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Rotational Shortening of Collateral Ligament in TKR With Severe Deformity

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Summary: Instability of the knee joint after total knee replacement (TKR) is one of the most important reasons for revision TKR. Inadequate release or tightening of the collateral ligaments in the knee joint may cause instability and early failure. This study presents a case series study of a new technique for ligament balancing wherein the collateral ligament is detached from its origin and rotated (twisted) around its longitudinal axis to tighten the ligament before the origin is reattached to its original position. The surgical technique for collateral ligament tightening during TKR was performed on 6 patients with a deformed knee caused by osteoarthritis and rheumatoid arthritis. The range of motion, knee society score, and laxity of the patients' knee joint, after 7 months to 13 years of follow-up, were evaluated. The technique was successful, achieving good range of motion and satisfactory stability of the joint. Further evaluation in a larger number of cases and a comparative analysis with different techniques would further support the usefulness of this rotational ligamentoplasty technique.

Key Words: arthroplasty—rotational ligamentoplasty—TKR.

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Instability of the knee joint after total knee replacement (TKR) is one of the most important reasons for revision TKR.[1] Inadequate release or tightening of the collateral ligaments in the knee joint may cause instability, poor functional results, and hence early failure.[1] In most of the varus or valgus knee deformities, the collateral ligaments can be balanced by release and lengthening at the contracted side of the joint.[2–4] However, the collateral ligament at the tension side in a severely deformed knee may require the insertion of a thick polytethylene insert, which may result in leg length discrepancy and an elevated joint line. An inadequate release or insertion without sufficient thickness of the ligament may lead to joint laxity of the knee, pain, or, in severe cases, knee joint instability.[1,5] Surgical techniques for the severely deformed knee include using a constrained knee prosthesis,[6,7] tightening by detaching, and reattaching the origin of collateral ligaments on the femur or its insertion on the tibia.[8]

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The authors declare that they have nothing to disclose.

For reprint requests, or additional information and guidance on the techniques described in the article, please contact Atul Kumar, MBBS, DRE, at sharmaatul11@gmail.com or by mail at IRCAD-Taiwan, No 6-1, Lugong Road, Lukang Township, Changhua County, 505 Taiwan, R.O.C. You may inquire whether the author(s) will agree to phone conferences and/or visits regarding these techniques.

The constrained knee prosthesis has mechanical weakness and is usually the last resort.[9] The proximal transfer of the ligament origin changes the rotation center of the knee. Furthermore, the distal transfer of the collateral ligament may have poor fixation because of poor bone condition, especially in rheumatoid arthritis. This study presents a case series study of a new technique for ligament balancing wherein the collateral ligament is detached from its origin, rotated (twisted) around its longitudinal axis to tighten the ligament, and the origin of the ligament is then reattached to its original position. To our knowledge, this is the first report of such a technique.

METHODS

Patients

The technique was applied to 6 patients (3 female individuals and 3 male individuals, aged between 54 and 85 y) in the Show Chwan Memorial Hospital, Changhua, Taiwan, R.O. C between 2006 and 2015. The patients had a diagnosis of osteoarthritis or rheumatoid arthritis with varus or valgus deformity ($\pm$ 12 to 30 degrees) of the knee (Table 1). The surgeries were performed by the same surgeon. The patients were assessed by range of flexion, joint laxity,[10] and knee society score (KSS) score[11] in their subsequent follow-up visits. The technique was applied to the patients who had a coronal deformity in the complete lower limb radiograph. The patients were selected for the new technique if the opening gap was >6 mm on the stretched side of the knee condyles or the varus knee deformity caused the knee to move outside the range of the radiograph film.

Surgical Technique

A medial midvastus approach was adopted for all cases. The contracted capsule was routinely released, and a mechanical alignment device was used to cut the bone on the distal femoral condyles and tibial plateau. After alignment, a spacer block was inserted into the extended joint space to examine the soft tissue balance. If the difference between spaces on both sides of the knee was within 5 mm, the ligament on the tight side was further released. If the difference was >10 mm, no further release was performed. A 4-in-1 cutting of the bone was performed where the posterior cruciate ligament was removed using a posterior stabilizing TKR, which further opens up the joint space. A trial reduction of the joint was performed, and the stability of the joint at flexion and extension was assessed. A valgus and varus stress test, and anteroposterior drawer test at extension, midflexion, and 90-degree flexion were performed. The rotational stability of the joint was also investigated. If laxity >3 to 5 mm at 1 side was evident, a thick (2 to 4 mm) polyethylene insert was selected, and the tight ligament was released by puncture with a needle. Usually, no tightening procedure was needed. However, if the laxity of the loose side was >10 mm or moderate instability was detected during the

