CLINICAL ARTICLE

Posteromedial Corner Release with the Knee in Figure-of-Four Position *vs* Conventional Position for Varus Knee Arthroplasty

Quan-bo Ji, MD[†], Jun-cheng Li, MB[†], Qing-yuan Zheng, MS[†], Zong-jie Geng, MB, Ming Ni, PhD, Jing-yang Sun, MS, Yan Wang, MD, Guo-qiang Zhang, MD

Department of Orthopaedics, General Hospital of Chinese People's Liberation Army, Beijing, China

Objective: To introduce posteromedial corner release with the knee in the figure-of-four position *versus* the conventional position for varus knee arthroplasty.

Methods: This is a retrospective study. From March 2015 to September 2019, a series of 123 patients (139 knees) with varus knee were randomly and blindly allocated to experimental group (60 patients; 68 knees) and control group (57 patients; 65 knees). Patients in experimental group underwent posteromedial corner release with the knee in the figure-of-four position; and patients in control group with the knee in the conventional position. If soft tissue balance was not completely achieved or the medial gap was still tight, an additional loosening technique were used to achieve symmetric medial and lateral space in both groups. Time for soft tissue balancing was defined as the time from the start of the spacer test to the end of the balance test. Length of release was defined as the distance from the osteotomy surface of the tibial plateau to the farthest structures released. The rating system of Hospital for Special Surgery (HSS) knee score was used to evaluate the clinical results. Quantitative variables were described as mean and standard deviation, and compared by one-way analysis of variance.

Results: The mean age of experimental group and control group was 70.2 ± 8.7 years and 68.7 ± 6.2 years, respectively ($P > 0.05$). Preoperatively, the mean HSS score of the groups was 38.2 ± 11.3 and 39.1 ± 10.7, respectively ($P > 0.05$). The mean varus knee angle was 19.7° ± 9.3° and 19.3° ± 10.7°, respectively ($P > 0.05$). The mean time for soft tissue balancing was 8.4 ± 3.3 min and 11.3 ± 6.9 min in experimental and control group, respectively ($P < 0.05$). The mean length of releasing posteromedial corner structures was 35.5 ± 13.4 mm and 27.3 ± 9.7 mm in experimental and control group, respectively ($P < 0.05$). Additional special loosening techniques were performed in eight knees in experimental group and seven knees in control group. The HSS scores 5 years after surgery were 95.1 ± 16.9 and 94.8 ± 17.2 respectively ($P > 0.05$). No complications were found during the follow-up time, and the clinical symptoms were observed to be significantly improved in the patients.

Conclusion: The posteromedial corner can be released more extensively and thoroughly when the knee is placed in the figure-of-four position during varus knee arthroplasty.

Key words: Figure-of-four position; Posteromedial corner; Release; Total knee arthroplasty

Address for correspondence Guo-qiang Zhang, MD and Yan Wang, MD, Department of Orthopaedics, General Hospital of Chinese People's Liberation Army, Beijing, China Tel: +86-10-66939439; Fax: +86-10-66938403; Email: zhanggq75@yeah.net (Zhang) and Email: yanwang301@126.com (Wang)

Grant Sources: We thank the research supported by the National Natural Science Foundation of China (81472094, 81902250).
Disclosure: The authors declare that they have no conflict of interest.
[†]Quan-bo Ji, Jun-cheng Li and Qing-yuan Zheng contributed equally to the paper.
Received 1 July 2020; accepted 19 January 2021

Orthopaedic Surgery

Introduction

Total knee arthroplasty (TKA) has been frequently performed for severe degenerative arthritis in senior patients[1]. It can reduce pain and reconstruct function in osteoarthritic patients. The medial compartment is the most commonly affected compartment and is often accompanied with varus knee deformity in this patient population,[2–4]. TKA can be challenging in these knees with varus deformity as it is typically followed by progressively contracted medial soft tissues and attenuated lateral soft tissues. So ligament balance is been considered essential to the success of TKA[5, 6].

Obtaining the balance of mediolateral (ML) ligamentous structures during TKA requires release of contracted medial soft tissues and removal of medial osteophytes. A widely technique which applied to correct varus knee deformity is a step-by-step release of contracted medial soft tissues from their attachment sites until appropriate medial-lateral soft tissue tension is achieved. In patients who are presenting with severe varus knee deformity, an extensive medial release is almost always required, which including progressive release of the deep medial collateral ligament (MCL), superficial MCL, posteromedial capsule, semimembranosus tendon, and pes tendons[3, 4, 7, 8]. This technique, however, has a risk of over-release leading to subsequent ML instability, which can in return require a thicker polyethylene insert or even a constrained implant[9–11].

