postoperative management protocols.

All TKAs were performed under spinal anesthesia without peripheral nerve block. TKA with modified gap balancing was performed using the following technique. Once the patient was anesthetized, a midline skin incision was made and a mini-midvastus arthrotomy was performed. The meniscuses, anterior cruciate ligament, and all osteophytes were removed. Then, the tibia was subluxated anteriorly and the proximal tibia resected perpendicular to the MA, using an extramedullary alignment guide, 6-8 mm from the lateral tibia plateau depending on the degree of bone and cartilage loss. The distal femur was resected using the intramedullary guide to ensure the bone was cut perpendicular to the mechanical alignment. The resection depth was 9 mm or less from the medial femoral condyle, depending on the degree of distal femoral bone and cartilage loss. The medial soft tissue was released sequentially to create a rectangular extension gap. At this stage, a spacer block and laminar spreader were used to determine soft-tissue balance. The standard varus correction procedures included deep medial collateral ligament release, posteromedial soft-tissue release, and tibial reduction osteotomy. These procedures were performed sequentially to correct varus deformity. The extension gap was then evaluated. If there was <2 mm between the medial and lateral sides of the extension gap, the sMCL will be left untouched and these patients were assigned to the sMCL-intact group. However, if there was tight medial soft tissue causing an obvious trapezoidal extension gap after the varus correction procedures; the sMCL was deemed to require complete release. Generally, the difference between the medial and lateral sides of the joint in extension before sMCL release was >3-4 mm in this group. Those patients in whom the sMCL was completely released were assigned to the sMCL-released group in this study.

We utilized modified sMCL release technique in all patients who need sMCL release. The periosteal elevator was used to raise the sMCL by subperiosteal manner from proximal attachment to distal attachment with all layers of the medial soft tissue, including the sMCL [17] as showed in Figure 1. The procedure was carefully performed while maintaining a continuous soft-tissue sleeve and preserving the anterior insertion of the pes anserinus. After sMCL release, the extension gap was reassessed. After ensuring that the extension gap was balanced, the TKA procedures afterward were the same in both groups.

Femoral rotation was determined using soft-tissue tension as described in gap balancing technique [22]. The femoral size was also determined to equalize the flexion–extension gap. A final femoral resection guide was then placed, and final femoral bone resection was done. Final tibial preparation was completed, then prosthesis trials were inserted. We tested the stability of tibiofemoral articulation throughout the range of motion and we manually applied varus–valgus force in full extension to assess coronal plane stability before prosthesis implantation. The patella resurfaced in all patients. Intraoperative assessment of patellar tracking was performed using the no-thumb technique. A periarticular injection with local anesthetic and Ketorolac cocktail was administered in all cases before wound closure. The same postoperative management and pain management protocols were used with all

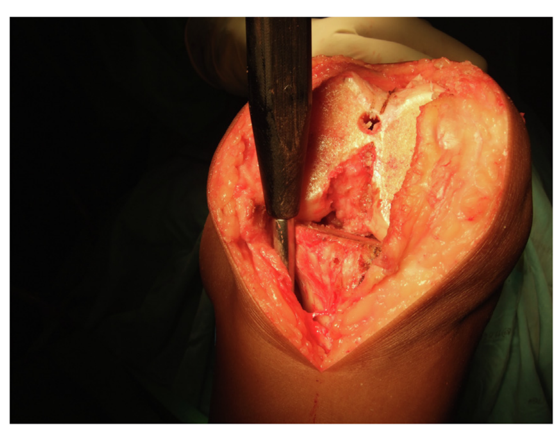

Figure 1. Picture showed a periosteal elevator insert subperiosteally from cut surface of tibia anteromedially under superficial MCL to the level of 8-10 cm below joint line. Finger palpation was done afterward to confirm complete release.

patients. Full-weight-bearing and early active range-of-motion exercises were encouraged as early as possible, mostly on the second day after surgery. All patients were seen regularly on an outpatient basis after discharge. Postoperative radiographic evaluations were conducted 1-3 months postoperatively and consisted of anteroposterior and lateral radiographs of the knee and long film standing HKA alignment evaluations.