TABLE 1. Demography and Diagnosis of the Ligamentoplasty Patients

Case Numbers	Age (y)	Sex	Diagnosis	Preoperative Deformity	Prosthesis Type	Ligament Tightened	Follow-up Duration	ROM	KSS Postoperatively	Index Ligament Laxity
1	71	Female	OA	Valgus	United CR	MCL	13 y	0-135	159	Grade 1
2	56	Female	OA	Valgus	United CR	MCL	9 y	0->90	180	Grade 1
3	54	Female	OA	Varus	Wright CR	LCL	7 y	0-120	174	Grade 1
4	76	Male	OA	Valgus	Zimmer PS	MCL	10 y	0-110	164	Grade 1
5	64	Female	RA	Varus	Zimmer PS	LCL	9 y	0-120	134	Grade 2
6	84	Female	RA	Valgus	Zimmer PS	MCL	7 mo	0-130	170	Grade 1

KSS indicates knee society score; LCL, lateral collateral ligament; MCL, medial collateral ligament; OA, osteoarthritis; PS, posterior stabilized; RA, rheumatoid arthritis; ROM, range of motion.

above mentioned tests, a tightening procedure was used for the loose stretched ligament.

The procedure for the rotational tightening of the collateral ligament was started after the cement fixation of the implant. To accomplish this, a screw hole at the center of the epicondyle, where the collateral ligament originates, was predrilled and the epicondyle was shoveled up with a 1 cm square-shaped chisel with a thickness of 0.5 cm. The ligament to be twisted was cleared of synovial tissue; thereafter the bone block followed the twist (clockwise or anticlockwise) of the ligament for 1 or 2 turns. The length (measured using paper ruler) and tightness of the ligament was manually tested by the surgeon, and the resected epicondyle was fixed with a long screw and spiked soft tissue washer to the cortex (Fig. 1). The epicondyle should

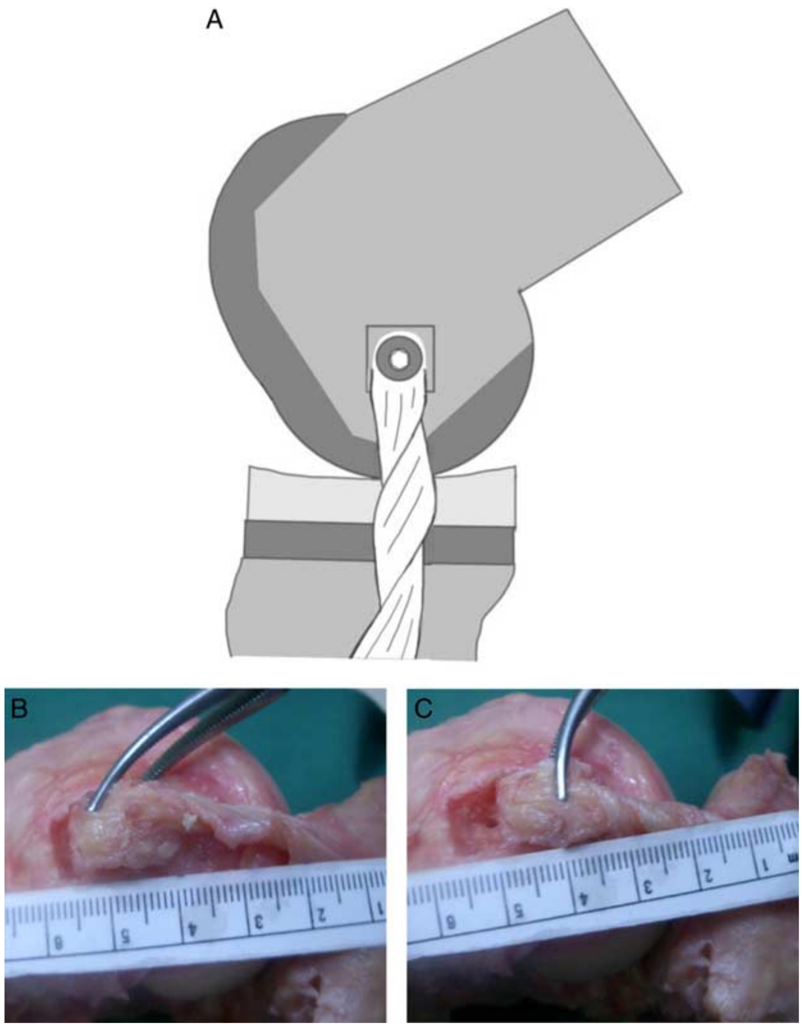

FIGURE 1. A, Diagram to show the collateral ligament rotation (twist). B, Rotation of the ligament in 1 turn (360 degrees), the ligament shortened only by 2.5 mm (in cadaver knee). C, The same ligament rotated at 2 turns (720 degrees) shortened by 7 mm (in cadaver knee). The increment is not proportional. full color online

