

A Clinical Study of Comparing Cruciate-Retaining Versus Cruciate-Substituting Total Knee Arthroplasty

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Conflict of interest: Nil

Abstract:

Background: This prospective clinical study was performed to compare the clinical outcomes between patients with cruciate-retaining (CR) and cruciate-substituting (CS) total knee arthroplasty (TKA).**Methods:** from June 2018 to may 2021, 52 patients (32 females and 20 males) with a total of 70 knees with a mean age of 61.11 years (range, 46 to 78 years) were enrolled in this study. Patients were randomly divided into two groups including group A (Cruciate-Retaining Total Knee Arthroplasty (CR-TKA) underwent 35 CR TKA, and group B (Cruciate- Substituting Total Knee Arthroplasty (CS-TKA) underwent 35 CS total knee Arthroplasty. The evaluation parameters included knee scores, pain score, functional scores, radiographs of the knees and ROM (Range of motion). Regular follow up done at 4 weeks, 12weeks and then every 6 months. All data were collected and analyzed with the help of suitable statistical parameters.**Results:** Both designs give equal and good results. We preferred CR Knees in relatively young patients and patients with smaller knees as its bone conserving implant and CS knees in patients with Inflammatory arthritis, patient with severe Varus or flexion deformity, when tibia cut is more than 10 mm and when intra-operatively findings suggestive of non-functional posterior Cruciate ligament. However, in our short term randomized interventional study Posterior Cruciate substitution TotalKnee Arthroplasty had a marginally better outcome than the posterior Cruciate retaining in terms of range of motion but it needs a long-term analysis.**Keywords:** Cruciate substitution Total Knee Arthroplasty, Cruciate-Retaining.

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Introduction

Patients with severe osteoarthritis (OA) of the knee have difficulty with many of the normal activities of daily living. Total knee Arthroplasty has evolved over the past decades into a very much reliable surgical treatment for advanced arthritis of knee. Total knee replacement has been shown to restore patient function and relieve pain and deformity that results from knee arthrosis. The success of a total knee replacement is determined by many factors including pain relief, functional outcome, and range of motion, radiographic loosening or component revision. [1] There have been numerous changes in the total condylar type of total knee Arthroplasty during the past 20 years. These modifications include alterations in component geometry, understanding of the rotational alignment of the components, sizing options and modularity, accurate instrumentation for correcting deformity and improved cementation techniques. The total condylar prosthesis which was developed in 1974 was subsequently modified to a posterior Cruciate substituting the posterior stabilized version in around 1978 for the purpose of improving stair climbing, better range of knee motion, prevention of posterior sub-

luxation and more conforming knee kinematics.² The best knee replacement is one, which reproduces the kinematics of the normal knee. Amongst several factors affecting the kinematics, variations in surface geometry and the retention or sacrificing the posterior Cruciate ligament is considered especially important. Yet, there is no clear evidence of how best to deal with the posterior Cruciate ligament at the time of knee replacement surgery. There are four options available to the surgeon. The first is to retain the ligament and to preserve as much as possible of the normal anatomy and function of the knee. Preservation of the ligament is thought to enhance stability, femoral rollback, mechanical advantage of the quadriceps muscle and proprioceptive properties. [2,3,4]

The second option is to excise the ligament in order to facilitate the correction of any fixed deformities. This allows more accurate and reliable soft tissue balancing resulting in improved fixation of the components. The third option is to substitute the ligament with a posterior stabilized tibial insert. These inserts have a central post, which can engage on a femoral cam during flexion, mimic

femoral rollback and reproduce near normal kinematic profiles. The central post may also allow some stability in the anteroposterior plane and act as a secondary stabilizer to a Varus or valgus stress. The fourth option is to release the ligament; this offers a compromise between preservation and excision. [5,6,7 8] In modern orthopaedics 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. Both posterior Cruciate-retaining (CR) and posterior Cruciate-substituting (PS) TKAs have at least 90% of patients obtaining good or excellent scores at long-term follow up. Controversy still continues concerning the role of the posterior Cruciate ligament (PCL) in TKA. Proponents of retaining the PCL have considered that the PCL produces normal knee kinematics, especially femoral rollback and that it improves joint proprioception. On the other hand, those in favour of sacrificing the PCL have argued that excision of the PCL makes ligament balance easier and that the cam–spine mechanism provides more reliable femoral rollback. Most previous clinical studies have reported short-term results. [7, 8,9]