The conventional ligament balancing procedure involves removal of degenerative osteophytes and release of the contracted medial soft tissue at the tibial attachment site to obtain symmetrical medial-lateral tension in extension and flexion of the knee[12]. A review study[13] questioned the need for an epicondylar osteotomy in severely varus knees. With this technique, the knee can become more unstable in flexion and an implant with higher constraint may be necessary. A previous study[14] found the piecrusting technique was safe, efficient, and reliable for the soft tissue balancing in varus TKA. However, a cadaver study[15] considered the success of the MCL pie-crusting technique is likely technique dependent since failure occurs within the ligament itself. A new-published article[16] also found that the pie-crusting technique has a higher rate of failure in the ML gap balance compared with reduction osteotomy.

The concept of constitutionally varus alignment that restores pre-arthritic natural anatomical alignment is emerging in recent years[17]. During TKA, the medial release technique consists release of the capsule and deep medial collateral ligament, selective release of superficial medial collateral ligament or posterior oblique ligament, and selective tibial reduction osteotomy. The most widely used release technique is the soft tissue sleeve of tibia, which is proposed by Insall *et al.*[18] and popularized by Whiteside *et al.*[7]. The proximal medial tibia is exposed when the knee is fully flexed and externally rotated, but it is difficult to expose the posteromedial corner structures. It is also difficult to release the structures fully. In order to obtain a good alignment and balancing in flexion and extension, we placed the knee in the figure-of-four position to achieve an easier way of posteromedial corner release.

The first objective of this prospective report is to introduce the posteromedial corner release with the knee in the figure-of-four position for varus knee arthroplasty. The second objective of this study is to assess effectiveness and safety of the "figure-of-four" technique. The third objective of this study is to compare the posteromedial corner release with the knee in the conventional position.

Materials and Methods

Patient Demographics

From March 2015 to September 2019, 527 consecutive patients were selected and examined in our department were screened for research. The institutional review boards of the participating hospitals reviewed the study and approved the protocol. Informed consent was obtained from each patient. Our criteria for eligibility included: (i) adult patients; (ii) severe (stage 4 osteoarthritis) knee joint osteoarthritis confirmed on X-ray, CT, or MRI; (iii) needed a primary knee replacement surgery or knee arthroplasty; (iv) a fixed valgus knee >10°; and (v) unilateral or bilateral involvement. Exclusion criteria were: (i) stage 0 to 3 osteoarthritis; (ii) revision knee arthroplasty; (iii) active local or widespread infection; (iv) medical conditions that put the patient at high risks of complications; (v) discontinued intervention; (vi) severe disease affecting peripheral blood vessels or nerves; and (vii) lost to follow-up.

A total of 123 patients (139 knees) were randomly and blindly allocated into experimental group (60 patients; 68 knees) and control group (57 patients; 65 knees) using a computational pseudorandom number generator (Fig. 1). One surgeon who did not attended the assessments and treatments generated the random allocation. All operations were performed by the same surgical team. Implants were selected preoperatively based on radiological and clinical evaluations, but the final decision was made after osteotomy and soft tissue balancing.

Surgical Technique

Step 1: Under general anesthesia, the patients were placed in the prone position. The location of the skin incision was marked.

Step 2: Operations were performed through the anteriomedian incision of the knee and the lateral paracondylar approach[16]. We exposed the medial aspect of the knee by subperiosteally elevating the anteromedial capsule. The anterior and posterior cruciate ligaments, residual meniscus and osteophytes were removed, and the medial collateral ligament of deep layer was released.

Step 3: Using the measured resection technique, we performed the osteotomy followed by the sequence of tibia osteotomy and femur osteotomy. We performed the tibial osteotomy with extramedullary alignment technique, and the

