

Laxity after complete release of the medial collateral ligament in primary total knee arthroplasty

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Abstract

Purpose Medial collateral ligament (MCL) release is one of the essential steps toward the achievement of ligament balancing during the total knee arthroplasty (TKA) in patients with varus deformity. When the varus deformity is severe, complete release of the MCL until balanced is often required. However, it is believed that complete MCL release may lead to catastrophic laxity. The purpose of this prospective study is to compare the medial joint gap opening in postoperative valgus stress radiograph in patients with complete MCL release against patients with partial release.

Methods Out of 209 primary TKAs performed for degenerative osteoarthritis, complete MCL release was required in 33 cases (group I) by sub-periosteal detachment at proximal tibia using periosteal elevator. For the remaining 176 knees (group II), partial release of MCL was done. At postoperative 6 months and 1 year, both groups were evaluated for comparing the joint gap on valgus stress radiographs using modified Telos device in 0°, 45°, and 90° of flexion. Additional parameters which were analyzed included preoperative varus and valgus stress radiographs in full

extension and pre- and postoperative mechanical alignment in each group. The knee range of motion (ROM) and clinical scores were evaluated at 1-year follow-up.

Results The mean values of the joint opening on the postoperative valgus stress test with the knee joint extended, and in the 45° and 90° flexed states at 6 months and at 1 year postoperatively in group I were not statistically significantly different from those of group II. The clinical scores also did not show a statistically significant difference between two groups. There was a statistically significant difference in ROM between two groups, pre- and postoperatively and the difference was 5°, respectively.

Conclusion This study suggests that complete MCL release for ligament balancing is a safe procedure and does not lead to postoperative laxity.

Keywords Complete medial collateral ligament release · Ligament balancing · Total knee arthroplasty

Introduction

Ligament balancing is thought to be the most important prognostic factor for successful total knee arthroplasty (TKA) [8, 11, 23, 29, 32, 35, 37]. In most cases of osteoarthritis, the knee joint shows varus deformity which needs release of the contracted medial soft tissues, including the medial collateral ligament (MCL) [3, 36, 38]. The sequence and type of medial releases still remain controversial. Subperiosteal release of the superficial MCL has been widely used for medial release by many surgeons [14, 33, 35]. The extent of the release of the MCL depends on several factors, including the degree of bony deformity, soft tissue contracture, contralateral laxity, and the type of implant used.

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When the varus deformity is severe, complete release of the MCL is often required in order to achieve medio-lateral balance of the knee joint [34, 38]. However, many surgeons do not perform complete release of the MCL due to the possibility of laxity which might be caused by the complete release. Through cadaveric studies, Mihalko et al. [22] suggested that the release of medial soft tissues is associated with an increase in valgus laxity.

Despite some worrisome reports [14, 22], the authors experienced excellent clinical results without laxity in patients with complete release of the MCL. The hypothesis was that complete sub-periosteal release of the MCL in patients with severe varus deformity is safe and would not lead to postoperative laxity when the procedure is performed with good alignment and in consideration with contralateral laxity.

To the authors' knowledge, there is a lack of prospective clinical studies evaluating the extent of postoperative laxity objectively when the MCL is completely released in order to balance the knee joint.

The purpose of this study is to compare prospectively: (1) the amount of medial joint gap opening in valgus stress radiographs taken at 0°, 45°, and 90° of flexion as a primary outcome; (2) alignment as secondary outcomes; and (3) clinical scores including the range of motion (ROM) in patients who underwent complete MCL release compared with those patients in whom the MCL was only partially released.

Materials and methods

Between March 2011 and February 2012, the senior author performed 368 primary total knee arthroplasties in 247 patients for degenerative osteoarthritis with varus deformity. Patients with post-traumatic arthritis (three patients, three knees), rheumatoid arthritis (six patients, nine knees), mechanically valgus deformity (five patients, five knees), and the patients who have been operated with a mobile-bearing prosthesis (54 patients, 76 knees) were excluded from the study. Twelve patients (19 knees) were excluded because they refused to participate, and 28 patients (47 knees) were lost to follow-up. Therefore, 209 knees from 139 patients were included in this study. The patients were divided into two groups postoperatively, i.e., group I (complete MCL release) and group II (partial MCL release). Group I consisted of 33 knees in 27 patients (27 women) with a mean age of 68.5 years (± 6.3). Group II consisted of 176 knees in 112 patients (107 women and five men) with a mean age of 69.6 years (± 6.2).