During the 3- to 6-year follow-up, we evaluated TKA laxity using stress radiography. Prior to laxity measurement, we identified the thickness on the medial and lateral sides of the tibia insert using a standing anteroposterior radiograph to measure the shortest distances between the most distal points of the medial and lateral femoral prostheses (Fig. 2). Stress radiography was then performed with the patient in a supine position with the knee fully extended on a standard radiographic examination table. The distance between the knee and the radiation beam tube was fixed at 1 meter to minimize magnification error. A digital ligament stress device Figure 3, Patent number 2101002860, Navamindradhiraj University, Bangkok, Thailand) was then applied to the knee with a force of 90 N in the valgus and varus directions in turn to determine laxity of the knee ligament. Stress radiography was used to measure and compare the shortest distance from the most distal point of the medial femoral prosthesis to the flat surface of the tibia and the shortest distance from the most distal point of the lateral femoral prosthesis to the flat surface of the tibia in true anteroposterior. We measured the changes in angulation and gap distance after both valgus and varus stress radiography (Figs. 4 and 5). Radiographic data and clinical outcomes were evaluated by an outcome assessor who was unaware of each patient's status in the study. We compared final modified Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score and preoperative and postoperative global limb alignment by measuring the HKA angles of the patients in both the groups.

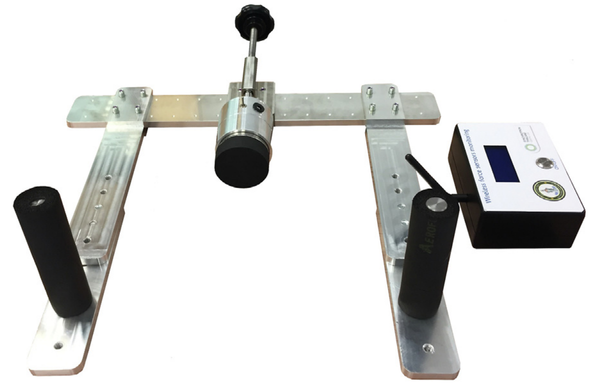

Figure 3. Digital ligament stress device: The constant force applied by the device, during radiographic examination.

Results

Demographic results

Initially, there were 47 patients in this study. However, 1 patient was excluded because an intraoperative medial epicondyle fracture was detected. Therefore, 46 patients (59 knees) were included for evaluation. The sMCL-intact group consisted of 14 patients (16 knees), and the sMCL-released group consisted of 32 patients (43 knees). The sMCL-intact group had a mean age of 73.56 years (60-91 years) and a mean body mass index of 27.28. The mean preoperative MA of sMCL-intact group was 4.84° varus. The sMCL-released group had a mean age of 69.5 years (55-86 years) with a mean body mass index of 28.14. Their mean preoperative MA angle was 14.74° varus. We implanted cruciate-retaining prosthesis in

Figure 2. Standing AP radiography: We measured the medial and lateral joint gap distance from the shortest line start at the most distal point of medial and femoral prosthesis to the tibial tray.