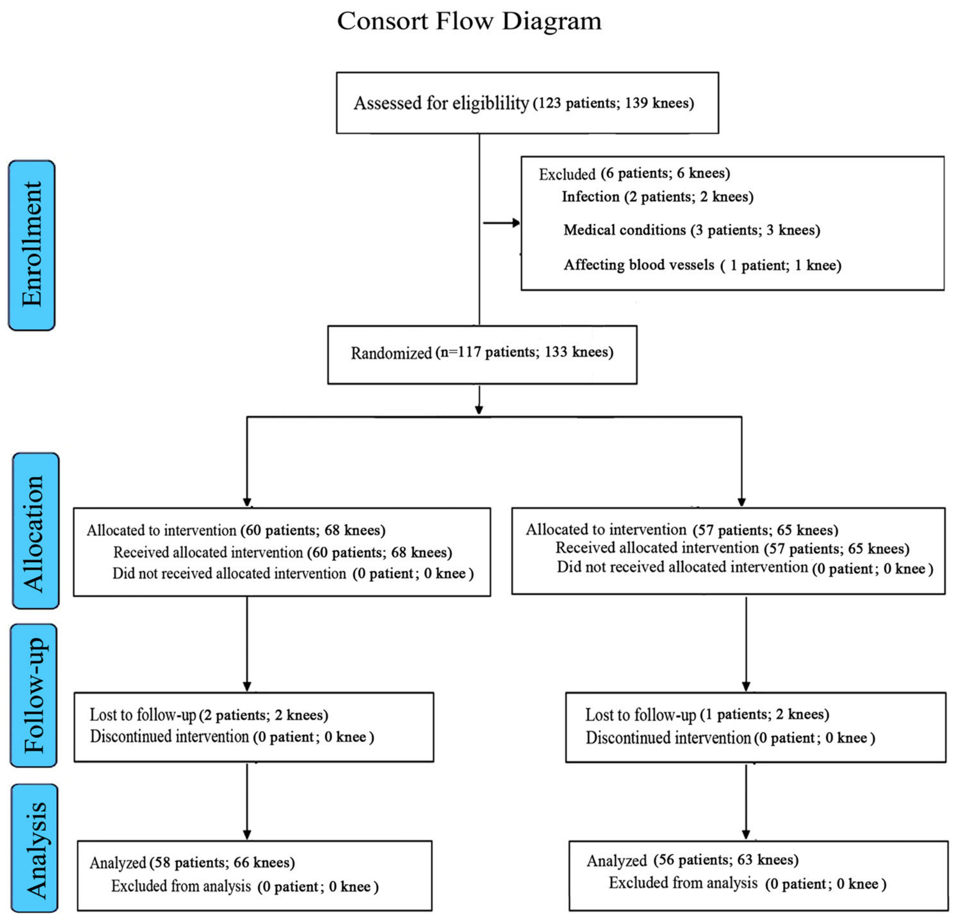

Fig 1 The consort flow diagram of 123 patients (139 knees).

osteotomy plane was perpendicular to the axis of tibia. The posterior corner osteotomy was set at 7°, and the thickness was 10 mm. Distal femoral valgus osteotomy for valgus deformity of the knee was set at 6°. The anterior and posterior femoral osteotomies were positioned using the anterior reference method. The size of the prosthesis was determined, and the reference was 3° of external rotation to determine the external femoral osteotomy using the posterior condylar line. After osteotomy, we used a gap module to test the tension and balance of the medial and lateral gaps during extension and flexion of the knee.

Step 4: We took the ankle and rest it across the contralateral leg with the knee bent to 90° in the figure-of- four position (Figs 2 and 3). In order to visualize the posteromedial corner structures, we dislocated the knee anteriorly using a Hoffman hook placed behind the tibial plateau. We subperiosteally released the structures (posterior half of the superficial medial collateral ligament, semi-membrane tendon insertion, and posteromedial joint capsule) of the posteromedial corner. As described by Tang *et al.*[16], we fully flexed the knee to subluxate the joint forward and outward using a Hoffman hook. The tibial plateau and posteromedial corner structures were completely exposed, and subperiosteal release was performed as that in experimental group.

Step 5: If soft tissue balance was not completely achieved or the medial gap was still tight, additional loosening techniques, such as pie-crusting technique, tibial stripping of the superficial medial collateral ligament, and medial femoral epicondyle up-sliding osteotomy, were used to achieve symmetric medial and lateral spaces[19,20]. The femoral component, tibial component, patellar component, and plastic spacer (German Link Inc, Los Angeles, CA) were implanted. The wound was closed in layers. After surgery, the routine therapies and rehabilitation program were used in both groups. The patients were followed up 3 months, 6 months, 1 year, and 5 years after surgery[21].

Outcome Evaluation

Assessments were performed by a senior orthopedic surgeon who did not attend the treatments.

Varus Knee Deformity

Varus knee deformity was measured on the frontal X-ray (varus/valgus position) as the angle formed from the intersecting femoral and tibial mechanical axes[22]. The femoral axis was defined as a line drawn from the center of the femoral head to the center of the femoral intercondylar notch.