TABLE 2. Guideline for Ligament Rotation (The Rotation is Defined as the Ligament Turn While Facing it From the Proximal to Distal Direction. Usually in a 5-mm Thick Ligament, 360 degree Turn Led to its Shortening by 5 mm. Hence, a 90-degree Turn Led to its Shortening Only by 1.25 mm)

	Right Knee		Left Knee	
	Flexion Gap > Extension Gap	Flexion Gap < Extension Gap	Flexion Gap > Extension Gap	Flexion Gap < Extension Gap
MCL	Counter clockwise	Clockwise	Clockwise	Counter clockwise
LCL	Clockwise	Counter clockwise	Counter clockwise	Clockwise

LCL indicates lateral collateral ligament; MCL, medial collateral ligament.

return to its original position with increased tightness of the ligament. The opened joint space under manual stress (gap) after the epicondyle fixation should not be > 2 to 3 mm (measured using paper ruler). Usually in a 5-mm thick ligament of an overweight patient, 1 turn of the ligament led to a shortening of the ligament by 0.5 cm.

The synovial tissue, if included, may weaken the reconstructed ligament over time because the synovial tissue is inflamed. The direction of the ligament's rotation was considered on the basis of flexion and extension gap (Table 2). If the flexion gap was wider than the extension gap, as seen in most of the cases in this study, the surgeon selected the rotational direction that would make the ligament tighter during the flexion of the knee. If the extension gap was wider than the flexion gap, the surgeon selected the reverse direction. The direction of rotation was decided during the surgery. If the rotated ligament is too short for balancing, then we unscrew the bone fragment, and the screw is retightened after trimming the ligament.

Postoperative Rehabilitation

All the patients underwent routine physiotherapy after the TKR, including passive continuous motion. The rehabilitation started after removal of the Hemovac drain on the third postoperative day. Patients were encouraged to walk on the operated knee with a walker from day 2 or 3 after surgery. As none of the patients were overweight or with inadequate fixation, they did not require a brace. Walking with the walker was advised for 6 weeks after surgery. Patients were taught exercises for regaining muscle power and to increase the range of motion (ROM) of the joint before discharge on day 7 after surgery.

The outcome of the surgery was assessed with the ROM, laxity, and KSS score of the knee joint at the follow-up visits of the patients.

RESULTS

The surgical technique for collateral ligament tightening during TKR was performed on 6 patients with a deformed knee caused by osteoarthritis and rheumatoid arthritis. The range of flexion, KSS, and laxity of the patients' knee joint after 7 months to 13 years of follow-up are shown in Table 1. All ligaments were successfully tightened by rotational ligamentoplasty, with all knees functioning well without any complications such as instability, ligament rupture, detachment of the bony fragment, or prominence of the screw head. Radiographs from one of the patients before and after surgery are shown in Figure 2.

DISCUSSION

This study presents a new technique of ligamentoplasty during TKR. The surgery was successful, achieving a good ROM of the knee joint with a low grade of laxity. The technique described was not associated with any complications reported in other conventionally used ligamentoplasty techniques. To the best of our knowledge, this is the first report of this ligamentoplasty technique in TKR.

Current solutions for preventing an unstable knee after TKR include using a constrained knee prosthesis,[6,7] tightening by detaching, and reattaching the origin of collateral ligaments on the femur or its insertion on the tibia.[8] However, such techniques have certain limitations. For example, a constraint knee prosthesis as a salvage procedure for TKR may result in early loosening of the implant because of the rotational torque imparted from the ligament to the bone-cement interface.[12–14] Moreover, the constraint prosthesis is more expensive than a conventional knee prosthesis. Ligament balancing[3,4] is not recommended because of the paucity of such knee deformities, especially in developed

