Original Article

The effect of C-arm fluoroscope on unicompartmental knee replacement arthroplasty

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ABSTRACT

Purpose: The aim of this study was to identify the effectiveness of C-arm fluoroscope in unicompartmental knee replacement arthroplasty through the clinical and radiologic results.

Materials and methods: We investigated the 33 cases of unicompartmental knee replacement arthroplasty in 31 patients who diagnosed degenerative arthritis of knee between February 2011 and March 2014. We divided 2 groups, one is 15 cases using C-arm fluoroscope during operation (group A), the other is 18 cases not using that (group B). We measured femoro-tibial angle (FTA), medial proximal tibial angle (MPTA), posterior tibial slope angle (PTSA), femoral component coronal rotation angle (FCRA) by simple X-ray. We evaluated femur and tibia varus/valgus mismatch and posterior slope mismatch by above parameters after operation. And also we evaluated clinically by knee and functional score.

Results: In group A, FTA average changes from -0.6° to 6.1° , MPTA changes from 84.5° to 87.6° , PTSA changes from 6.2° to 5.2° through operation. In group B, FTA changes from -0.4° to 5.8° , MPTA changes from 84.7° to 87.1° , PTSA changes from 6.3° to 5.5° , and FCRA is 0.6° in A group, 0.4° in B group after operation. The tibial varus/valgus mismatch cases after operation ($nl: 87 \pm 3^\circ$) was 1 in group A, 5 in group B. Post. slope mismatch cases after operation ($nl: 7 \pm 3^\circ$) was 1 in group A, 1 in group B. All cases in both A and B group were not included in femoral varus/valgus mismatch ($nl: 0 \pm 3^\circ$) after operation. In group A, Knee score improved from 56.3 to 90.7, Functional score from 54.3 to 86.9 through operation. In group B, Knee score improved from 54.9 to 89.8, Functional score from 52.8 to 84.6.

Conclusion: There was no statistically significant difference in radiologic and clinical results between group A and B, but the number of tibial varus/valgus mismatch case were fewer in fluoroscope guided group. So we consider that the fluoroscope is helpful for tibial cutting in unicompartmental knee replacement arthroplasty.

1. Introduction

Unicompartmental knee replacement arthroplasty (UKA) is surgical method that only one part of knee is selectively replaced. Since mid-1990s, development of surgical method and prostheses lead to increase of UKA cases. Compared with Total knee replacement arthroplasty (TKA) in degenerative knee arthritis, UKA minimizes bone resection and conserves cruciate ligament and knee-patella joint so that physiologic functions are still remained.^{1,16} Also 15 to 10 years of survival rate of UKA is comparable to TKA and good results are reported.^{2,15} However, long-term results of UKA are not published yet and there are still some controversies about indication range, clinical results and so on.^{3,4}

The most common cause of UKA failure is due to complications associated with wear of polyethylene. To prevent these kind of complications, reduction of ligament balance and exact lower limb arrangement are important.^{5,6} If this balance is not made up, there are possibilities of prostheses dissociation, wear or damage of implant⁷ and progression of arthritis of unplaced area.⁸

Authors think that use of C-arm fluoroscope in unicompartmental knee replacement arthroplasty can help to make exact balance and arrangement of lower limb so that complications associated with unbalance can be decreased. Through radiological and clinical evaluation, we studied the effectiveness of C-arm fluoroscope in unicompartmental knee replacement arthroplasty.

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Table 1
Patient's Data.

	Group A (C-arm guided)	Group B (C-arm nonguided)	P-value
Number of case	15	18	0.75
Gender (male/female)	2/13	4/14	0.49
Age (y)	57.2 ± 2.3	58.3 ± 1.9	0.46
Body mass index	26.8 ± 0.9	25.7 ± 0.7	0.77
Mean follow up period (m)	17.2 ± 6.2	19.6 ± 8.4	0.28

2. Materials and methods

2.1. Study object

After approval of IRB, we investigated retrospectively the 33 cases of unicompartmental knee replacement arthroplasty in 31 patients who diagnosed degenerative arthritis of knee between February 2011 and March 2014. We divided 2 groups, one is 15 cases using C-arm fluoroscope during operation (group A), the other is 18 cases not using C-arm fluoroscope (group B). 6 males and 27 females were involved and average age was 58.1 years old (Range: 51–67 years old). The mean follow-up period was 18.9 months (Range: 12–36months) (Table 1). Indications of UKA involves limited knee osteoarthritis in medial compartment, medial meniscus degenerative tear and medial femoral condylar or tibia plateau cartilage damage in MRI, normal finding of anterior cruciate ligament, above 50years old age patients who do not need much physical labor, patients who have below average of BMI score 30, below average angle of flexion contracture 10° and patients who have above average of 75° of MPTA (Medial proximal tibial angle).