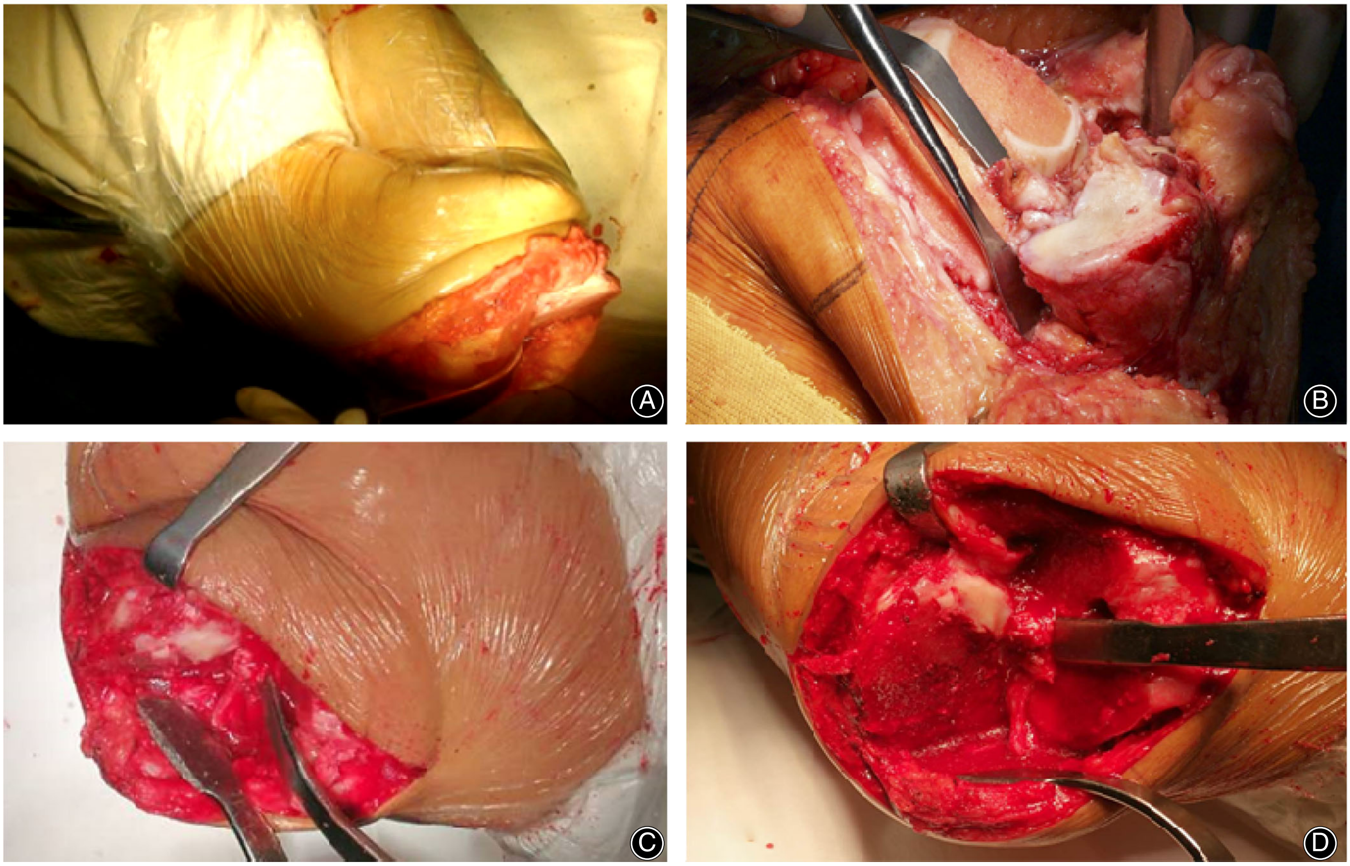

Fig 2 Application of the figure-of-four position to release the soft tissue in the varus knee medial-posterior corner in total knee arthroplasty. (A) The ankle was taken across the contralateral leg with the knee bent to 90° in the figure-of-four position; (B) To visualize the posteromedial corner structures, the knee anteriorly was dislocated using a Hoffman hook placed behind the tibial plateau. Then, the structures of the posteromedial corner were released. (C, D) The other two patients who got the application of the figure-of-four position to release the soft tissue in the varus knee medial-posterior corner in total knee arthroplasty.