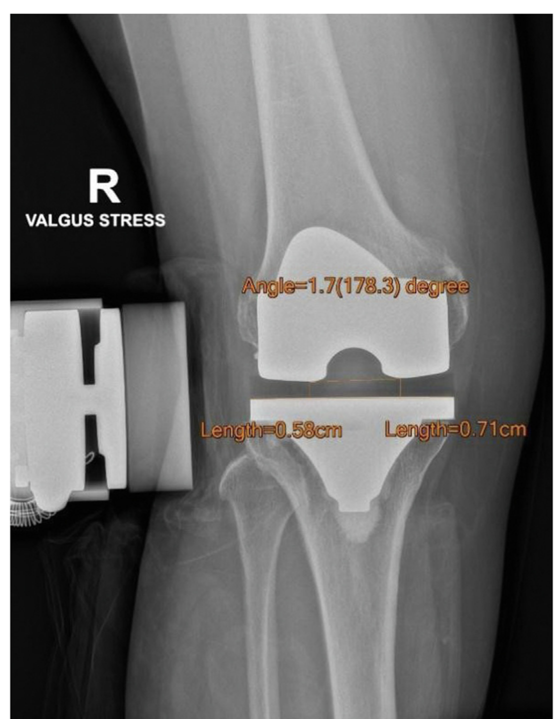

Figure 4. Valgus stress radiography: a 90 N force applied during radiography. The joint opening gap was evaluated by measuring the distance from the shortest line starts at the most distal point of medial and femoral prosthesis to the tibial tray.

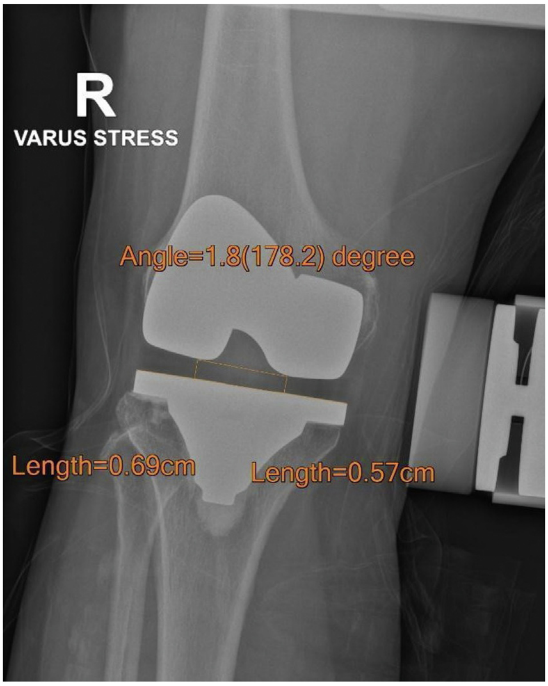

Figure 5. Varus stress radiography: a 90 N force applied during radiography. The joint opening gap was evaluated by measuring the distance from the shortest line starts at the most distal point of medial and femoral prosthesis to the tibial tray.

most cases (15 knees in sMCL-intact group and 41 knees in sMCL-released group). Patients' demographic data are summarized in Table 1.

Knee laxity results

During operation, we detected no evidence of overcorrection in either group, either intraoperatively or immediately post-operatively. Using digital ligament stress device, the average laxity on the medial side (valgus laxity) was 1.64 ± 0.84 mm (range, 0.6-3.6 mm) in the sMCL-intact group and 1.96 ± 0.86 mm (range, 0.4-4.8 mm) in the sMCL-released group. The average laxity on the lateral side (varus laxity) was 1.01 ± 0.71 mm (range, 0-3.1 mm) in the sMCL-intact-group and 1.57 ± 1.19 mm (range, 0.10-5.90 mm) in the sMCL-released group. The average change in angular alignment after valgus stress was 177.78° ± 0.85° (176.40°-179.20°) in the sMCL-intact group and 177.41° ± 0.99° (174.50°-179.10°) in the sMCL-released group. The average change in angular alignment after varus stress was 178.58° ± 0.86° (176.2°-180°) in the sMCL-intact group and 177.85° ± 0.86° (173.4°-179.9°) in the sMCL-released group. There were no statistically significant differences in any of the stress radiography studies.