The posterior substituting (PS) types of three different prostheses were used in the present study. The prostheses were Triathlon in 92 cases (Stryker, Limerick, Ireland),

NRG Scorpio in 69 cases (Stryker, Limerick, Ireland), and Genesis II in 49 cases (Smith and Nephew, Memphis, TN, USA).

Surgical technique

Under pneumatic tourniquet control, a standard midline skin incision and medial parapatellar approach were used in all cases. Following the arthrotomy, preliminary medial release of the deep MCL was performed. Osteotomy was done following the guidelines provided by each manufacturer aiming the mechanical axis pass through the center of the knee joint. Three degrees of external rotation were given along the posterior condylar axis. After osteotomy, the balance was re-checked on inspection, on palpation of both collateral ligaments, and with the aid of a gapper in extension and 90° flexion state. The thickness of the gapper was determined using the flexion/extension gap balancing technique. The extension gap was considered appropriate when neither flexion contracture nor hyperextension of the knee was noted using gapper. Mild flexion gap widening (<3 mm or one thicker gapper) was considered to be acceptable. In case of medial tightness, the MCL was released enbloc with the help of a periosteal elevator. The periosteal elevator was inserted gradually deep into the MCL at the level of the tibial plateau up to distal 6–8 cm and was levered against the anteromedial aspect of the proximal tibia in order to release the MCL insertion (Fig. 1a). The MCL release was performed until the medial gap opened enough to balance the lateral gap. The tibial attachment site of the MCL was then examined in order to ascertain whether or not the insertion of the MCL was completely detached. The authors regarded complete release as when the MCL was completely detached from its insertion site and was freely movable (Fig. 1b). The pes anserinus and the posteromedial attachment of the semimembranosus were preserved in all cases in this current study. When more than 3 mm of medial opening was noted during flexion, balancing was re-checked in a patella-reduced state by approximating the arthrotomy site with a towel clip. Trial implants were then placed in situ and a varus/valgus stress test was performed manually to check for laxity when the knee joint was in a fully extended and 90° flexed state. Intra-operatively, the senior author did not allow more than 2 mm of laxity in full extension and more than 3 mm of medial opening in the 90° flexion state. All patellae were resurfaced and all prostheses were cemented in one stage as per senior author's standard knee replacement protocol.

Postoperative rehabilitation

Active and passive ROM as well as continuous passive motion exercises was initiated 2 days after operation.