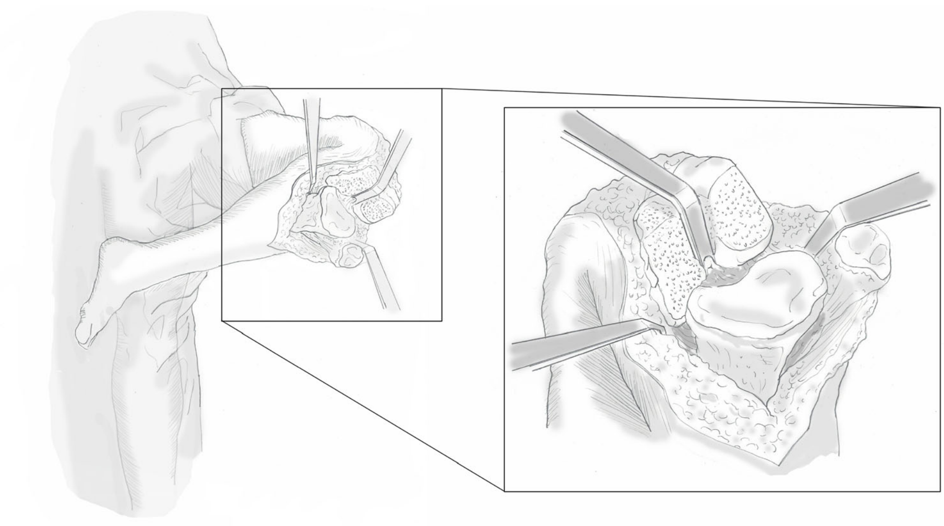

Fig 3 The surgical diagrams for the figure-of-four position to release the soft tissue in the varus knee medial-posterior corner in total knee arthroplasty.

Time for Balancing

Time for balancing the medial soft tissue was defined as the time from the start of spacer test to the end of balance test.

Length of Release

Length of release was defined as the distance from the osteotomy surface of the tibial plateau to the farthest structures released.

HSS Knee Score

The rating system of Hospital for Special Surgery (HSS) knee score was used to evaluate the clinical results of TKA[23].

Data Analysis

Quantitative variables were described as mean and standard deviation for symmetric distribution or median and interquartile range for asymmetric distribution. We used the one-way analysis of variance to determine whether there were any significant differences between the groups. Differences were considered statistically significant at $P < 0.05$. The collected data were analyzed with SPSS Version 11.0 (SPSS, Inc., Chicago, IL.).

Results

Follow-Up

The mean age of experimental group and control group was 70.2 ± 8.7 years and 68.7 ± 6.2 years, respectively (P = 0.2561) (Table 1). All patients were followed up for 5 years after the operation. The patients were followed up by questionnaire survey, which included HSS score. The average follow-up periods of the experimental group and control group were 60.6 ± 7.3 and 61.2 ± 6.7 months, and no significant difference was found between the experimental group and control group.

General Results

General results are shown in Table 2. The operative time of medial release for additional space balancing of the experimental group and control group were 8.4 ± 3.3 min and 11.3 ± 6.9 min, respectively (P = 0.0025) (Table 2). Intraoperatively, the medial release length of releasing posteromedial corner structures was 35.5 ± 13.4 mm and 27.3 ± 9.7 mm in experimental and control group, respectively (P = 0.0001) (Table 2). Additional special loosening techniques were performed in 8 knees in experimental group and seven knees in control group. The mean varus knee angle of the experimental and control group was 19.7° ± 9.3° and 19.3° ± 10.7°, respectively. The dominant blood loss of the experimental and control group was 10.7 ± 4.3 mL and 11.9 ± 3.9, respectively (P = 0.0023). However, no significant difference was found in varus knee angle between the two groups (P = 0.8190).

Functional Evaluation

The functional evaluation of posteromedial corner release with the knee in figure-of-four position and conventional position for varus TKA was investigated by the rating system of HSS knee score. Preoperatively. The mean HSS score of the experimental and control group was 38.2 ± 11.3 and 39.1 ± 10.7, respectively. And no significant difference was found between the two groups (P = 0.6391) (Table 3).

In order to achieve flexion-extension balance, additional osteotomy of distal femur was performed in 31 knees in the experimental group, and 30 knees in the control group. In the control group, a secondary osteotomy of distal femur was performed in 11 knees. The HSS scores at 3 months post-operation for the experimental and control group were 93.2 ± 18.1 and 92.9 ± 15.7, respectively. No differences were found in the HSS scores between the experimental and control group at 3 months post-operation (P = 0.6391) (P = 0.9191).