Material and Methods

Hospital based, prospective randomized, comparative interventional study. This study was conducted in the Department of Orthopaedics, All India Institute of Medical Sciences, Patna. with due permission from the institutional ethical committee and review board and after taking written informed consent from the patient

Data collection for study started from June 2018 to may 2021 or till the sample size is achieved (whichever is earlier). Then it took another two months to process and analyse data. Sample size was calculated to be 35 subjects in each groups (aged 46 years to 78 years) at alpha error-0.05 and study power- 80%, assuming mean difference of anteroposterior laxity 1 mm and standard deviation 1.5 mm. Total 52 patients (M/F=20/32) were taken and 16 Right, 18 Left, 18 Bilateral TKA were done.(70 knees)

Randomisation Method: The patients were randomized in 2 groups through chit box method.

Group A– (n= 35)

Cruciate-Retaining Total Knee Arthroplasty (CR-TKA)

Group B – (n=35)

Cruciate-Substituting Total Knee Arthroplasty (CS-TKA)

Inclusion Criteria

Patient with severe osteoarthritis (Kellgren and

Lawrence score Grade 3 and 4) of knee joint, Patients who are fit for surgery and given written informed consent for study.

Exclusion Criteria

Patients with associated hip and ankle arthritis, Surgical and medical contraindication, Poor skin conditions, Post traumatic arthritis

Data Analysis: Data was recorded as per Performa. The data analysis was computer based; SPSS-22 was used for analysis. For categorical variables chi-square test was used. For continuous variables independent samples' *t*-test was used. *p*-value <0.05 was considered as significant.

Method

In this study all patients were evaluated Scoring system formulated by the American knee society used to evaluate the patients before and after surgery. Both knee scores and functional scores calculated with each mounting to a total of 100 points. Preoperative full length radiograph from the hip to ankle was taken in all the patients who underwent knee replacement surgery and pre op mechanical axis was drawn and the amount of Varus or valgus deformity was quantified. Radiological grading as advocated by Kellgren and Lawrence was used to evaluate the severity of the arthritis and graded from I to IV.

All the cases were investigated thoroughly and comorbid medical conditions brought under control before surgery. All the cases were done under tourniquet control using pneumatic tourniquet. Anaesthesia by either epidural or spinal as per the anaesthetist discretion. DVT prophylaxis not given to any of our patients

Standard postoperative protocol followed as advised by the American knee society. Patients discharged after suture removal on the 12th to 14th postoperative day. Regular follow up done at 4 weeks, 12weeks and then every 6 months. Post operatively patients' functional outcome studied using knee society scores.

Operative Procedures

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. 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 trial prosthesis.

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 1 week. Follow-up examinations were scheduled at 1, 3, and 6 months after the operations. The evaluations of knee scores and

functional scores were based on The Knee Society Clinical Rating System,⁽¹⁶⁾ and The Knee Society Total Knee Arthroplasty Roentgenographic Evaluation and Scoring System was adapted for radiographic examinations. A grading scale will be used to quantify the anteroposterior and mediolateral laxities of the knee. For anterior laxity, 10 points will be 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 will be 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 will be performed using the SF-12 functional survey.