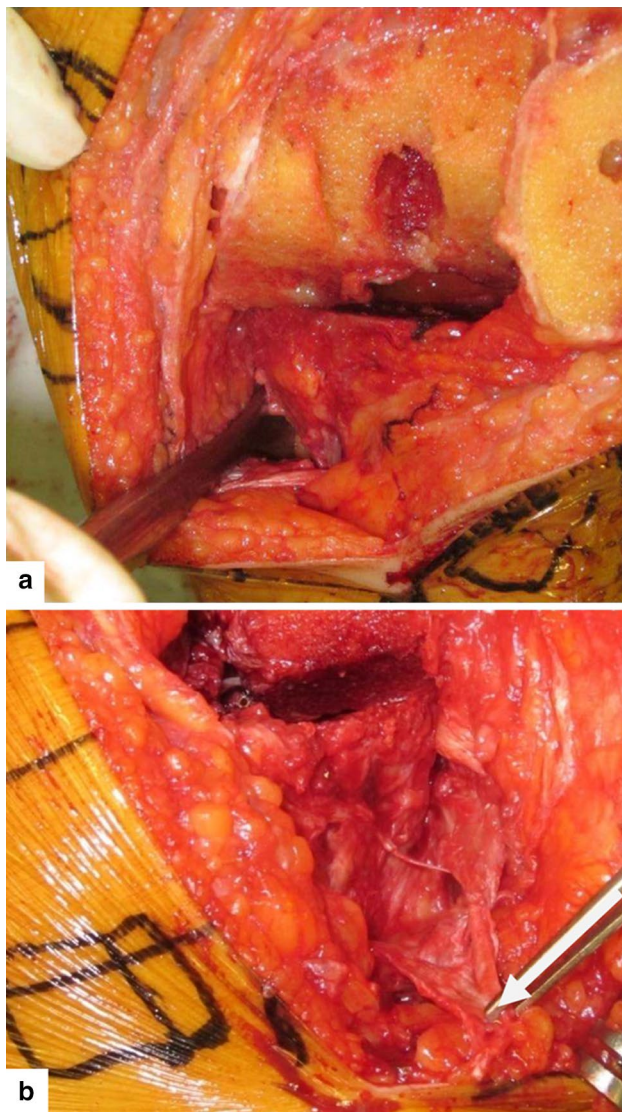


Fig. 1 Photograph shows the technique of sub-periosteal release of the MCL. **a** Sub-periosteal release of the MCL with periosteal elevator. **b** The tibial attachment of the MCL in the case of complete MCL release. (White arrow indicates the tibial attachment of the completely released MCL)

Partial weight-bearing was initiated 3 days postoperatively, and patients were encouraged to progress to full weight-bearing ambulation according to their tolerance of pain. None of the patients in either group required brace fitting.

Radiologic evaluation

The preoperative radiologic evaluation included standing hip–knee–ankle true antero-posterior and true lateral radiographs, and varus/valgus stress radiographs of the knee joint in full extension with the aid of a Telos device (Telos, Griesheim, Germany; 130 N load). At 6 months and 1 year postoperatively, standing hip–knee–ankle and valgus stress

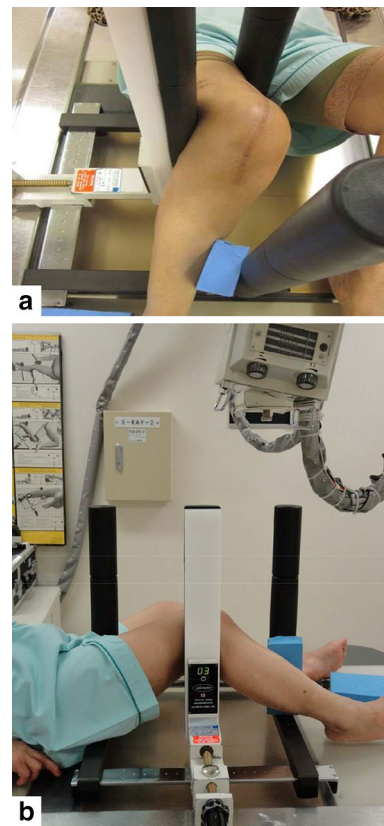


Fig. 2 Photographs show how to apply Modified Telos Device for Valgus stress radiograph (**a**) and how to get valgus stress radiograph in flexion state (**b**)

radiographs with the knee joint extended, and in 45° and 90° flexed states with the same load were taken. The original Telos device was modified by the senior author for the purpose of applying a valgus load in 45° and 90° of flexion (Fig. 2). To minimize the magnification bias, the distance between the knee and the radiographs tube was maintained at 1.1 m. The angle of knee flexion was measured with a goniometer before performing the radiographs. Twenty cases were used for pilot study before this study to fix the methods of taking radiographs, to improve accuracy of radiographs, and to determine statistical effect size.

The radiographs were evaluated by an independent observer who was unaware of the patients' status in relation to the study. Picture archiving and communication system (PACS) software was used to assist with these measurements. On the PACS system, the closest vertical distance between the most distal point of the femoral articulating surface and its corresponding point on the tibial articulating surface was measured to evaluate the gap on the stress radiographs (Fig. 3).

