Comparing Cruciate-Retaining Total Knee Arthroplasty and Cruciate-Substituting Total Knee Arthroplasty: A Prospective Clinical Study

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Background: This prospective clinical study was performed to compare the clinical outcomes and radiographic changes between patients with cruciate-retaining (CR) and cruciate-substituting (CS) total knee arthroplasty (TKA).

Methods: From 1997 through 1998, 228 patients (183 females and 45 males) with a total of 267 knees with an average age of 55 years (range, 20 to 83 years) were enrolled in this study. Patients were randomly divided into two groups including group I of 137 patients underwent 157 CR TKA, and group II of 91 patients underwent 110 CS total knee arthroplasties. The evaluation parameters included knee scores, functional scores, radiographs of the knees and SF-12 surveys. The average follow-up period was 42 months (range, 24 to 66 months).

Results: The overall results for group I were 74.3% excellent, 17.7% good, 7.1% fair and 0.9% poor for; and 76.9% excellent, 19.2% good and 3.8% fair for group II. No significant differences were noted in the overall results between the two groups. The radiographic changes showed no discernable differences.

Conclusions: Cruciate-retaining and cruciate-substituting total knee arthroplasties function equally well at 2 to 5 years postoperatively. The ultimate differences between the patients who underwent CR TKA and CS TKA need to be examined after long-term follow up.

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Key words: **total knee arthroplasty, cruciate-retaining, cruciate-substituting.**

Total knee arthroplasty (TKA) has provided pain relief and improved knee function for a variety of arthritic condition with good long-term results.[1-12] The total condylar prosthesis which was developed in 1974 was subsequently modified to a posterior cruciate substituting (CR) the posterior stabilized version in around 1978 for the purpose of improving stair climbing, better range of knee motion, prevention of posterior subluxation and more conforming knee kinematics.[13] Many researchers have addressed the problem of either excising or retaining the posterior cruciate ligament (PCL) in total condylar knee prosthesis.[1-5,7,14-19] In modern orthopedics most knees have been replaced with some form of PCL-substituting prosthesis when the PCL is excised. Several researchers have compared cruciate-retaining (CR) TKA and CS TKA.[20,21] Ranawat et al.[2] reported good to excellent clinical results in 98.9% of patients with PCL sacrificing the total condylar TKA with an average of 9 years of follow-up. In the meantime,

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Laskin et al.[22] recommended a posterior stabilized prosthesis in patients with rheumatoid arthritis. Stern et al.[23] showed better results using the posterior stabilized prosthesis and recommended this prosthesis in patients with knees with severe deformities. More recently, Dejour et al.[21] reported a statistically significant higher rate of excellent knee scores in patients that underwent CS TKA than those that underwent CR TKA. Therefore, the arguments between CR and CS prosthesis remain unsettled. The purpose of this prospective clinical study was to compare the clinical outcomes and radiographic changes between CR TKA and CS TKA with a short-term follow up.

METHODS

The Institutional Review Board approved this study. All patients signed an informed consent form. From June 1997 through June 1998, 228 patients (183 females and 45 males) with 267 knees were enrolled in this study. Thirty-nine patients (32 females and 7 males) had bilateral TKA performed at different time intervals. The patients were randomly divided by the hospital admission into two groups with group I consisting of 137 patients who received 157 CR prostheses, and group II consisting of 91 patients who received 110 CS prostheses. During the course of this study, there was an inventory shortage for CS prosthesis, and this resulted in a disproportion in the number of patients in both groups. Both groups had similar ages, gender, body weight, body height and the diagnoses. The patient demographics are summarized in Table 1, and the preoperative assessments of the knee are summarized in Table 2.

Surgical technique

Two surgeons (CJW and JWW) performed all of the operations with similar surgical technique using the same instruments. The ligament balance was similarly performed, however, the bony resection differed between the two groups. For the varus knees, the soft tissue releases included superficial medial collateral ligament, portion of pes anserinus, and the direct head of semimembranosus tendon. For the valgus knees, the releases included the conjoined tendon of lateral collateral ligament and popliteus tendon, and the iliotibial band. The magnitude of soft tissue releases was determined according to the severity of the deformity. Lateral retinacular release with preservation of the genicular vessels was performed in 25 (15.9%) knees that underwent CR TKA and in 15 (13.6%) knees that underwent CS TKA .