2.2. Surgical method

All cases were done in supine position. Through small medial

longitudinal incision, We used extramedullary guided technique with minimally invasive surgical method and prostheses were Zimmer® Unicompartmental High Flex Knee System (Zimmer Inc, Warsaw, Ind). Under the extramedullary guidance, we used C-arm fluoroscope to check out position of guide which placed in knee and ankle joint before excision of medial tibia (Fig. 1). After excision of tibia, we took C-arm X-ray of Knee AP and LATERAL to find out the MPTA (Medial proximal tibial angle) and PTSA (posterior tibial slope angle) (Fig. 2). By using spacer block and guide, we identified the arrangement of lower leg before resection of femoral part through spacer block technique (Fig. 3). After implanting the prostheses, we checked out position of prostheses and status of arrangement by using C-arm fluoroscope (Fig. 4).

2.3. Radiologic evaluation

We measured femoro-tibial angle (FTA), medial proximal tibial angle (MPTA), posterior tibial slope angle(PTSA), femoral component coronal rotation angle (FCRA) by simple X-ray. We comparatively analyzed femur and tibia varus/valgus mismatch and posterior slope mismatch by above parameters after operation in group A and B. FTA(Femoro-tibial angle) was measured by Bauer⁹ method based on Knee standing AP X-ray. FTA(femoro-tibial angle) was measured by two longitudinal axis which cross over each other to make acute angle. The one is composed of mid-point of femur shaft which is 10 cm above of knee joint and mid-point of femur metaphysis which is 4 cm above of knee joint. The other is composed of mid-110 point of tibia shaft which is 4 cm below knee joint and mid-point of tibia metaphysis which is 4 cm below knee joint. Bowleg was indicated negative angle and knock-knee was indicated positive angle (Fig. 5). MPTA (medial proximal tibial angle) was measured based on knee standing AP X-ray. Same method as FTA, we measured the angle which was composed of anatomical axis of tibia and vertical axis of medial condylar tibia plateau. After UKA, MPTA was measured by anatomical axis of tibia and vertical axis of tibia prostheses (Fig. 6). PTSA (posterior tibial slope angle) was measured based on simple knee lateral X-ray and we used method

Fig. 1. Fluoroscopic measurement of knee and ankle joint before tibia cutting by extramedullary guide.

Fig. 2. Anteroposterior and lateral fluoroscope view after tibia cutting for check the medial proximal tibial angle and posterior tibial slope.

Fig. 3. Alignment recheck by spacer block and extramedullary guide.

described by Brandon et al.¹¹ We measured angle made by two axis. The one tibia longitudinal line is made up of mid-point of AP diameter just below tibia tubercle and mid-point of AP diameter which is 5 cm below tibia tubercle. The other axis is vertical line of medial condylar tibia plateau. After surgery we measured PTSA based on tibia anatomical longitudinal axis and under-line of tibia prostheses (Fig. 7).

After surgery, we used knee standing AP X-ray to measure FCRA (femoral component coronal rotation angle) for evaluation of varus & valgus arrangement. Longitudinal anatomical axis of tibia and femur prostheses longitudinal axis were used to measure FCRA. If distal part of femur prostheses is medially rotated, we defined varus¹² (Fig. 8).

Also, we standardized disarrangement based on study by Gulati et al.¹³ After surgery, we evaluated varus-valgus of femur and tibia and disarrangement of posterior tibial slope angle (PTSA). Normal range of tibia varus-valgus is $87 \pm 3^\circ$, femur varus/valgus is $0 \pm 3^\circ$ and posterior tibial slope angle (PTSA) is $7 \pm 3^\circ$. If varus/valgus is $0 \pm 3^\circ$ and

posterior tibial slope angle (PTSA) is $7 \pm 3^\circ$. If these values are beside the point, we evaluated it disarrangement.