Reliability of valgus stress test was determined. Two observers performed measurements for inter-observer reliability and same observer measured joint space width twice

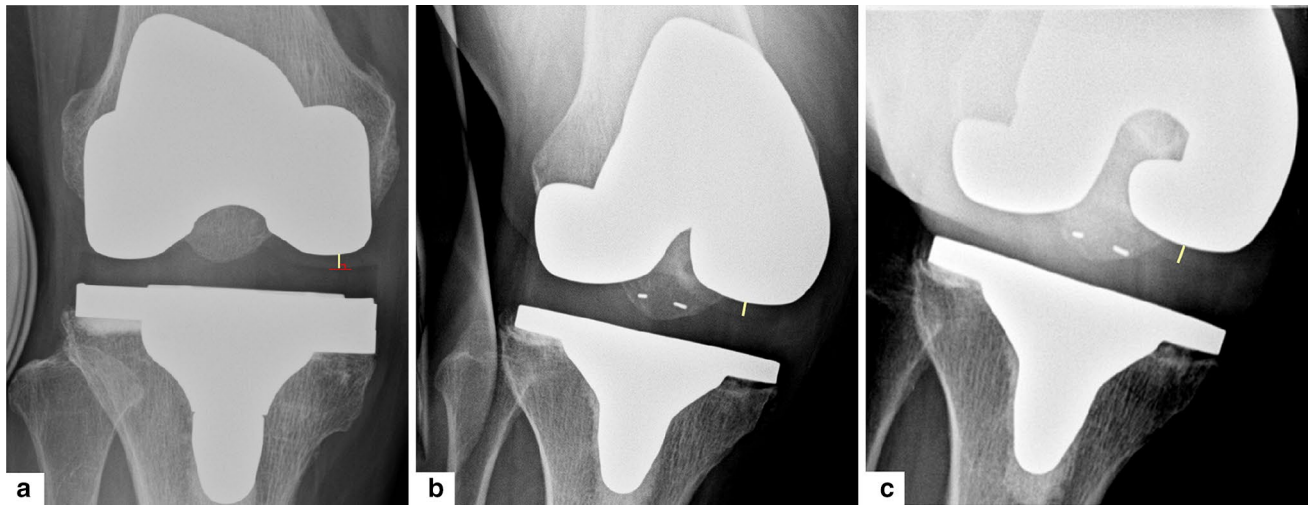


Fig. 3 Radiographs shows how to measure joint gaps on the valgus stress radiograph in 0° (a), 45° (b), and 90° (c) of flexion using the PACS System. (Yellow line indicates the joint gap which is the closest

vertical distance between the most distal point of the femoral articulating surface and its corresponding point on the tibial articulating surface)

at intervals of 1 month for intra-observer reliability. Intra-class correlation coefficient (ICC) was used for inter- and intra-observer reliability.

Clinical evaluation

Clinical evaluation included assessment of the knee ROM, knee society scores, Hospital for Special Surgery (HSS) scores, and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores; all of which were performed 1 year postoperatively.

This prospective study was conducted following approval from the institutional review board of Asan Medical Center (identification number: 2010-0351), and signed informed consent was obtained from all of the study patients.

Statistical analysis

To determine study sample size, a power analysis for detection of differences among the two groups was conducted using a significance level of 0.05, an effect size of 0.7 determined according to the results of the preliminary study, and a power of 0.80. It suggested that 30 patients were needed in each group. And assuming a 20 % probability of data loss, we initially enrolled more than 36 cases in each group. At last follow-up, group I had 33 patients, thus the results of this current study have more statistical power than the above.

The Mann–Whitney test was used to compare the data pertaining to preoperative and postoperative continuous variables such as mechanical alignment, joint gaps, clinical scores, and the ROM between the two groups.

The Wilcoxon signed rank test was performed to analyze the continuous variables in each group, such as the change and difference of joint gaps between postoperative 6 months and 1 year.

Fisher's exact test was used to evaluate the categorical variables between the two groups.

P values <0.05 were considered to be statistically significant.

Medcalc version 11.6 (MedCalc Software, Mariakerke, Belgium) was used for sample size calculation. And SPSS version 19.0 for Windows (IBM, Chicago, IL, USA) was used for statistical analysis of all the data except sample size calculation.

