Effects of Posterior Cruciate Ligament Resection in Total Knee Arthroplasty Using Computer Assisted Surgery

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Objective: *The authors prospectively measure the effects of Posterior Cruciate Ligament (PCL) excision in Total Knee Arthroplasty (TKA) using Computer Assisted Surgery (CAS)*
Material and Method: *Between April 2008 and June 2008, sixteen knees of fifteen patients with varus deformity less than 20 degree and grossly intact PCL were included in this study. Using CAS and tensioning device to maintain consistent pressure, extension and flexion gap on both medial and lateral side before and after resection of PCL was recorded.*
Results: *The mean increases of extension gap on medial and lateral side after resection of PCL are 0.17 $\pm$ 0.22 mm (-0.17 to 0.5 mm) and 0.25 $\pm$ 0.37 mm (-0.33 to 1.16 mm) respectively. The mean increases of flexion gap on medial and lateral side are 1.29 $\pm$ 1.02 mm (0-3 mm) and 2.09 $\pm$ 1.12 (0.5-4.66 mm) respectively.*
Conclusion: *Resection of PCL showed increase of flexion gap more than extension gap (p-value < 0.05) and lateral side of flexion gap always increase more than medial side (p-value < 0.05).*

Keywords: *Computer Assisted Surgery, CAS, Total Knee Arthroplasty, Posterior Cruciate Ligament, PCL*

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Total knee arthroplasty (TKA) has been one of the most common orthopedic operations due to the increase of affected population which are elderly. Comprehensive knowledge of knee anatomy, kinematics, prosthesis design and surgical techniques are vital for surgeons to ensure the satisfactory long-term operative results.

Posterior Cruciate ligament (PCL) has played a major role in knee stabilization. It acts as primary stabilizer prevents posterior subluxation of femur over tibia[1,2]. There are three designs of total knee prosthesis with respect to Posterior Cruciate ligament (PCL). These includes the PCL Retaining (CR prosthesis), PCL resection and substitution with post and cam mechanism (PS prosthesis) and PCL resection without substitution post and cam mechanism (PCL sacrifice prosthesis). PCL retaining and PCL substitution prosthesis are most widely use in orthopedics nowadays. During TKA with CR prosthesis, surgeons may need to change from CR prosthesis to PS prosthesis by various reasons[3]. As a result, the major knee prosthesis manufacturers have proposed the knee instrumentation system which can switch from CR prosthesis to PS prosthesis by integrating of femoral-notch cutting box. This bone cut will ultimately resects PCL and then substitute it with post-and-cam mechanism to create femoral roll back and prevent posterior translation of tibia. However, this final femoral bone cut may affect in the gap balancing.

Previous study reported the changes of flexion and extension gap in total knee arthroplasty after PCL resection. Oshner et al[4] showed that there was an equal increase in both flexion and extension gap with the range of 1.4-2.3 mm. However, Mihalko et al[5] reported different of the increased flexion gap which was approximately 3.2-9.1 mm without extension gap change in unloaded model. Kadoya et al[6] studied 30 patients with tensioning device at 40 lb distracting force and found the increase flexion gap 4.8 $\pm$ 0.4 mm and extension gap increase approximate 1 mm. These

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studies were done either in a cadaveric model or in a conventional measurement method and instruments used. Computer assisted surgery (CAS) was introduced to orthopedics community more than 10 years[7,8]. Using this CAS, physicians can detect and record even a very small gap change down to the level of 0.1 mm and angular change of 0.1 degree[9]. This ability allows using CAS to determine intra-operative kinematics. This study is aimed to examine the effect of PCL resection by using CAS in patients underwent total knee arthroplasty.