Results

Table 1: Preoperative assessment of patient's characteristics in CR & CS groups

Parameters	CR (N=35)	CS (N=35)	'p' value*
	Mean ±SD	Mean ±SD	
Degree of deformity	14.71 ±4.46	13.57 ±2.86	0.207
Flexion deformity	12.29 ±3.01	11.43 ±2.59	0.204
ROM/Pre op	98.43 ±6.27	96.71 ±8.31	0.332
PAIN/PRE op	16.29 ±4.90	18.00 ±4.06	0.117
KS/Pre op	44.77 ±7.24	46.51 ±7.37	0.323
FS/Pre op	40.14 ±10.86	44.29 ±8.06	0.074

Pre op =preoperative, ROM=range of motion, KS=knee score, FS=functional score

Table 2: Comparison of ROM (Range of motion) under same group

Parameters	CR (N=35)	'p' value*	CS (N=35)	'p' value*
	Mean ±SD		Mean ±SD	
ROM/Pre	98.43 ±6.27	--	96.71 ±8.31	--
Pre v/s Post 4	100.57 ±6.74	<0.001	105.66 ±6.80	<0.001
post 4 v/s Post 12	111.86 ±7.28	<0.001	114.71 ±4.84	<0.001
Post 12 v/s Post 6m	111.14 ±6.87	0.134	116.29 ±5.47	0.009

Paired t-test Pre=preoperative, post 4=postoperative 4 weeks, post 12=postoperative weeks, Post 6 m=postoperative 6months.

Table 3: Comparison of pain score between CR and CS group

Parameters	CR (N=35)	CS (N=35)	'p' value*
	Mean ±SD	Mean ±SD	
PAIN/PRE	16.29 ±4.90	18.00 ±4.06	0.117
PAIN/POST 4	36.29 ±4.90	37.29 ±5.19	0.410
PAIN/POST 12	44.71 ±3.42	44.14 ±2.84	0.451
PAIN/POST 6 m	47.57 ±2.81	47.43 ±2.54	0.828

*Unpaired 't' test Pre =preoperative, Post 4=postoperative 4 weeks, post 12=postoperative 12 weeks Post 6 m=postoperative 6 month

Pain score: In our study there was no significant difference in pain score between CR and CS group at 4weeks, 12weeks and 6 months follow up. This concluded that both the procedures were equally good in their respective pain scores.

Table 4: Comparison of knee score between CR and CS group

Parameters	CR (N=35)	CS (N=35)	'p' value*
	Mean ±SD	Mean ±SD	
KS/Pre	44.77 ±7.24	46.51 ±7.37	0.323
KS/Post 4	81.34 ±4.95	82.17 ±5.58	0.513
KS/Post 12	92.03 ±3.65	91.94 ±2.78	0.908
KS/Post 6 m	94.74 ±3.01	95.74 ±2.65	0.145

*Unpaired 't' test

Ks =knee score, Pre =preoperative, Post 4=postoperative 4 weeks, post 12=postoperative 12 weeks, Post 6 m=postoperative 6month

Knee Score: In this study, there was no significant

difference ('p' value=0.513, 0.908, 0.145) in knee score between CR and CS groups at 4weeks, 12weeks and 6months follow up. This concluded that both the procedures were equally good in their respective knee scores.

Table 5: Comparison of functional score between CR and CS group

Parameters	CR (N=35)	CS (N=35)	'p' value*
	Mean ±SD	Mean ±SD	
FS/Pre	40.14±10.86	44.29±8.06	---
FS/Post 4weeks	41.57 ±5.04	41.71 ±4.69	0.074
FS/Post 12 weeks	74.14 ±6.60	74.00 ±6.28	
FS/Post 6 months	86.14 ±7.75	84.57 ±6.57	

*Unpaired 't' test, FS=functional score. Pre =preoperative, post 4=postoperative 4 weeks, post 12=postoperative 12 weeks, Post 6 months=postoperative 6 month

Functional score: In this study, there was no significant difference ('p' value=0.074) in functional score between CR and CS groups at 4weeks, 12weeks and 6months follow up. This concluded that both the procedures were equally good in their respective functional scores.