The bone resections were performed using the standard cutting jigs and guides. The distal femoral cut was made with an intramedullary guide at 5˚ to 7˚ valgus. Additional central recess was made with the housing device for CS prosthesis. The proximal tibia cut was made perpendicular to the axis of the tibia using an intramedullary rod or an external cutting guide at the surgeon's preference. The patellar bone was cut using a cutting jig. The balance of flexion and extension gaps was performed with a trial prosthesis. Partial PCL release or recess of less than 5 mm at the distal end was performed in 43 knees that received CR prostheses. Bone grafts were performed in 21 knees (19 tibia and 2 femur) for those

Table 1. Patient Demographics

	Total cases	PCL-retaining	PCL-substitute	*p*
Number of patients	228	137		91
#Number of knees	267	157		110
Ave. age	55 (20-83)	54.5 (31-69)	55 (20-83)	0.310
Female	183	110	73	0.559
Male	45	27	18	
Body weight (Kg)	65.0±11.0	65.9±10.7	63.7±11.0	0.541
Body height (cm)	153.0±6.9	153.6±6.4	152.2±7.5	0.105
Lt / Rt	146/121	92/65	54/56	0.909
Osteoarthritis	243	152	91	0.003
Rheumatoid arthritis	20	3	17	
Osteonecrosis etc	4	2	2	

Abbreviations: PCL: posterior cruciate ligament; Rt: Right; Lt: Left.

Table 2. Preoperative Assessments of the Knees between PCL-retaining and PCL-substituting TKA

	PCL-retaining	PCL-substituting	*p*
Alignment			
Varus knee			
Case number	146	103	
Average alignment	7.6 ±5.7 (0-25˚)	9.6± 6.1 (0-25˚)	
Valgus knees			
Case number	11	7	
Average alignment	12.2 ±4.0 (10-30˚)	15.5± 4.4 (10-35˚)	
Range of motion			
Extension	6.8˚ ±7.0˚	9.4˚± 9.6˚	0.293
Flexion	114˚ ±21.1˚	110˚ ±20˚	0.754
Stability			
M-L (range)*	13.5 ±3.20 (0-15)	11.6± 4.5 (0-15)	
A-P (range)**	9.76±1.08 (5-10)	9.0± 2.46 (0-10)	
Knee Scores	51.7 ±20.3	45.9±20.7	0.617
Functional	41.0 ±19.9	39.2±21.9	0.872

Abbreviations: PCL: posterior cruciate ligament; TKA: Total knee arthroplasty; M-L: Mediolateral; A-P: Anteroposterior.

* For mediolateral laxity, 15 points was assigned for knee with 0 to 5˚, 10 points for 6˚ to 9˚, 5 points for 10˚ to 14˚ and 0 point for greater than 15˚ laxity;

** For anterior laxity, 10 points was assigned for knee with 0 to 5 mm, 6 points for 5 to 10 mm, and 0 point for over 10 mm laxity.

who received CR prostheses and 34 knees for those who received CS prosthesis (31 tibia and 3 femur). Press-fit condylar (PFC) total knee prostheses (Johnson & Johnson, Ryndum, Mass) were used in all patients, and all components were cemented.

Postoperatively, all patients received prophylactic antibiotic and anticoagulation. The same protocol for postoperative management was utilized in both groups. This included bedside continuous passive motion machine (CPM) and physical therapy with partial weight bearing, and quadriceps and hamstring strengthening exercises starting on the second postoperative day. Full weight bearing as tolerated was allowed after 4 weeks.

Follow-up examinations were scheduled at 1, 6, and 12 months after the operations, and then once a year from then on. The evaluations of knee scores and functional scores were based on The Knee Society Clinical Rating System,[24] and The Knee Society Total Knee Arthroplasty Roentgenograhic Evaluation and Scoring System was adapted for radiographic examinations.[25] A grading scale was developed to quantify the anteroposterior and mediolateral laxities of the knee. For anterior laxity, 10 points was assigned for knee with 0 to 5 mm, 5 points for 6 to 10 mm, and 0 points for over 10 mm laxity. For mediolateral laxity, 15 points was assigned for knee with 0 to 5˚, 10 points for 6˚ to 9˚, 5 points for 10˚ to 14˚ and 0 points for greater than 15˚ laxity. In addition, functional assessments were performed using the SF-12 functional survey (Table 3).

Table 3. SF-12 Functional Survey

1. Heath
2. Climbing several flights of stairs
3. Were limited in the kind of work
4. Moderate activities
5. Accomplished less than you would like (physic)
6. Accomplished less than you would like (emotion)
7. Didn't do work
8. Have you felt calm and peaceful
9. Have you felt downhearted and blue
10. Interfere with normal work
11. Did you have a lot of energy
12. Interfere with social activities

Abbreviations: SF: short form

Statistical analysis

The pre- and postoperative data of the same group was compared statistically with a paired t test, and the data between the two groups with Independent sample t test with statistical significance

at $p \leq 0.05$. The different categories were compared using the chi-square test.

