

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

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## Research article

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# Abstract

**Background:** The objective of this study is to introduce posteromedial corner release with the knee in the figure-of-four position versus the conventional position for varus knee arthroplasty.

**Methods :** From March 2015 to September 2019, 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. Time for soft tissue balancing was defined as the time from the start of spacer test to the end of 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. Differences were considered statistically significant at  $p < 0.05$ .

**Results:** The mean time for soft tissue balancing was  $8.4 \pm 3.3$  minutes and  $8.4 \pm 3.3$  minutes in experimental and control group, respectively ( $p < 0.05$ ). The mean length of releasing posteromedial corner structures was  $35.5 \pm 13.4$  mm and  $27.3 \pm 9.7$  mm in experimental and control group, respectively ( $p < 0.05$ ). HSS scores 5 years after surgery were  $95.1 \pm 16.9$  and  $94.8 \pm 17.2$  respectively ( $p > 0.05$ ).

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

## Introduction

Total knee arthroplasty (TKA) has become the most effective method for the treatment of end-stage knee joint diseases [1]. Valgus knee deformity ( $\geq 10^\circ$ ) is observed in nearly 10% of patients who underwent TKA [2]. Valgus knee deformity is a challenge in TKA because the soft tissue release and balancing are crucial for long-term success [3]. Currently, yet the optimal technique is still controversial [4].

The concept of constitutionally varus alignment that restores pre-arthritic natural anatomical alignment is emerging in recent years [1]. 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 [5] and popularized by Whiteside et al [6]. 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 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. In order to assess effectiveness and safety of the technique, we compared 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 1) adult patients; 2) severe (stage 4 osteoarthritis ) knee joint osteoarthritis confirmed on X-ray, CT, or MRI; 3) needed a primary knee replacement surgery or knee arthroplasty; 4) a fixed valgus knee  $> 10^\circ$ ; 5) and unilateral or bilateral involvement. Exclusion criteria were 1) stage 0 to 3 osteoarthritis; 2) revision knee arthroplasty; 3) active local or widespread infection; 4) medical conditions that put the patient at high risks of complications; 5) discontinued intervention; 6) severe disease affecting peripheral blood vessels or nerves; and 7) 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 attend 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 techniques

### Step 1 in both groups

As described by Sheth et al [7], operations were performed through the anteriomedian incision of the knee and the lateral para-condylar approach. 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. 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 osteotomy plane was perpendicular to the axis of tibia. The posterior corner osteotomy was set at  $7^\circ$ , and the thickness was 10 mm. Distal femoral valgus osteotomy for valgus deformity of the knee was set at  $6^\circ$ . The anterior and posterior femoral osteotomies were positioned using the anterior reference method. The size of the prosthesis was determined, and the reference was  $3^\circ$  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 2 in experimental group (figure-of-four position)

We took the ankle and rest it across the contralateral leg with the knee bent to  $90^\circ$  in the figure-of-four position (Fig. 2). 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.

### **Step 2 in control group (conventional full flexion)**

As described by Tang et al [8], we fully flexed the knee to sublunate 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 3 in both groups**

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 [9]. The femoral component, tibial component, patellar component, and plastic spacer (German Link Inc) 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 [10].

### **Outcome Evaluation**

Assessments were performed by a senior orthopedic surgeon who did not attend the treatments. 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 [11]. The femoral axis was defined as a line drawn from the center of the femoral head to the center of the femoral intercondylar notch. 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 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 of TKA [12].

### **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, Ill.).

## **Results**

The mean age of experimental group and control group was  $70.2 \pm 8.7$  years and  $68.7 \pm 6.2$  years, respectively ( $p = 0.2561$ ). Preoperatively, the mean HSS score of the groups was  $38.2 \pm 11.3$  and  $39.1 \pm$

10.7, respectively ( $p = 0.6654$ ). The mean varus knee angle was  $19.7^\circ \pm 9.3^\circ$  and  $19.3^\circ \pm 10.7^\circ$ , respectively ( $p = 0.8190$ ).