FIGURE 2. A, The preoperative x-ray of a 71-year-old woman with right knee osteoarthritis showing a 30-degree valgus change. B, After 13 years of follow-up of the same patient, x-ray films did not show loosening or wearing. The range of motion was 0 to 135 degrees and KSS was 159. C, Telos (Telos Medical, USA) tensioning of MCL demonstrated a well-functioning MCL. MCL indicates medial collateral ligament; KSS, knee society score. full color online

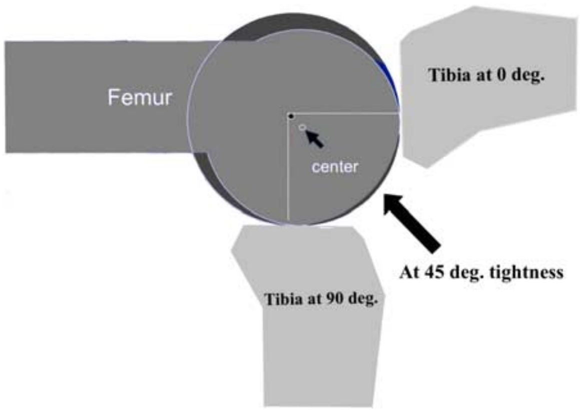

FIGURE 3. Midflexion tightness developed with anterosuperior transfer of a stretched collateral ligament. full color online

countries. One such ligament balancing technique involves ligament tightening by elevating the ligament's epicondylar origin and reattachment at a drilled hole proximal and anterior to the original position of the epicondyle.[15] As the reattached position of the ligament is not at the center of rotation, the ligament would be tight at midflexion, loose at extension and flexion, and looser at deep flexion (Fig. 3). Other techniques in which the ligament is distally transferred have the issue of poor fixation (stapling) of the ligament,[15] as the tibial plateau bone at the tension side of deformity is frequently porotic in patients undergoing TKR. The lateral femoral collateral ligament inserts at the proximal fibula where the peroneal nerve passes over the surface of the fibulae neck; therefore, removal of a segment of fibular bone and fixation of the ligament with a screw would risk peroneal nerve palsy. Consequently, such a procedure requires another incision in the skin.[15]

The technique used in this study preserves the anatomy of the ligament origin by repositioning of the elevated bone block, fixation with a soft tissue washer, and cortical screw purchasing at the opposite cortex, which make it sufficiently strong to hold the ligament tight. Twisting a fibrous structure, like a ligament, provides a strong, less stiff tightening.[16,17] The strength provided by the twisted ligament was sufficient to avoid additional protection for the knee ligament, such as a knee brace or cast.

The technique was only performed on patients with a severe knee deformity, wherein balancing of the joint space could be achieved with the appropriate release of the contracted capsule, and moderate soft tissue laxity persisted at the convex side because of the marked elevation of the joint line. The procedure was performed after cement fixation so that osteotomy of the epicondyle would not break the integrity of the condylar bone, which is frequently porotic and weak. The ligament to be twisted must be clear from synovial tissue, as the synovial tissue may weaken the reconstructed ligament over time.

The technique used in this study lacks the quantitative assessment of ligament tightness; therefore, achieving the appropriate ligament tightness requires prior experience of ligament or tendon reconstruction. Several factors need to be considered during ligament tightening, such as the thickness of the medial collateral ligament in comparison with the lateral, stretching makes the ligament thinner, ligament size may vary with sex, weight, and the disease process. A larger rotation (twist) is needed when the ligament is thin, and the correct coronal alignment of the bones is key to avoid recurrent stretching of the ligament. In addition, pretensioning (achieved by pulling the ligament gently and making it straight, without undue strength on the bone) of the rotated ligament before fixation is important to avoid undue stretching during movement. Furthermore, bracing after surgery may be necessary, especially if the patient is overweight or ligament fixation quality is dubious. The technique described in this study is relatively new and was only performed by 1 surgeon; therefore, further procedures performed by different surgeons are required to verify its efficacy. Although no fixation failed with this technique, in a case with failed fixation, we can use nonabsorbable sutures such as No 5 Tycron or Ethicon to perform Krachow[18,19] whip stitches and pull them through drilled bone tunnels to tie at the other side of the femur above the prosthetic component in addition to the screw and washer.

CONCLUSIONS

This study presents a new technique of collateral ligament tightening required for ligament balancing during TKR. The technique was successful, acheiving a good degree of freedom and satisfactory laxity of the joint. However, surgeons require training and practice to achieve the appropriate tightening of the ligaments. Further evaluation of this technique in more patients, performed by different surgeons and a comparison with different techniques would further support the usefulness of this rotational ligamentoplasty technique.

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