Material and Method

We collected data from patients who underwent primary CAS TKA at our institution during April 2008 and June 2008. Approval from hospital ethic committee was obtained before we started the study. General data such as age, sex, and body mass index were recorded for demographic purpose. Knee score and functional score were recorded at preoperative period for clinical evaluation while a long-standing hip-knee-ankle AP film, 18 inches knee AP and lateral film were taken for radiographic evaluation. Patients to be included were those with primary osteoarthritis and they physicians planned to perform the implantation either with PCL substituting (PFC Sigma, DePuy, Johnson and Johnson) or PCL sacrificing (LCS, DePuy, Johnson and Johnson) prosthesis. The permission to evaluate the effect of PCL resection as a part of procedure was obtained from included patients. We excluded patients who had a history of prior knee surgery, previous PCL injury, CR TKA, intraoperative varus deformity more than 20 degrees measured by CAS or intraoperative findings of partial or complete tear of PCL. Patients with rheumatoid arthritis or valgus deformity were also excluded from this study.

Mini-Midvastus approach was used in all patients following by the anterior cruciate ligament resection and initial medial release for adequate exposure. The CAS system used in this study was Ci™ system installed with MITKR 2.0 software (DePuy, Johnson and Johnson). This is a passive infrared tracking system that conferred a high accuracy of 0.1 mm of distance change and 0.1 degree of angular change without a noise effect from metal device. We used Tibial First workflow as it allowed us to measure (i) the distance between distal femoral condyle and proximal surface of tibial bone cut in extension (extension distance) and (ii) the distance between posterior condyle and proximal surface of tibial bone cut in flexion (flexion distance) before cutting the femoral bone. The actual computer screen used for measurement extension gap was shown in Fig. 1.

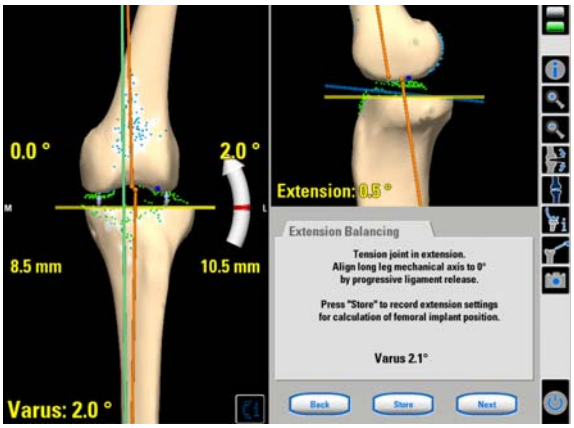

Fig. 1 Actual screen of extension distance measurement

The extension distance and flexion distance difference before and after PCL resection were referred as the differences of extension gap and flexion gap in this study. We did not measure the difference of extension and flexion gap after final femoral preparation because from our previous observation, the significant gap changes may occur after PCL resection. This gap changes required careful procedure to correct this effect therefore measuring the extension and flexion distance instead. After CAS system was set up and the registration of all landmarks was done, the proximal tibia was cut using CAS guide with the thickness of 10 mm.

The tibial posterior inclination was done based on the device manufacturer's recommendation. Although the bone segment at PCL insertion was not created, the proximal tibial resection was carefully done to prevent the inadvertent injury to PCL. At this point, if the inadvertent injury was found, the patient was then excluded from study. After examining the competency of PCL, we performed the further medial release to correct alignment to be less than 5-degree varus of mechanical axis in all cases. Then CAS measurements of extension gap at zero degree flexion and flexion gap at 90 degrees flexion on both medial and lateral side were done consecutively using a tensioning device (Knee Balancer, DePuy, Johnson and Johnson) which consistently maintained distraction force. We set the tension at 26 lbs, which is the same average tension as tension we used in TKA operation.

The measurement procedure was done three times separately. We then completely removed PCL from

femoral origin and released PCL from tibial insertion. We ensured the completeness of resection by palpation the PCL on extension and flexion under tension. Then we repeated the measurement with the same technique as describe above three times. After this measurement, the following steps of standard CAS TKA with Tibial first workflow were done routinely. Patients went through the same standard rehabilitation program after the operation. Comparisons of the continuous variables were done by paired t-test. P-value less than 0.05 was considered statistically significant.