All the pictures are used by Picture archiving and communication system (PACS) and two independent observers measured knee X-ray to reduce error of measures.

2.4. Clinical evaluation

We have done clinical and function evaluation before surgery, 6month, 1year, 2year after surgery and last follow-up. Clinical evaluation includes pain degree, motion range of knee joint, knee and function score based on standard which was made by American knee association.¹⁴

2.5. Statistical analysis

We used IBM SPSS Statistics version 21.0 (IBM Co., Armonk, NY,

Fig. 4. Final checking the alignment by fluoroscope after prosthesis insertion.

Fig. 5. Pre and postoperative measurement of femoro-tibial angle. The subsequent two points on the femur and two points on the tibia were connected. The angle subtended between these two lines was the FTA.

USA) for statistical verification. In case of Continuous variables, we used Shapiro-Wilk test for normal distribution. Changes between before surgery and after surgery were done by Paired *t*-test and difference of two groups was verified by Independent *t*-test and Mann-Whitney *U* test. P-value under 0.05 is defined standard value. Also we have done Weighted kappa (κ) coefficient for evaluation of observer consistency.

3. Results

According to the radiologic results, in group A, FTA (femoro-tibial angle) average changes from -0.6° to 6.1° , MPTA (medial proximal tibial angle) changes from 84.5° to 87.6° , PTSA (posterior tibial slope angle) changes from 6.2° to 5.2° through operation. In group B, FTA changes from -0.4° to 5.8° , MPTA changes from 84.7° to 87.1° , PTSA changes from 6.3° to 5.5° . FCRA (femoral component coronal rotation angle) is 0.6° in A group, 0.4° in B group after operation. There were no significant difference between both groups ($p > 0.05$) (Table 2).

According to the clinical results, Knee score improved from 56.3 to 90.7, Functional score from 54.3 to 86.9 through operation in group A. In group B, Knee score improved from 54.9 to 89.8, Functional score from 52.8 to 84.6. The range of motion changes from 123.2° to 134.8° at group A and 122.5° to 133.4° at group B. There were no significant difference between both groups ($p > 0.05$) (Table 3).

Also a criteria for misalignment was set and postoperative femoral and tibial varus/valgus mismatch, posterior slope mismatch were assessed. The tibial varus/valgus mismatch cases after operation ($nl.:87 \pm 3^\circ$) was 1 in group A, 5 in group B. Post. slope mismatch cases after operation ($nl.:7 \pm 3^\circ$) was 1 in group A, 1 in group B. All cases in both A and B group were not included in femoral varus/valgus mismatch ($nl.:0 \pm 3^\circ$) after operation (Table 4). There were no significant difference between both groups on the radiologic or clinical results but cases with tibial varus/valgus mismatch in group A who used C-arm fluoroscope were relatively lesser than group B.

During follow up Complication happened at 2 cases, 1 case had polyethylene change because of abrasion of polyethylene, 1 case undergone total knee replacement because aseptic loosening of the implant occurred.

Also to assess the coincidence of the measurement of the images between different observers, Weighted kappa (κ) coefficient value was checked as 0.82 which means “almost perfect agreement”.

4. Discussion

For surgical treatment of degenerative arthritis of knee joint there are many methods such as arthroscopic surgery, femoral of tibial osteotomy, partial or total knee joint replacement and for each surgery various advantages and disadvantages, indications were reported.^{4,10} For treatment of knee arthritis localized at the medial side, there are many reports of unicompartmental knee replacement arthroplasty. There are advantages such as lesser bleeding, minimize the extent of bone excision to reserve the bone structure so even though the unicompartmental knee replacement fails it is easy to change to total replacement.¹⁵ Also ACL and PCL, femoro-patellar joint are preserved to maintain stability of knee joint and early recovery so it is more used recently.^{1,16,17}

But there were limitations at the early times because of loosening, wearing and instability of the implant, mainly related to the failure of implant. Varus more than 5° of the proximal tibia, excessive varus/valgus of the femoral implant, valgus of the distal femur, excessive tibial slope were reported as the causes.^{16,17} Kim et al.¹⁸ reported that deviation of the mechanical axis and FTA could be changed by the size of implant and polyethylene, the angle of tibial excision, the location of the femoral implant so they could effect the alignment after surgery.