Postoperatively, the mean HKA was 2.59° ± 2.39° in the sMCL-intact group and 0.92° ± 3.00° in the sMCL-released group. Post-operative MA outliers, defined as either valgus or varus deviations in the postoperative MA of >3°, were found in 56% of the sMCL-intact group and 35% of the sMCL-released group. All outliers in the sMCL-intact group were in varus alignments. Thirteen from 15 outliers in the sMCL-released group were in varus alignment, while 2 of them were in valgus alignment. A summary of our radiographic findings is provided in Tables 2 and 3. None of patients from both the groups need further procedure for the treatment of knee stiffness. There is no reoperation in 90 days after surgery. At the most recent follow-ups, all patients reported knee stability and there were no clinical symptoms or signs of instability. No revisions of any cause occurred in either group.

Modified WOMAC

The average modified WOMAC score at the time of follow-up was 14.8 (range 1-66) in the sMCL-intact group and 13.5 (range 1-85) in the sMCL-released group (Table 4). Most of patients in both the groups had a WOMAC score less than 25. The WOMAC score higher than 40 was found in 3 cases, 2 from the sMCL-intact group and 1 case in the sMCL-released group. One out of these 3 is in radiographic outlier. All of them had symptomatic spondylosis with a significant degree of lumbar spinal stenosis. In fact, the patient in the sMCL-release group also underwent spinal fusion surgery to alleviate the symptoms. The difference between group neither reach minimum clinically importance difference [23] nor showed statistically significant between groups (*P* value .79)

Discussion

Although it was recommended for correction of severe varus knee [7], the benefits of releasing the sMCL in total knee replacement are subject to debate because overcorrection which may cause postoperative instability was reported [9]. Concerns about overcorrection and potential instability have led many surgeons nowadays to avoid sMCL release, even for the correction of severe varus knee. We conducted this study to analyze the laxity differences between patients with intact sMCLs and those with completely released sMCL. We found that patients who required sMCL release to correct varus deformity originally had greater varus deformity than those not requiring it, which was to be expected. After surgery, there was a slightly difference without statistically significant in the final MA between groups, with the sMCL-released group achieved better final MA than the sMCL-intact group. sMCL release resulted in a higher degree of varus correction. And finally, both the groups achieved the same level of clinical outcomes in terms of mid-term longevity and modified WOMAC scores.

Table 1
Demographic data of patients in both groups.

Demographic data	sMCL-released	sMCL-intact
Number of knees (N)	43	16
Number of patients		
Male	1	-
Female	31	14
Age (y)	69.5 ± 7.8 (55-86)	73.56 ± 9.74 (60-91)
Follow-up (mo)	48.53 ± 10.67 (31-70)	47.50 ± 11.3 (30-64)
Body mass index	28.14 ± 5.17 (18.9-36.8)	27.28 ± 4.34 (19.4-35.1)
Prosthesis constraint	CR = 41, PS = 2	CR = 15, PS = 1

CR, cruciate retaining; PS, posterior stabilized; sMCL, superficial medial collateral ligament.
Mean ± SD (range).

Table 2
This table shows collateral ligament laxity between two groups.

Collateral ligament laxity	Intervention	Mean	Range	SD	*P* value
Medial laxity (mm)	sMCL-intact (N = 16)	1.64	0.6-3.60	0.84	.21
	sMCL-released (N = 43)	1.96	0.4-4.80	0.86	
Lateral laxity (mm)	sMCL-intact (N = 16)	1.01	0.-3.10	0.71	.08
	sMCL-released (N = 43)	1.57	0.1-5.9	1.19	

SD, standard deviation; sMCL, superficial medial collateral ligament.

Table 3
Radiographic data between 2 groups.

HKA (degree)	sMCL-released	sMCL-intact	*P* value
Preoperative[a]	14.74 ± 5.32 (8.0-28.1)	4.84 ± 2.78 (1.0-9.3)	<.0001[a]
Postoperative[a]	0.92 ± 3.00 (−4.3 to 8.0)	2.59 ± 2.39 (−2.9 to 7.0)	.05
Postoperative HKA outlier (HKA >3 degrees)	15/43 (35%)[b]	9/16 (56%)[c]	.14
Angular alignment after valgus stress	177.41° ± 0.99° (174.50°-179.10°)	177.78° ± 0.85° (176.40°-179.20°)	.23
Angular alignment after varus stress	177.85° ± 0.86° (173.4°-179.9°)	178.58° ± 0.86° (176.2°-180°)	.95

sMCL, superficial medial collateral ligament.
[a] Varus alignment is presenting in positive value while valgus is in negative value.
[b] 2 cases of sMCL-released group were in valgus alignment, the rest were in varus.
[c] All outlier in sMCL-intact group were in varus alignment.