RESULTS

Forty-two patients with 43 knees including 29 that underwent CR and 14 that underwent CS were excluded for reasons including three deaths unrelated to knee surgery, three knees with deep wound infections, one above the knee amputation due to diabetic gangrene, one patient with cerebral vascular accident (CVA), one patient with Parkinson disease, one patient (2 knees) with colon cancer and 32 patients were lost to follow up. The remaining 185 patients with 224 knees including 128 that underwent CR TKA and 96 that underwent CS TKA who had completed a minimum of 2 years of follow-up examinations were included in the analysis. The average follow-up was 42±18 months (range, 24-66 months).

Functional assessments

The pain scores, knee scores, and functional scores of the patients are summarized in Table 4. The pain scores improved dramatically in 3 months, and continued to improve up to 6 months postoperatively in both groups. However, the differences in pain scores between the two groups were not statistically significant ($p = 0.929$). The knee scores steadily improved for up to 1 year with the most improvement noted at 6 months. The functional scores continued to improve for up to 2 years with the most improvement noted at 1 year. However, the differences in knee scores and functional scores were not statistically significant between the two groups ($p = 0.315$ and 0.507). The overall results were 74.3% excellent, 17.7% good, 7.1% fair and 0.9% poor for those in group I, and 76.9% excellent, 19.2% good and 3.8% fair for those in group II. The patients who underwent CS showed a relatively higher rate of excellent scores, however, the differences in the overall results were not statistically significant between the two groups ($p = 0.772$).

Physical findings and Ligament laxity of the knees

The physical finding and ligament laxity of the patients are summarized in Table 5. No statistically significant differences were noted in the overall alignment and the range of motion of the knees

Table 4. Pain Scores, Functional Scores and Knee Scores of Cruciate-retaining and Cruciate-substituting TKA at Follow-up.

Type of prosthesis	Cruciate-retaining	Cruciate-substituting	*p*
Number of patients	108	77	
Number of knees	128	96	
Pain scores	48.3± 4.0	49.6± 1.4	0.929
Knee scores	90.7± 5.3	91.0± 4.8	0.315
Functional scores	84.2±20.8	87.0±19.6	0.507

TKA: Total knee arthroplasty

Table 5. Comparison Results of Physical Findings and Ligament Laxity of the Knee

Type of prosthesis	Cruciate-retaining	Cruciate-substituting	*p*
Alignment (Valgus)			
Average	6.9°±1.5°	6.6°±1.7°	0.617
Range	(0-10°)	(0-10°)	
Range of motion			
Extension/flexion	-1.00 / 110°	-2.80 / 112°	0.786
Mediolateral laxity*	14.8±1.6	14.9±1.3	0.872
Anteroposterior laxity**	9.0±2.1	7.9±2.1	< 0.001

* For mediolateral laxity, 15 points was assigned for knee with 0 to 5°, 10 points for 6° to 9°, 5 points for 10° to 14° and 0 point for greater than 15° laxity.

** For anterior laxity, 10 points was assigned for knee with 0 to 5 mm, 5 points for 5 to 10 mm, and 0 point for over 10 mm laxity.

Table 6. Comparison Results of Radiographic Findings of the Knee.

	Cruciate-retaining	Cruciate-substituting	*p*
Femorotibial angle (Valgus)	7.3°±1.6°	6.3°±1.7°	0.317
Tibia angle	89.5°±2.2°	89.3°±2.3°	0.903
Lateral patellar tilt			
Incidence	16.2%	16.4%	
Average tilt	5°	4°	
Radiolucency *	4.4%	5.1%	

* The radiolucency was 1.0 mm or less in all cases except one knee.

between the two groups ($p > 0.05$). No significant differences in the mediolateral laxity were noted between the two groups ($p = 0.872$). However, differences in anterior laxity were statistically significant ($p = 0.001$) favoring the patients who underwent CR. The significance of anteroposterior laxity of the knee was clinically irrelevant because comparable clinical results were noted in both groups.

Radiographic examination

The results of the radiographic examinations are summarized in Table 6. No statistically significant differences were noted in the femorotibial angle, tibia angle, patellar tilt and the incidence of radiolucency between the two groups ($p > 0.05$). The magnitude of radiolucency was less than 1.0 mm and non-progressive in all cases with except for one knee.

SF-12 functional survey

Preoperatively, approximately 87% of the patients claimed that their normal work and social activities were interfered with by their knee conditions. Postoperatively, normal work was either not affected at all or a little bit of interference was reported in approximately 96% of the patients, and normal social activities in approximately 86% of the patients. A statistically significant improvement was noted in each category of the SF-12 functional survey postoperatively ($p < 0.05$). However, no statistically significant differences were noted in SF-12 functional survey between the two groups ($p > 0.05$). Both groups of patients performed equally well at work and in social activities.