Results

The mean value of the preoperative mechanical axis and the joint gap on the preoperative varus stress test showed statistically significant difference between groups ($P = 0.040$ and <0.001 , respectively, Table 1). The mean value of the gap on the preoperative valgus stress test did not show statistically significant difference between groups (Table 1).

The mean values of the joint opening on the valgus stress test with the knee joint extended, and in the 45° and 90° flexed states at 6 months and at 1 year postoperatively in group I were not statistically significantly different from those of group II (Table 2). In both groups, the mean values of the joint gaps with full extension and the 45° flexed and 90° flexed states at postoperative 1 year were lower than those of postoperative 6 months, and the differences were statistically significant ($P = 0.006$, <0.001 , 0.045 , <0.001 , 0.015 and <0.001 , respectively).

Table 1 Patient demographics and preoperative clinical status

	Group 1 (<i>n</i> = 33)	Group 2 (<i>n</i> = 176)	* <i>P</i> value
Sex (female/male) (no.)	33/0	171/5	n.s. [†]
Age	68.5 ± 6.3 (57–83)	69.6 ± 6.2 (53–89)	n.s. [§]
Range of motion (°)	112 ± 16 (80–140)	119 ± 18 (65–150)	0.021 [§]
Flexion contracture	8 ± 5 (0–20)	6 ± 5 (0–20)	0.010 [§]
HSS score	58.3 ± 5.9 (44–69)	61.4 ± 7.0 (44–73)	n.s. [§]
Knee society score			
Knee score	51.9 ± 7.5 (32–60)	55.1 ± 7.3 (32–75)	0.013 [§]
Knee function score	42.7 ± 9.6 (10–50)	44.3 ± 9.2 (0–60)	n.s. [§]
Joint gap on varus stress radiographs (mm)	9.7 ± 2.1 (6.3–13.9)	8.1 ± 1.6 (3.3–12.1)	<0.001 [§]
Joint gap on valgus stress radiographs (mm)	7.4 ± 1.4 (4.85–10.02)	7.4 ± 1.8 (3.1–15.0)	n.s. [§]
Mechanical axis (°)	13.0° ± 5.6° Varus (6°–26° varus)	9.5° ± 3.9° Varus (2°–25° varus)	0.040 [§]

The values presented as the mean and the standard deviation with the range in parenthesis

n.s. nonsignificant

* *P* value <0.05: considered significant

[†] Fisher's exact test

[§] Mann–Whitney test

Table 2 Comparison of radiologic and clinical results

	Group 1 (<i>n</i> = 33)	Group 2 (<i>n</i> = 176)	* <i>P</i> value [§]
6 months			
Extension	3.4 ± 1.4 (1.5–7.1)	3.8 ± 1.4 (0.6–7.2)	n.s.
45° flexion	5.7 ± 2.5 (1.5–14.3)	6.3 ± 2.4 (1.6–14.6)	n.s.
90° flexion	6.1 ± 2.8 (1.9–15.7)	6.7 ± 3.0 (1.7–17.4)	n.s.
1 year			
Extension	2.9 ± 1.5 (0.9–7.1)	3.3 ± 1.4 (0.4–7.1)	n.s.
45° flexion	5.2 ± 2.2 (2.5–10.5)	5.8 ± 2.1 (1.9–14.4)	n.s.
90° flexion	5.3 ± 2.0 (2.4–10.5)	5.9 ± 2.4 (1.4–15.6)	n.s.
Mechanical axis (°)	1.3° ± 2.8° varus (9° varus–4° valgus)	1.3° ± 2.6° varus (9° varus–6° valgus)	n.s.
Range of motion (°)	116 ± 12 (90–140)	123 ± 9 (90–140)	<0.001
Flexion contracture (°)	0 ± 2 (0–10)	0 ± 1 (0–5)	n.s.
HSS score	92.9 ± 4.9 (78–98)	94.2 ± 3.5 (78–100)	n.s.
Knee society score			
Knee score	96.0 ± 7.0 (69–100)	97.6 ± 4.3 (69–100)	n.s.
Knee function score	65.9 ± 8.8 (45–90)	66.2 ± 11.1 (35–100)	n.s.
WOMAC score	7.1 ± 6.7 (1–34)	6.3 ± 6.0 (0–39)	n.s.