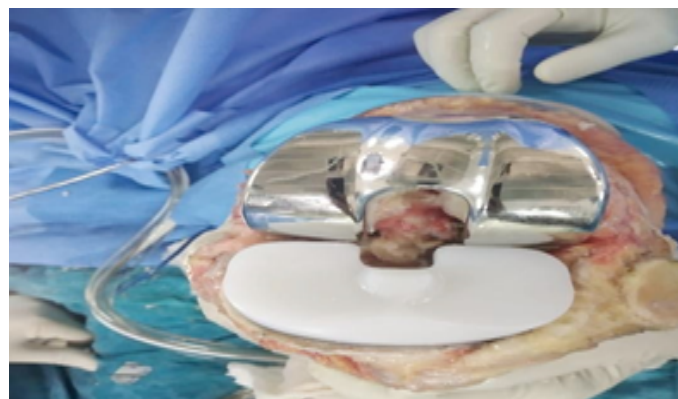


Figure 1: Cruciate Retaining Prosthesis



Figure 2: Cruciate Substitution Prosthesis

Discussion

Total knee Arthroplasty for arthritic patients in whom all the conservative measures are exhausted, is an excellent procedure if proper attention paid to the patient selection. As total knee Arthroplasty is a surface replacement within the existing soft tissue sleeve, it functions within normal anatomic and physiologic boundaries. Impaired functionality after total knee Arthroplasty attributed to sequelae of the arthritic disease, the surgical trauma and the design of the prosthesis. Recent information on the

outcome of minimally invasive procedures suggests the reduction of the surgical trauma offers early improvement and faster rehabilitation. This effect levels off after 3 months to a result similar to that in patients who had a standard exposure. This means factors other than the exposure and extensor mechanism violation are involved in the reduced functionality after total knee Arthroplasty. Various factors are associated with the onset and progression of osteoarthritis. [10-17] These include genetic factors, age, sex, obesity, occupation, abnormal loading of the joint in kneeling, squatting and

cross-legged sitting. [10-17]

The mean age of this study that had osteoarthritis is lesser than the data available from the western population. The earlier onset of osteoarthritis in individuals with normal range of body mass index explained by the habit of kneeling, squatting, cross-legged sitting practiced by the population in this part of the world. Various studies have confirmed the abnormal loading of knee joint during heavy physical activity, particularly kneeling, squatting and cross-legged sitting. It has been theorized that the PCL plays an important role in the femoral roll back mechanism, which is responsible for deep knee flexion. Furthermore, preserving the PCL may improve joint proprioception and thus the clinical outcome [18]. In a study by Condit et al. [19] CR knees were found to be more functional than PS knees in activities of daily living such as squatting, kneeling and gardening. However, in recent prospective studies, a lack of normal femoral roll back was shown in CR knees, no notable difference seen between the CR and PS knees in joint proprioception. [20]. Retention of posterior Cruciate ligament in total knee Arthroplasty, advocated as a way to transmit load through the ligament to the tibia, to encourage femoral component rollback to increase flexion, and to assist in maintaining the joint line. Retention of posterior cruciate ligament results in a central contact area of the femur on the tibia that helps to distribute load evenly on the tibial component. In our study flexion and standing view radiographs taken postoperatively for all patients. PCL retained cases exhibits femoral rollback when compared to the PCL sacrificed knees. In 99% of the virgin arthritic knees requiring Arthroplasty including rheumatoid posterior cruciate ligament was found to be intact. [21] The intact PCL may have to be sacrificed in rare instances. We have used the scoring system as advocated by the American knee society. [22] According to this system only three main parameters pain, stability, range of motion judged. Flexion contracture, extension lag and misalignment dealt with as deductions. Thus, 100 points given to knee with no pain, 125 degrees of motion and less than 5mm of anteroposterior and 5 degrees of mediolateral instability. Functional score considers walking distance and stair climbing with deductions for walking aids. The maximum functional score 100 is given to patients who can walk unlimited distance and go up and down stairs normally. Although some advocate retaining the posterior Cruciate ligament in all patients and others argue for posterior Cruciate ligament sacrifice and substitution in all patients Laksin et al [23] suggest a more appropriate approach in which implant design selection based on an individual's pathologic criteria. In our study, posterior Cruciate ligament sacrifice was done in patients who had severe end stage degenerative arthritis, valgus and Varus deformities of more than 25 de-