Moreover, the HSS scores at 5 years post-operation for the experimental and control group were 95.1 ± 16.9 and 94.8 ± 17.2, respectively. And the differences between the experimental and control group were significant (P = 0.9196) (Table 3). Taken together, these above data indicated that the posteromedial corner can be released more extensively and thoroughly when the knee was placed in the figure-of-four position during varus knee arthroplasty.

Complications

For the experimental figure-of-four position group, no infection, DVT, bone nonunion, bone fracture, or revision occurred during the hospitalization and follow-up period. For the control conventional position group, no periprosthetic fracture, prosthetic loosening, or DVT occurred during the hospitalization and follow-up period. No other

TABLE 1 Comparison on the basic data between the two groups

	Experimental group	Control group	P
Patient/knee (n)	58/66	56/63	
Age (years)	70.2 ± 8.7	68.7 ± 6.2	0.2561
Body mass index (Kg/m^2)	27.3 ± 6.9	26.8 ± 6.3	0.6654
Follow up (months)	60.6 ± 7.3	61.2 ± 6.7	0.7266

SD, standard deviation.

TABLE 2 Comparison on the general data between the two groups

	Experimental group	Control group	*P*
Dominant blood loss (mL)	10.7 ± 4.3	10.9 ± 3.9	0.3223
Varus knee angle (mean ± SD; °)	19.7 ± 9.3	19.3 ± 10.7	0.8190
Medial release time (mean ± SD; min)	8.4 ± 3.3	11.3 ± 6.9	0.0025
Medial release length (mean ± SD; mm)	35.5 ± 13.4	27.3 ± 9.7	0.0001

SD, standard deviation.

TABLE 3 Comparison on the HSS scores between the two groups

	Experimental group	Control group	*P*
Preoperative HSS (mean ± SD)	38.2 ± 11.3	39.1 ± 10.7	0.6391
3 months postoperative HSS (mean ± SD)	93.2 ± 18.1	92.9 ± 15.7	0.9191
5 years postoperative HSS (mean ± SD)	95.1 ± 16.9	94.8 ± 17.2	0.9196

HSS, Hospital for Special Surgery; SD, standard deviation.

serious complications were found in the experimental and control group during the follow-up time, and the clinical symptoms were observed to be significantly improved in the patients.

Discussion

Outcome of Figure-of-Four Position

We found that the posteromedial corner release can be performed with the knee in both the figure-of-four position and conventional position. In the figure-of-four position, more extensive and complete surgical release can be easily achieved, resulting in a good immediate balance gap and quite stable knee joint without a bad influence on the longevity of the implant.

Background of Figure-of-Four Position

The posteromedial corner of the knee is comprised of the structures between the posterior border of the superficial medial collateral ligament and medial border of the posterior cruciate ligament, including the posterior oblique ligament and semimembranosus tendon that merges into the posterior capsule[24]. For severe varus knees, the pathoanatomy usually involves erosion of medial tibial bone stock with medial tibial osteophyte formation, and contracture of the medial collateral ligament, posteromedial capsule, pes anserinus, and semimembranosus muscle[25]. Elongation of the lateral collateral ligament and flexion contracture may also coexist[26].

Soft tissue balancing is an important surgical procedure for correcting the malalignment of the lower limb[27]. The beneficial effects of medial soft tissue release and reduction osteotomy were evident on the analysis of joint gap kinematics[22]. The goal can be achieved using soft tissue release and additional surgical techniques[28]. Subperiosteal release of the posteromedial corner structures is the conventional technique, but is often a cumbersome surgical procedure in severe varus knee[29]. The release is usually carried on after resecting the osteophyte, and gradually carried on until the medial collateral ligament is well balanced[30].

Other Loosening Techniques

In addition to posteromedial corner release, there were some loosening techniques, such as subperiosteal release of soft tissue sleeve, narrowing technique for the tibial osteotomy, piecrusting technique, tibial stripping of the superficial medial collateral ligament, and medial femoral epicondyle up-sliding osteotomy[31]. The options depend on the degree of varus deformity[32, 33]. For conventional posteromedial corner release, the knee is flexed and subluxated using a Hoffman hook. These techniques are unable to release the soft tissue structures extensively and sufficiently. Meanwhile, the posterior cruciate ligament may be avulsed, resulting in an excessive dislocation after the prosthesis has been implanted[34].