The values presented as the mean and the standard deviation with the range in parenthesis

PE polyethylene insert, HSS Hospital for Special Surgery, WOMAC Western Ontario and McMaster Universities Osteoarthritis Index

* *P* value <0.05: considered significant

[§] Mann–Whitney test

On reliability analysis for the radiologic measurements, ICC for inter-observer comparisons ranged from 0.86 to 0.89 and ICC for intra-observer comparisons from 0.89 to 0.93 (Table 3).

Mechanical alignment was corrected to 1.3° (±2.8) of the varus in group I and to 1.3° (±2.6) of the varus in group II, with no statistically significant difference (Table 2).

The mean postoperative ROM was 116° in group I and 123° in group II, and the difference was statistically significant (*P* < 0.001; Table 2). The mean postoperative flexion contracture was 0° in group I and II, and the difference was not statistically significant (Table 2). The postoperative clinical evaluation scores did not show statistically significant difference between groups (Table 2).

Table 3 Inter-observer and intra-observer reliabilities of radiographic measurements

	Inter-observer reliability (95 % CI)	Intra-observer reliability (95 % CI)
Extension		
6 months	0.89 (0.86–0.92)	0.91 (0.88–0.93)
1 year	0.89 (0.86–0.92)	0.91 (0.88–0.95)
45° flexion		
6 months	0.87 (0.83–0.90)	0.89 (0.86–0.92)
1 year	0.87 (0.83–0.91)	0.91 (0.89–0.94)
90° flexion		
6 months	0.88 (0.84–0.91)	0.93 (0.91–0.95)
1 year	0.86 (0.82–0.90)	0.92 (0.90–0.94)

CI confidence interval

There was no case of laxity which required brace fitting or revision surgery.

Discussion

The most important finding of the present study was that there was no significant increase in the postoperative medial joint gap in the complete MCL release group compared with the partial release group through the prospective study of measuring the actual amount of the joint opening on valgus stress radiographs taken at 0°, 45°, and 90° of flexion, indicating that complete release of the MCL does not lead to laxity.

Achieving ligament balance and neutral alignment in the TKA of osteoarthritic knees with varus deformity need equalization of the tension of the contracted ligamentous and tendinous structures on the medial aspect of the knee to the lateral side [3, 33, 38] along with an accurate osteotomy. The traditional methods of balancing the ligaments during a TKA with varus deformity involve progressive sub-periosteal release of the superficial MCL, depending on the severity of the varus deformity [14, 33, 35]. The survivorship data and the results of clinical and radiologic studies have demonstrated that this technique has been both predictable and durable [4, 5, 15, 31, 36].

Conversely, other researchers have suggested that this technique could lead to over-release of the MCL, resulting in coronal laxity [8, 28]. Due to this worrisome result, many surgeons hesitate to release the MCL completely, even though medio-lateral balance is not achieved.

The pie-crusting technique of the superficial MCL has been recommended as an alternative method of sub-periosteal MCL release for correction of varus deformity [20, 34]. Verdonk et al. [34] suggested an algorithmic approach including pie-crusting of the superficial MCL; however,

5 % of their cases required release of the superficial MCL from its attachment site at the proximal tibia for patients with severe varus deformity. And the pie-crusting technique has a risk for MCL rupture, and the mode of failure after the pie-crusting technique is intra-substance tear which is more difficult to treat than sub-periosteal detachment [21].

Alternative approaches, including medial epicondylar osteotomy, have been devised to correct severe varus deformity without excessive releasing of the superficial MCL [8–10, 24]. However, there is a risk of complications of this technique such as heterotrophic ossification, non-union, or fibrous union of the osteotomy [10, 30]. Dixon described another technique whereby the tibial component is downsized and placed slightly laterally and the uncapped medial tibial condylar bone is removed [6]. However, Dixon's shift and resection technique may reduce the size of the tibial component leading to femoral and tibial size mismatch [1, 24].