grees, where surgical exposure is challenging and balancing soft tissue is difficult. All 52 patients evaluated preoperatively and postoperatively using knee society score and functional score. There was Statistically no significant differences in the mean pain score ('p' value=0.410, 0.451, 0.828), mean knee score ('p' value=0.513, 0.908, 0.145) and mean functional score ('p' value=0.074) observed 4 weeks, 12 weeks and 6 months follow up between the cruciate retained and substitution group total knee Arthroplasty. In addition to this, there was significant improvement ('p' value=<0.001) in pain score (16.29 to 47.57), knee score (44.77 to 94.74) and functional score (40.14 to 86.14) between pre-operative and postoperatively observe under CR group TKA similarly pain score (18.00 to 47.43), knee score (46.51 to 95.74) and functional score (44.29 to 84.57) under CS group TKA at 6 month.

Significantly, greater improvement in range of movement from preoperative to most recent follow-up assessment seen in patients in the posterior cruciate substituting group TKA compared to the retaining group. There was postoperative improvement in the range of motion of CR and CS knee at 4 weeks, 12 weeks and 6 months. The respective 'p' value* were 0.003, 0.058, <0.001. A statistically significant difference (p= <0.001) was observed between mean range of motion of the CR and CS knee at 6 months follow-up. At six months, mean range of motion in CR group was 111.14 and in CS group was 116.29. (Table 2) Several other studies have directly compared the two prosthetic designs, with mixed results. did prospective, randomized comparison of posterior cruciate-retaining (PCR) and posterior stabilized (PS) total knee arthroplasties (TKAs) conducted in 20 patients who underwent bilateral TKAs for osteoarthritis (One knee was implanted with a PCR TKA, and a contralateral knee with a PS TKA). Patients had a clinical and radiographic evaluation at a mean of 31.7 months for PCR TKAs and 30.6 months for PS TKAs postoperatively and there were no significant differences between the PCR and PS TKAs in postoperative knee scores. However, postoperative improvement in range of motion was significantly superior in the PS group (131° versus 122°, p<0.05). Yoshiya et al [21] performed in vivo kinematic analysis of 20 patients who underwent bilateral total knee arthroplasties with a posterior-stabilized implant in one knee and a cruciate-retaining implant in the other. In the PCR TKA, an anterior femoral translation from 30 degrees to 60 degrees of flexion was observed in the weight-bearing condition indicating that the PCL might not be functioning while flexion kinematics for the PS TKA was more stable characterized by the maintenance of a constant contact position under weight bearing conditions and posterior femoral rollback in passive flexion. They also found a greater range of motion of the knees that had posterior-stabilized

implants ($131^{\circ}\pm 12^{\circ}$ versus $121^{\circ}\pm 16^{\circ}$). But the average age of our total knee Arthroplasty patients is less when compared to Western literature; the need of revision will be more. Hence, in posterior cruciate retaining Arthroplasty, less bone cut as compared to Cruciate substituting Arthroplasty and the bone stock was preserved. So that in subsequent Arthroplasty, revision will be easier in Cruciate substitution Arthroplasty.

Conclusion

Both designs give equal and good results. We preferred CR Knees in relatively young patients and patients with smaller knees as its bone conserving implant and CS knees in patients with Inflammatory arthritis, patient with severe Varus or flexion deformity, when tibia cut is more than 10 mm and when intra-operatively findings suggestive of non-functional posterior Cruciate ligament. However, in our short term randomized interventional study Posterior Cruciate substitution Total Knee Arthroplasty had a marginally better outcome than the posterior cruciate retaining in terms of range of motion but it needs a long-term analysis.

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