The Advantage of Figure-of-Four Position

The varus knee deformity is often associated with flexion deformity of knee. The posteromedial corner release benefits the correction of flexion deformity in both coronal and sagittal planes[3]. However, sometimes, extensive release and releasing the superficial medial collateral ligament can lead to instability in flexion[35]. Our results showed employing a combined release technique are effective than a single technique, because maximal tension exists at the initial phase of each release procedure. In addition, performing stepwise release procedures can avoid unnecessary over release. Niki *et al.*[36] found that 4-mm reduction osteotomy provided about 1.7° and 0.7° varus improvement in flexion and extension, respectively; and 8-mm reduction osteotomy only improves 2.8° and 0.9° in flexion and extension, respectively.

Similar to the conventional position of the knee, with the knee in the figure-of-four position, it could be argued that the classic extensive medial release associated with iatrogenic injury to the pes anserine and saphenous nerve, instability, and abnormal knee kinematics may be unnecessary[10, 27].

Limitation of Study

There are several limitations in our study. First, because of the large number of patients, the operations were performed by the same surgical team but not the same surgeon. Surgeon preference, experience, and ability may influence ascertaining the effects of the techniques. Second, for posteromedial corner release, the comparison between figure-of-four position and subperiosteal release of soft tissue sleeve or pie-crusting technique need to be investigated in the further research. Besides, long term follow-up assessment will be needed to identify the functions and complications in patients.

Conclusions

In varus knee arthroplasty, the figure-of-four position is beneficial for posteromedial corner release. It is effective and safe method to obtain balanced extension-flexion gaps in primary TKA.