Intraoperatively, the mean time for additional space balancing was  $8.4 \pm 3.3$  minutes and  $8.4 \pm 3.3$  minutes in experimental and control group, respectively ( $p = 0.0025$ ). The mean length of releasing posteromedial corner structures was  $35.5 \pm 13.4$  mm and  $27.3 \pm 9.7$  mm in experimental and control group, respectively ( $p = 0.0001$ ). Additional special loosening techniques were performed in 8 knees in experimental group and 7 knees in control group.

In order to achieve flexion-extension balance, additional osteotomy of distal femur was performed in 31 knees in experimental group, and 30 knees in control group. In control group, a secondary osteotomy of distal femur was performed in 11 knees. HSS scores 5 years after surgery were  $95.1 \pm 16.9$  and  $94.8 \pm 17.2$  respectively ( $p = 0.9196$ ) (Table 1).

Table 1  
Demographic and Clinical Characteristics for 114 Patients (129 knees).

	Experimental group	Control group	t value	p value
Patient / knee (n)	58 / 66	56 / 63		
Age (years)	$70.2 \pm 8.7$	$68.7 \pm 6.2$	1.141	0.2561
Body mass index ( $\text{Kg}/\text{m}^2$ )	$27.3 \pm 6.9$	$26.8 \pm 6.3$	0.435	0.6654
Preop HSS (mean $\pm$ SD)	$38.2 \pm 11.3$	$39.1 \pm 10.7$	-0.47	0.6391
Varus knee angle (mean $\pm$ SD; $^\circ$ )	$19.7 \pm 9.3$	$19.3 \pm 10.7$	0.229	0.8190
Time for medial release (mean $\pm$ SD; min)	$8.4 \pm 3.3$	$11.3 \pm 6.9$	-3.08	0.0025
Length for medial release (mean $\pm$ SD; mm)	$35.5 \pm 13.4$	$27.3 \pm 9.7$	4.027	0.0001
Adding special techniques (knee)	8	7		
Failed arthroplasty (knee)	1	1		
Preop HSS 3 months (mean $\pm$ SD)	$93.2 \pm 18.1$	$92.9 \pm 15.7$	0.102	0.9191
Preop HSS 5 years (mean $\pm$ SD)	$95.1 \pm 16.9$	$94.8 \pm 17.2$	0.101	0.9196
HSS, Hospital for Special Surgery; SD, standard deviation.				

## Discussion

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.

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 [13, 28]. 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 [14]. Elongation of the lateral collateral ligament and flexion contracture may also coexist [15].

Soft tissue balancing is an important surgical procedure for correcting the malalignment of the lower limb [16]. The beneficial effects of medial soft tissue release and reduction osteotomy were evident on the analysis of joint gap kinematics [11]. The goal can be achieved using soft tissue release and additional surgical techniques [17]. Subperiosteal release of the posteromedial corner structures is the conventional technique, but is often a cumbersome surgical procedure in severe varus knee [18]. The release is usually carried on after resecting the osteophyte, and gradually carried on until the medial collateral ligament is well balanced [19].

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, pie-crusting technique, tibial stripping of the superficial medial collateral ligament, and medial femoral epicondyle up-sliding osteotomy [20]. The options depend on the degree of varus deformity [21, 22]. For conventional posteromedial corner release, the knee is flexed and subluxated using a Hoffman hook. This technique is 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 [23].

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 [24]. However, sometimes, extensive release and releasing the superficial medial collateral ligament can lead to instability in flexion [25]. 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 [26] 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 [27, 28]. Our prospective study has a limitation. 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.

## **Conclusion**

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.

## **Declarations**

### **Acknowledgments**

Not applicable.

### **Authors' contributions**

GQZ was responsible for study concept, design, screening, data extraction, data analysis, and writing of this manuscript. QBJ completed the second screening of abstracts, second extraction of data, and review of the manuscript. QYZ, JCL, ZJG, MN and JYS were responsible for study concept, design, and writing of the manuscript.

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### **Availability of data and materials**

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

### **Ethics approval and consent to participate**

This study has been approved by the Ethics Committee of Chinese PLA General Hospital. Written consent was obtained from all participants in the study.