In this study, we used a digital ligament stress device that allows the operator to apply constant force during stress radiography. Our results showed the average difference in laxity between the sMCL-intact group and sMCL-released group was less than 0.5 mm, which was neither statistically nor clinically significant. The between-group difference in angular change after stress film was neither statistical nor clinical significance as well. None of the patients who underwent sMCL release showed any clinical symptoms of instability either immediately postoperatively or during the 3- to 6-year follow-up period. We believe midterm postoperative follow-up, which allows the ligament to fully heal and adjust, could shed further light on the efficacy of this procedure.

Our results showed no laxity whatsoever after sMCL release. This may be attributable to the modified gap technique that we use in knee replacement, in which balancing of the extension gap is followed by the determination of femoral rotation using the soft-tissue tension technique. This approach may have played a crucial role in the overall knee stability of our patients. Also, the sMCL release technique that we use is modified from the original technique, in that the anterior insertion of the pes anserine is preserved. Pes Anserine, which is the common insertion of Sartorius, Gracillis, and Semi-tensinosus muscles, acts as a strong dynamic stabilizer and could also be a vital contributor to the absence of laxity in our patients. When using this technique for sMCL release, several important points must be followed. First, surgeons need to adequately release other contracted soft tissue and remove collateral ligament-tenting osteophyte before the decision to perform sMCL release was made. The corner of the posteromedial soft tissue may or may not release, depending on the degree of flexion contracture detected. Second, the anterior insertion of the pes anserinus at the medial proximal tibia must be preserved as previously mentioned. Third, sMCL release must precede femoral rotation bone resection because release of the sMCL will loosen the flexion gap on the medial side and could considerably alter the flexion gap geometry. If femoral rotation bone resection was performed before sMCL release, it could result in an imbalanced flexion gap. We believe that proper flexion and extension gap balancing is also crucial to the prevention of instability.

Our study has some limitations which are relatively small number of patients and no randomization. However, the stress radiograph outcomes which is the main outcomes were almost similar in both groups without statistic and clinical differences detected as mentioned previously. We could not conduct randomization because of the nature of the treatment selection in different deformity groups.

Table 4
This table shows modified WOMAC score.

Score	Intervention	Mean	Range	SD	*P* value
Modified WOMAC	sMCL-intact (N = 16)	14.8	1-66	5.20	.79
	sMCL-released (N = 43)	13.5	1-85	2.54	

SD, standard deviation; sMCL, superficial medial collateral ligament; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

Conclusions

Limb alignment correction with ligament balance and proper bone resection are both crucial in knee arthroplasty. Using a modified gap balancing technique, sMCL release was found to be safe and effective method in the correction of severe varus deformity. We were able to demonstrate the safety of this technique and ongoing mediolateral stability of the knee for up to 6 years postoperatively. Therefore, we believe that sMCL release is a valid procedure for the correction of varus deformity.

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Conflicts of interest

The authors declare there are no conflicts of interest.
For full disclosure statements refer to https://doi.org/10.1016/j.artd.2023.101301.

Data Availability

TCTR (Thai Clinical Trial Registry) 20220411001.

Ethical statement

This study was conducted in accordance with the ethical standards in the 1964 Declaration of Helsinki and with relevant regulations of the US Health Insurance Portability and Accountability Act. The study was approved by Navamindradhiraj University with Certificated of Approval (COA) number159/59. Signed statements of informed content to procedures performed, study participation, and publication were obtained from participants before the study.

Location

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