References

1. Mullaji AB, Padmanabhan V, Jindal G. Total knee arthroplasty for profound varus deformity: technique and radio logical results in 173 knees with varus of more than 20 degrees. J Arthroplasty, 2005, 20: 550–561.
2. Insall JN, Binazzi R, Soudry M, *et al*. Total knee arthroplasty. Clin Orthop Relat Res, 1985, 192: 13–22.
3. Krackow KA, Mihalko WM. The effect of medial release on flexion and extension gaps in cadaveric knees: implications for soft-tissue balancing in total knee arthroplasty. Am J Knee Surg, 1999, 12: 222–228.
4. Seo JG, Moon YW, Jo BC, Kim YT, Park SH. Soft tissue balancing of varus arthritic knee in minimally invasive surgery total knee arthroplasty: comparison between posterior oblique ligament release and superficial MCL release. Knee Surg Relat Res, 2013, 25: 60–64.
5. Mullaji AB, Padmanabhan V, Jindal G. Total knee arthroplasty for profound varus deformity: technique and radiological results in 173 knees with varus of more than 20 degrees. J Arthroplasty, 2005, 20: 550–561.
6. Fujimoto E, Sasashige Y, Masuda Y, *et al*. Significant effect of the posterior tibial slope and medial/lateral ligament balance on kneeflexion in total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc, 2013, 21: 2704–2712.
7. Whiteside LA, Saeki K, Mihalko WM. Functional medical ligament balancing in total knee arthroplasty. Clin Orthop Relat Res, 2000, 380: 45–57.
8. Mullaji A, Sharma A, Marawar S, Kanna R. Quantification of effect of sequential posteromedial release on flexion and extension gaps: a computer-assisted study in cadaveric knees. J Arthroplast, 2009, 24: 795–805.
9. Cho WS, Byun SE, Lee SJ, Yoon J. Laxity after complete release of the medial collateral ligament in primary total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc, 2015, 23: 1816–1823.
10. Hunt NC, Ghosh KM, Athwal KK, Longstaff LM, Amis AA, Deehan DJ. Lack of evidence to support present medial release methods in total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc, 2014, 22: 3100–3112.
11. Okamoto S, Okazaki K, Mitsuyasu H, Matsuda S, Iwamoto Y. Lateral soft tissue laxity increases but medial laxity does not contract with varus deformity in total knee arthroplasty. Clin Orthop Relat Res, 2013, 471: 1334–1342.
12. Matsueda M, Gengerke TR, Murphy M, Lew WD, Gustilo RB. Soft tissue release in total knee arthroplasty: cadaver study using knees without deformities. Clin Orthop Relat Res, 1999, 366: 264–273.
13. Whiteside LA. Soft tissue balancing: the knee. J Arthroplast, 2002, 17: 23–27.
14. Ahn JH, Yang TY, Lee JY. Reduction osteotomy vs. pie-crust technique as possible alternativesfor medial release in total knee arthroplasty and compared in a prospective randomized controlled trial. J Arthroplast, 2016, 31: 1470–1475.
15. Meneghini RM, Daluga AT, Sturgis LA, Lieberman JR. Is the pie-crusting technique safe for MCL release in varus deformity correction in total knee arthroplasty? J Arthroplast, 2013, 28: 1306–1309.
16. Tang Q, Yu HC, Shang P, *et al*. Selective medial soft tissue release combined with tibial reduction osteotomy in total knee arthroplasty. J Orthop Surg Res, 2017, 12: 174.
17. Rodriguez-Merchan EC. Important topics on contemporary Total knee Arthroplasty: what does recent literature say? Arch Bone Jt Surg, 2019, 7: 476–477.
18. Murray DG. Total knee arthroplasty. Clin Orthop Relat Res, 1985, 192: 59–68.
19. Sheth NP, Husain A, Nelson CL. Surgical techniques for total knee arthroplasty: measured resection, gap balancing, and hybrid. J Am Acad Orthop Surg, 2017, 25: 499–508.
20. Meloni MC, Hoedemaeker RW, Violante B, Mazzola C. Soft tissue balancing in total knee arthroplasty. Joints, 2014, 2: 37–40.
21. Joshi RN, White PB, Murray-Weir M, Alexiades MM, Sculco TP, Ranawat AS. Prospective randomized trial of the efficacy of continuous passive motion post total knee arthroplasty: experience of the Hospital for Special Surgery. J Arthroplast, 2015, 30: 2364–2369.
22. Rodriguez JA, Bas MA, Orishimo KF, Robinson J, Nicholas SJ. Differential effect of total knee arthroplasty on valgus and varus knee biomechanics during gait. J Arthroplast, 2016, 31: 248–253.
23. Insall JN, Ranawat CS, Aglietti P, Shine J. A comparison of four models of total knee-replacement prostheses. Clin Orthop Relat Res, 1999, 367: 3–17.
24. Jungmann PM. Posteromedial corner of the knee. Radiologe, 2019, 59: 155–168.
25. Mullaji AB, Shetty GM. Correction of varus deformity during TKA with reduction osteotomy. Clin Orthop Relat Res, 2014, 472: 126–132.
26. Völlner F, Fischer J, Weber M, *et al*. Weakening of the knee ligament complex due to sequential medial release in total knee arthroplasty. Arch Orthop Trauma Surg, 2019, 139: 999–1006.
27. Rossi R, Cottino U, Bruzzone M, Dettoni F, Bonasia DE, Rosso F. Total knee arthroplasty in the varus knee: tips and tricks. Int Orthop, 2019, 43: 151–158.
28. Kim MS, Koh IJ, Choi YJ, Kim YD, In Y. Correcting severe varus deformity using trial components during total knee arthroplasty. J Arthroplast, 2017, 32: 1488–1495.
29. Dold AP, Swensen S, Strauss E, Alaia M. The posteromedial corner of the knee: anatomy, pathology, and management strategies. J Am Acad Orthop Surg, 2017, 25: 752–761.
30. Bauer KL, Stannard JP. Surgical approach to the posteromedial corner: indications, technique, outcomes. Curr Rev Musculoskelet Med, 2013, 6: 124–131.
31. Ha CW, Park YB, Lee CH, Awe SI, Park YG. Selective medial release technique using the pie-crusting method for medial tightness during primary total knee arthroplasty. J Arthroplast, 2016, 31: 1005–1010.
32. Barmada R. Total knee replacement arthroplasty. Surg Annu, 1974, 6: 337–348.
33. Kim RH, Scuderi GR, Dennis DA, Nakano SW. Technical challenges of total knee arthroplasty in skeletal dysplasia. Clin Orthop Relat Res, 2011, 469: 69–75.
34. Guo L, Yang L, Briard JL, Duan XJ, Wang FY. Long-term survival analysis of posterior cruciate-retaining total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc, 2012, 20: 1760–1765.
35. Boettner F, Renner L, Arana Narbarte D, Egidy C, Faschingbauer M. Total knee arthroplasty for valgus osteoarthritis: the results of a standardized soft-tissue release technique. Knee Surg Sports Traumatol Arthrosc, 2016, 24: 2525–2531.
36. Niki Y, Harato K, Nagai K, Suda Y, Nakamura M, Matsumoto M. Effects of reduction osteotomy on gap balancing during total knee arthroplasty for severe varus deformity. J Arthroplast, 2015, 30: 2116–2120.