## Consent for publication

Not applicable.

## Competing interests

The authors declare that they have no competing interests.

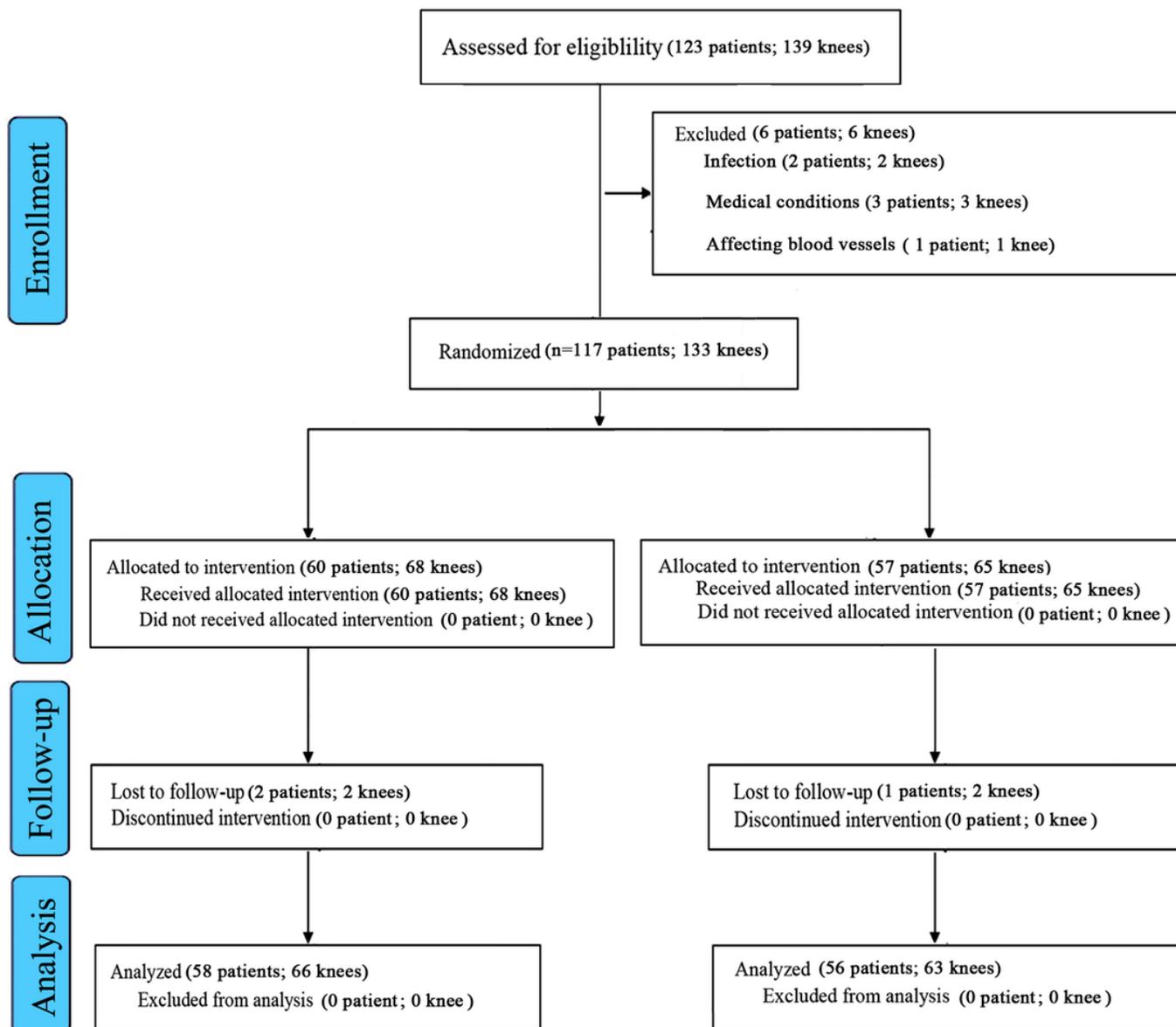
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## Figures

## Consort Flow Diagram



**Figure 1**

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



**Figure 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.