All of the above procedures are intended to avoid complete release of the MCL which can result catastrophic medio/lateral instability. However, the most common cause of instability is undercorrection rather than overcorrection of the contracted soft tissues [26, 35, 41]. This means that complete release of the MCL is necessary in patients with severe varus deformity. The major concern is that complete detachment of the MCL predisposes to the laxity of the knee joints resulting a poor prognosis.

The authors hypothesized that laxity will not occur in spite of complete detachment of MCL on the basis of following reasons. One of the reasons is that MCL has an excellent potential for spontaneous healing after injury [2, 13, 39]. Koo and Choi [16] showed successful result after conservative management of intra-operative detachment of the MCL from its tibial attachment site. Sub-periosteal release of the MCL is similar to injury of the MCL in that there is a good potential for healing. The second reason is that the prosthesis has their own inherent stability. If the lateral joint gap is aptly maintained and the axis of the knee joint is well-aligned in order to avoid continuous valgus stress, the implanted prosthesis itself provides adequate initial stability to allow the MCL to develop scar healing. Heesterbeek et al. [12] showed that TKA with release of most tight structures, including the MCL, did not show increased laxity on the varus and valgus stress tests in the presence of a properly filled joint gap with a prosthesis.

There have been only a few objective reports regarding how much medial opening developed after complete release of the MCL and what the clinical results were. For the objective data, the Telos device (Telos, Griesheim, Germany) was adjusted so as to check the valgus stress test in the 45° and 90° flexed positions. This device is simple to apply and can prevent medical personnel from possible radiation hazards. All of the patients included in this study

were evaluated using the same device with the same protocol. Therefore, in the authors' opinion, the results are sufficient for comparison between the two groups.

In this study, the MCL was completely released in 15.8 % of the study population. In these patients, wider lateral joint gap was seen on preoperative varus stress radiographs compared with those who required partial MCL release. This suggests that in the presence of lateral laxity, the medial structures need to be released to the same tension as those of the lax lateral structures.

Okamoto et al. [25] showed that there was no medial structure contraction but laxity of lateral soft tissue in severe varus knees and suggested that medial soft tissue release to the amount of the lax lateral structure is unnecessary. However, their study lacks postoperative results of which a tight medial structure can lead to early radiologic changes as well as poor clinical results [19, 27].

There have been reports which showed that complete release of the MCL leads to greater opening of the medial joint gap in flexion than in extension [17, 40]. In this current study, the postoperative valgus stress test in 90° of flexion showed more than 5 mm of joint opening, whereas the medial opening in the flexed state was <3 mm intraoperatively. The gap between the intra-operative and postoperative medial opening might be caused by the use of a different method of checking the opening, i.e., radiographs versus inspection and amount of applied stress.

Patients in this study showed good clinical results despite of more than 5 mm of joint opening and this corresponds with previous reports indicating that TKA with a lax ligament showed better results than tight knees in flexion [7, 18].

There was a statistically significant difference in the preoperative and 1-year postoperative ROM, and the discrepancy was almost equal pre- and postoperatively. This result corresponds to the more severe preoperative varus deformity of group I than that of group II.

There are some limitations to this present study. First, different types of implants were used. However, even though the types of implant used were different, all TKAs were performed by a single surgeon using the same balancing and other surgical technique including osteotomy and fixation. Thus, the bias that could have been introduced through the use of different implants was minimized. Second, complete release of the MCL was performed in 33 cases out of a total of 209 cases. Although this ratio may seem disproportionate, it reflects the clinical reality in which there are far fewer patients who require complete MCL release compared with those who require partial release. And statistically, the number of cases in both groups was sufficient to allow hypothesis to be tested. Lastly, the clinical follow-up period was only 1 year. Longer follow-up is needed to compare patient survival and the long-term prognosis.

The results of current study suggests that complete MCL release for balancing the knee joints can be performed without causing valgus laxity. The prerequisites for avoiding valgus laxity are a medio-laterally symmetric joint gap and a neutral limb alignment.

Conclusion

In conclusion, complete sub-periosteal release of the superficial MCL for ligament balancing does not lead to valgus laxity or poor clinical outcomes.

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