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.

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, poor functional results, and hence early failure. In most of the valgus or varus knee deformities, the collateral ligaments can be balanced by release and lengthening at the contracted side of the joint. However, the collateral ligament at the tension side in a severely deformed knee may require the insertion of a thick polyethylene 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. Surgical techniques for the severely deformed knee include using a constrained knee prosthesis, tightening by detaching, and reattaching the origin of collateral ligaments on the femur or its insertion on the tibia.

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 (±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, and knee society score (KSS) score 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
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

| Case Numbers | Age (y) | Sex | Diagnosis | Preoperative Deformity | Prosthesis Type | Ligament Tightened | Follow-up Duration | ROM Postoperatively | KSS | 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                | 0-135               | 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.

TABLE 1. Demography and Diagnosis of the Ligamentoplasty Patients

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.
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 balancing3,4 is not recommended because of the paucity of such knee deformities, especially in developed

### TABLE 2.

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

LCL indicates lateral collateral ligament; MCL, medial collateral ligament.
Consequently, such a procedure requires another incision in the mediastinal space, and reattachment at a different site could risk peroneal nerve palsy. Distally transferred tendons to the proximal tibia have the issue of poor orientation over the surface of the tibial crest; therefore, removal of a segment of bone with the ligament to avoid undue 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 non-absorbable sutures such as No 5 Tycron or Ethicon to perform Krackow[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, achieving 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.

REFERENCES

1. Sharkey PF, Hozack WJ, Rothman RH, et al. Why are total knee arthroplasties failing today? Clin Orthop Relat Res. 2002;404:7–13.
2. Krackow KA. Revision total knee replacement ligament balancing for deformity. Clin Orthop Relat Res. 2002;404:152–157.
3. Beverland D. Ligament balancing in tka: avoiding tissue releases. Bone Joint J Orthop Proc Suppl. 2015:97:127–127.
4. Babazadeh S, Stoney JD, Lim K, et al. The relevance of ligament balancing in total knee arthroplasty: how important is it? A systematic review of the literature. Orthopedic reviews. 2009;1:e26.
5. Mulhall KJ, Ghomrawi HM, Scully S, et al. Current etiologies and modes of failure in total knee arthroplasty revision. Clin Orthop Relat Res. 2006;446:45–50.
6. Hartford JM, Goodman SB, Schurman DJ, et al. Complex primary and revision total knee arthroplasty using the condylar constrained prosthesis: an average 5-year follow-up. J Arthroplasty. 1998;13:380–387.
7. Easley ME, Insall JN, Scuderi GR, et al. Primary constrained condylar knee arthroplasty for the arthritic valgus knee. Clin Orthop Relat Res. 2000;380:58–64.
8. Engh GA, Ammeen D. Results of total knee arthroplasty with medial epicondylar osteotomy to correct varus deformity. Clin Orthop Relat Res. 1999;367:141–148.
9. Barg J, Cacciolato A, Amstutz HC. Results with the constrained total knee prosthesis in treating severely disabled patients and patients with failed total knee replacements. J Bone Joint Surg Am. 1980;62:504–512.
10. Kiyomatsu H, Hino K, Kutsuna T, et al. Influence of pre-operative alignment on post-operative varus-valgus joint laxity in total knee arthroplasty. Bone Joint J. 2016;98:113–113.
11. Caplan N, Kader DF. Rationale of the Knee Society Clinical Rating System. Classic Papers in Orthopaedics. London: Springer; 2014:197–199.
12. Bargiota K. Long Term Outcome of Total Knee Arthroplasty. Condylar Constrained Prostheses Total Knee Arthroplasty. London: Springer; 2015: 169–177.
13. Rossi R, Rosso F, Cottino U, et al. Total knee arthroplasty in the valgus knee. Int Orthop. 2014;38:273–283.
14. Kader D, Caplan N, Kokkinakis M, et al. Constrained condylar knee systems: a review of five commonly used brands. J Arthroscopy Joint Surg. 2015;2:23–32.

15. Yercan HS, Selmi TAS, Sugun TS, et al. Tibiofemoral instability in primary total knee replacement: a review: part 2: diagnosis, patient evaluation, and treatment. Knee. 2005;12:336–340.

16. Kim DH, Wilson DR, Hecker AT, et al. Twisting and braiding reduces the tensile strength and stiffness of human hamstring tendon grafts used for anterior cruciate ligament reconstruction. Am J Sports Med. 2003;31:861–867.

17. Freeman JW, Woods MD, Laurencin CT. Tissue engineering of the anterior cruciate ligament using a braid-twist scaffold design. J Biomech. 2007;40:2029–2036.

18. Krackow KA, Thomas SC, Jones LC. Ligament-tendon fixation: analysis of a new stitch and comparison with standard techniques. Orthopedics. 1988;11:909–917.

19. Deramo DM, et al. Krackow locking stitch versus nonlocking premanufactured loop stitch for soft-tissue fixation: a biomechanical study. Arthroscopy. 2008;24:599–603.