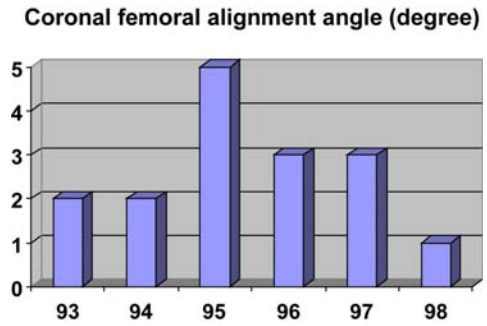

Fig. 2 Post-operative coronal femoral alignment angle

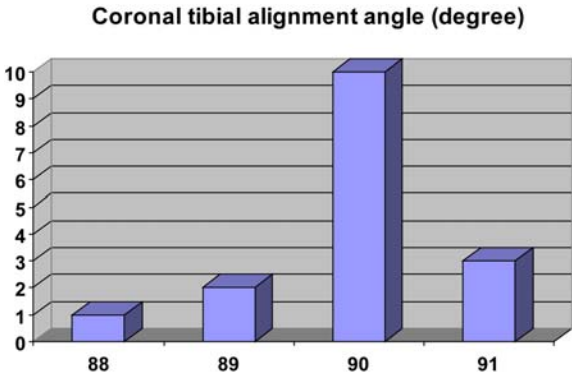

Fig. 3 Post-operative coronal tibial alignment

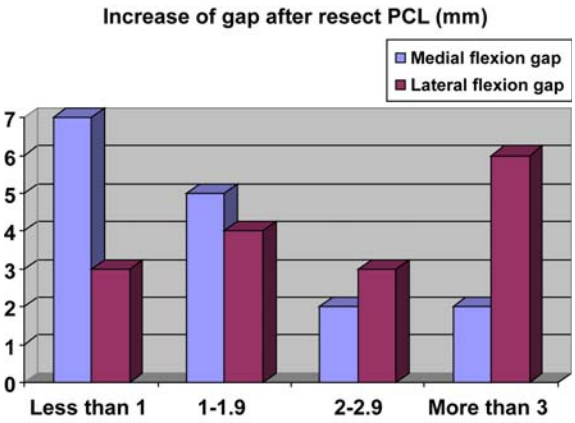

Fig. 4 Changes of medial and lateral side of flexion gap after PCL resection

Results

There were fifteen patients with sixteen knees included in this study. 13 female and 2 male were underwent staged bilateral TKA. The mean age is 63.5 years (range 51 to 76 years). The mean pre-operative varus deformity relative to mechanical axis measured by CAS was 9.99 $\pm$ 4.85 degrees with the range of 0 to 17.4 degrees varus. The mean post-operative deformity relative to mechanical axis measured by CAS is 0.59 $\pm$ 1.2 degrees with the range from valgus 2.7 to varus 3.0 degrees. 13 knees (81.25%) were in range of 1 degree deviation. Using the Knee Society radiographic analysis in a coronal plane, the mean femoral angle was 95.37 $\pm$ 1.45 degrees (range 93 to 98) and the mean tibia angle was 89.93 $\pm$ 0.77 degrees (range 88 to 91). The post-operative radiographic results were shown in Fig. 2 and 3.

We found the imbalanced changes of extension and flexion gap after resection of PCL. Flexion gap was found increased more than extension gap and lateral side of flexion gap increased more than medial side. The difference between extension gap changes and flexion gap changes was statistically significant (p-value < 0.001) as shown in Table 1. Similarly, the distance of medial side and lateral side of flexion gap changes was significantly different (p-value = 0.013). The increases of medial and lateral side of flexion gap were shown in Fig. 4.

Discussion

Computer assisted surgery in total knee arthroplasty was developed to increase the accuracy of bone cut and mechanical axis restoration[7,10]. Some systems have more features to facilitate equal gap balancing. In this study we used Ci™ system because it can effectively detect even a very small amount of distance and angular change and it can also measure the extension and flexion distance before actual cut of femur were made.