Fig. 6. Pre and postoperative measurement of medial proximal tibial angle. The varus/valgus alignments of the tibial components were measured relative to the long axis of the tibia.

Fig. 7. Pre and postoperative measurement of posterior tibial slope angle. The PTS angle is defined as 90° minus the angle made by the intersection of the line along the longitudinal axis of the tibia and the slope of the medial tibial plateau.

Weber et al.¹⁹ reported that certain increase of the tibial slope angle will reduce the abrasion of the implant, and by matching the alignment correctly complication such as implant failure can be reduced.

Recently techniques using navigation are used to maximize the accuracy of the alignment. Jung et al.²⁰ reported that unicompartmental

Fig. 8. Anteroposterior standing radiograph after the operation showing alignment of the femoral component against the long axis of the tibia.

knee replacement arthroplasty assisted by the navigation can enhance the accuracy of the femoral and tibial implant alignment on the sagittal plane. Seon et al.²¹ analyzed 31 cases using navigation during unicompartmental knee replacement and reported good results of alignment of lower extremities and implants. But due to disadvantages such as the more time and cost needed, the authors used C-arm fluoroscope and by using the accuracy of the alignment was increased and mismatch after tibial excision occurred less.

This study has limitations, it is a retrospective study, only assessed by radiologic and clinical results, risk of exposure of radiation, no assessment of the complications. But this study has a significance that C-arm fluoroscope is used during unicompartmental knee joint replacement and assessment of radiologic and clinical aspects of long term follow up are needed.

Table 2
Comparison of Radiographic Results.

	Group A (C-arm guided)	Group B (C-arm nonguided)	P-value
Femoro-tibial angle (FTA)			
Preoperative	$-0.6^\circ \pm 0.3$	$-0.4^\circ \pm 0.3$	0.32
Postoperative	$6.1^\circ \pm 0.2$	$5.8^\circ \pm 0.4$	0.29
Medial proximal tibial angle (MPTA)			
Preoperative	$84.5^\circ \pm 5.1$	$84.7^\circ \pm 6.2$	0.54
Postoperative	$87.6^\circ \pm 2.6$	$87.1^\circ \pm 3.2$	0.49
Posterior tibial slope angle (PTSA)			
Preoperative	$6.2^\circ \pm 2.0$	$6.3^\circ \pm 1.7$	0.62
Postoperative	$5.2^\circ \pm 0.9$	$5.5^\circ \pm 1.2$	0.58
Femoral component coronal rotation angle (FCRA)			
Postoperative	$0.6^\circ \pm 0.1$	$0.4^\circ \pm 0.1$	0.48

Table 3
Comparison of the Clinical Results at the Final Follow-Up Between Group A and B.

	Group A (C-arm guided)	Group B (C-arm nonguided)	P-value
Knee score			
Preoperative	56.3 ± 4.5	54.9 ± 3.9	0.54
Last F/U	90.7 ± 5.3	89.8 ± 5.1	0.76
Function score			
Preoperative	54.3 ± 2.7	52.8 ± 3.5	0.49
Last F/U	86.9 ± 3.6	84.6 ± 3.3	0.35
Range of motion			
Preoperative	$123.2^\circ \pm 7.5$	$122.5^\circ \pm 9.2$	0.69
Last F/U	$134.8^\circ \pm 9.6$	$133.4^\circ \pm 8.6$	0.62

Table 4
Postoperative number of mismatch case.

	Group A (C-arm guided)	Group B (C-arm nonguided)
Tibial varus/valgus mismatch (nl: $87 \pm 3^\circ$)	1 case	5 case
Post. slope mismatch (nl: $7 \pm 3^\circ$)	1 case	1 case
Femoral varus/valgus mismatch (nl: $0 \pm 3^\circ$)	0 case	0 case

5. Conclusion

There was no statistically significant difference in radiologic and clinical results between group A and B, but the number of tibial varus/valgus mismatch case were fewer in fluoroscope guided group. So we consider that the fluoroscope is helpful for tibial cutting in

unicompartmental knee replacement arthroplasty.

Conflict of interest

None.

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