DISCUSSION

The argument on PCL excision in TKA remains controversial. The proponents of CR claim that it acts as a biologic stabilizer and is capable of absorbing the shearing forces and reduces the stresses at the prosthesis-bone interface.[5,14,15,17,26-28] The opponents, however, state that the CS prosthesis was designed to improve stair climbing, better range of knee motion and prevention of posterior subluxation of the tibia.[1,3,10,13,20,22, 23,29] Some researchers stated that the normal mechanics of the knee are lost as soon as one or both cruciates are removed in TKA and increased shearing forces at the prosthesis-bone interface and abnormal knee kinematics occur.[14,15,17] Andriacchi et al[14,26] demonstrated that patients who received TKA with PCL preservation were better at stair climbing than those who sacrificed PCL. However, there were no significant differences on level walking with or without the PCL. Lewandowski et al.[30] and Su et al.[8] showed that patients that received PCL-sacrificing prosthesis might experience difficulty in activities requiring quadriceps power near full extension, such as rising from a chair or ascending or descending stairs. On the contrary, many researchers reported comparable results for patients who received CR TKA and CS TKA.[7,20] Bolanos et al.[20] showed that there were no differences in range of knee motion during level walking, stair ascent and stair descent between patients who received CR TKA and CS TKA. Shoji et al.[7] revealed no differences in knee scores between patients with CR and CS prosthesis. However, patients who ascended and descended stairs with one leg at a time tended to prefer the CR knee. Those who could use one leg in sequence to go up and down stairs, however, did not show preferential dependence on either knee. The results of the current study showed no significant differences in knee scores and functional scores between patients who received CR TKA and CS TKA. There was considerable improvement achieved in each category of

SF-12 functional survey including work performance and social life, however, no significant differences were noted between the two groups.

Dejour et al.[21] demonstrated a significantly higher rate of anteroposterior and mediolateral laxities in patients that underwent CR TKA than those that underwent CS TKA. The results of the current study showed significant differences in anteroposterior laxity, but not mediolateral laxity between patients that underwent CR TKA and CS TKA favoring those that underwent CR TKA. However, the finding of anteroposterior laxity was clinically irrelevant and did not affect the overall clinical results. Straw et al.[31] reported that worse results were noted in patients with release of the posterior cruciate ligament, but comparable results were noted between those that underwent CR TKA and CS TKA. In our study, we did not stratify the cases with PCL release, however, clinical observation showed no significant differences in the patients with release of the posterior cruciate ligament as compared with those without PCL release.

In conclusion, the results of this study suggested that retention of the cruciate was not the rate-limiting step in determining good function after TKA. The success of TKA relies upon surgical technique rather than the excision of the cruciate providing that the appropriate prosthesis is used. The need to keep the cruciate is sometimes not easy to achieve particularly where considerable deformity exists, thus, the CS prosthesis can be considered for easier ligament balance. The differences between the patients that underwent CR TKA and CS TKA need to be examined after long-term follow up.

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比較後十字韌帶保留或替代型人工膝關節置換：前瞻性臨床研究

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背　景： 此爲一比較後十字韌帶保留型及替代型人工膝關節置換的臨床結果及影像學研究之前瞻性報告。

方　法： 從1997年至1998年間，我們收集了228位病患，其中183位是女性及45位的男性，平均年齡爲55歲〔從20歲到83歲不等〕，在此一研究中，共施行267個人工膝關節置換。我們將病患隨機分配成兩組；第一組有137位病患，共有157個膝關節進行保留型人工膝關節置換，第二組有91位病患，進行110個替代型人工膝關節置換。評估方法包括膝關評分、功能評分、X光評分及SF-12評分。病例平均追蹤時間爲42個月〔從22個月到66個月〕。

結　果： 保留型人工膝關節的病患中有74.3%的病人是極佳結果，17.7%爲好的結果，7.1%的病人覺得普通，還有0.9%的病人覺得不好。而在施行替代型人工膝關節置換術的病患中，有76.9%的病人反應極佳，19.2%爲好的結果，3.8%的病人感到普通。這兩組之間的差異並無統計上的意義，在X光的變化上也沒有明顯差別。

結　論： 保留型與替代型人工膝關節置換，在術後2-5年間，功能表現是一樣好的，而成功的人工膝關節置換術靠的是開刀技術而非後十字韌帶的切除與否，特別是有相當程度的膝關節變形存在時，保留後十字韌帶是很困難，倘若要在保留型或替代型人工膝關節中找出二者的差異，只有靠更長期的追蹤。
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關鍵字：人工膝關節置換，後十字韌帶保留，後十字韌帶替代。

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