Our study results confirmed the previous studies on the flexion gap that it increased without a significant change of extension gap after PCL resection. However, there were two different findings in our study. The first one was the change of flexion gap which was

Table 1. Distance of extension gap and flexion gap before and after PCL resection

	Extension gap (mm, mean ± SD)		Flexion gap (mm, mean ± SD)	
	Medial side	Lateral side	Medial side	Lateral side
Before PCL resection	9.20 ± 2.26	9.83 ± 2.31	9.09 ± 2.07	11.96 ± 1.91
After PCL resection	9.36 ± 2.35	10.07 ± 2.33	10.38 ± 2.53	14.05 ± 1.73

relatively smaller while another one was the increase of lateral side of flexion gap which was found more than medial side after PCL resection. This will ultimately change femoral rotation

Although the mean increase of flexion gap was found relatively small, we yet found 6 from 16 patients had lateral side of flexion gap increased more than 3 mm. In addition, there were some patients had the 2-mm increased lateral side of flexion gap which was more than medial side. These findings may reflect the variations of deformity and structural changes in osteoarthritic patients. Larger number of patients with subgroup may enable us to identify this assumption.

We measured the effect of PCL resection on the change of flexion gap and rotational alignment before final ligament balance was done. Study rationale is based on our experience in which we found a significant change of flexion gap and rotational alignment if we resect PCL after final ligament balance. In some cases, the surgeon needs to perform further procedures to correct this so we decided not to employ this sequence. We believed that if we resect PCL after the final ligament balance was done, the gap change may be higher than the present study results.

Conclusion

During performing PCL substitute or PCL sacrificed total knee arthroplasty; we suggested that the complete resection of PCL should be done before final gap balancing was made. Final femoral notch resection will completely remove PCL and afterwards affect a gap balancing and femoral rotation. In the same circumstance of conversion from PCL retaining total knee arthroplasty to PCL substitute prosthesis, the increase of flexion gap and change of femoral rotation should be carefully noted.

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การศึกษาวัดผลที่เกิดขึ้นหลังการตัดเอ็นไขว้ในข้อเข่าด้านหลัง โดยใช้เครื่องคอมพิวเตอร์นำร่องในผู้ป่วยที่เข้ารับการผ่าตัดเปลี่ยนข้อเข่าเทียม

พฤกษ์ ไชยกิจ, สุรพจน์ เมฆนาวิน, ณัฐพงศ์ หงษ์คู

วัตถุประสงค์*: เพื่อศึกษาผลการใช้คอมพิวเตอร์วัดผลระยะห่างระหว่างกระดูกฟีเมอร์และกระดูกทิเบียของข้อเข่าที่เกิดขึ้นหลังจากที่ตัดเอ็นไขว้ในข้อเข่าด้านหลัง Posterior Cruciate Ligament (PCL)*

วัสดุและวิธีการ*: โดยใช้คอมพิวเตอร์วัดระยะห่างระหว่างกระดูกฟีเมอร์และกระดูกทิเบียของข้อเข่าในท่างอและเหยียดเข่า (Flexion Gap and Extension Gap) ก่อนและหลังตัด PCL ในผู้ป่วยที่เข้ารับการผ่าตัดเปลี่ยนข้อเข่าเทียม 15 ราย จำนวน 16 เข่า ที่มีความผิดรูปของข้อเข่าแบบ varus น้อยกว่า 20 องศาและเอ็นไขว้หลังปกติ*

ผลการศึกษา*: พบว่าระยะห่างเฉลี่ยหลังตัด PCL ในท่าเหยียดเข่ามีค่าเพิ่มขึ้นทางด้านใน (Medial side) 0.17 $\pm$ 0.22 mm และทางด้านนอก (Lateral side) 0.25 $\pm$ 0.37 mm ส่วนในท่างอเข่ามีค่าเพิ่มขึ้นทางด้านใน 1.29 $\pm$ 1.02 mm และทางด้านนอก 2.09 $\pm$ 1.12 mm*

สรุป*: การตัด PCL ทำให้ Flexion gap เพิ่มขึ้นมากกว่า Extension gap และ Flexion gap ด้านนอกอาจเพิ่มมากกว่าด้านใน*