Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 1, 2021, Pages. 2448 - 2461
Received 15 December 2020; Accepted 05 January 2021.

A PROSPECTIVE STUDY OF FUNCTIONAL, RADIOLOGICAL AND CLINICAL OUTCOMES IN PCL RETAINING VERSUS PCL SUBSTITUTING TECHNIQUE IN TOTAL KNEE REPLACEMENTS(TKR)

HariPrasath P[1], Madhukar A[2*]
[1,2]Department of Orthopaedics,SreeBalaji Medical College & Hospital, Chromepet, Chennai, India
*madhukar.ortho@bharathuniv.ac.in

ABSTRACT

The purpose of the study is to prospectively compare the functional, clinical and radiological outcomes between posterior cruciate ligament retaining and posterior cruciate ligament sacrificing total knee arthroplasty and also study includes a comparison of outcomes in pain, stability between two groups.

Keywords
radiological outcomes, total knee arthroplasty, posterior cruciate ligament (PCL), Kneeling, Osteoarthritis

INTRODUCTION

The most common complaint or symptom with which patients present themselves to the physician is pain, along with swelling, reduction in function and movement of the affected and symptomatic knee. The common causes of arthritis are Osteoarthritis(OA), followed by Rheumatoid arthritis(RA), juvenile rheumatoid arthritis, post-traumatic arthritis otherwise known as secondary osteoarthritis and all other types of inflammatory arthritis of the knee joint[1].Total knee Replacement(TKR) over the past decades has become a reliable surgical option and accepted unanimously as the treatment for a severely arthritic knee. The successful outcome of treatment is determined by various factors like pain relief, restoring the normal kinematics like the range of movement and function. Total knee Replacement(TKR) gives pain relief, reasonable improvement of the function in patients with severe progressive degenerative changes [2].

The main goal of total knee arthroplasties is the achievement of stable tibiofemoral and patellofemoral joints, which relies on accurately aligning these joint components and balancing the soft tissues. In order to achieve these criteria, it is important to utilize appropriate surgical techniques and well-designed implants [3]

Over the past 30 years, there have been many changes to the procedures and implant choices in TKA including modularity and size options, improved cementing techniques and deformity correction, rotational alignment and in-depth knowledge about the geometry of the component.

The role of Posterior cruciate ligament(PCL) in Total knee arthroplasty(TKR) is debatable. Preservation of the ligament is believed to enhance stability, femoral rollback, quadriceps muscle's mechanical superiority and proprioceptive characteristics[4,5,6]. This in return reduces excessive polyethylene wear and loosening by reducing the shear stresses at the surfaces. The other choice is to remove the ligament completely, this simplifies the fixed deformities correction[7]. This allows more precise and reliable soft tissue balancing resulting in improved fixation of the components. The 3rd possibility is to remove the ligament and replace it with a posterior stabilized implant insert's over the tibia. These implant inserts have a central cam post in which the femoral cam can engage during flexion, which aids in mimicking femoral rollback in return reproducing near-normal knee kinematic profiles[8]. The tibial central post also allows stability to a degree in the antero-posterior plane and works as a secondary stabilizer to a varus or valgus force[8,9].

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 1, 2021, Pages. 2448 - 2461
Received 15 December 2020; Accepted 05 January 2021.

The 4th option is a compromise between preservation and excision by releasing the ligaments [10].

MATERIALS AND METHODS

This is a prospective study done at SreeBalaji Medical College from July 2017 to September 2019, which includes 40 patients admitted to our hospital for Total knee Arthroplasty (TKR).

Inclusion criteria:
1) Osteoarthritis & Rheumatoid arthritis
2) Age> 50 years
3) Kellegran and Lawrence score Grade 3 and 4

Exclusion Criteria:
1) Poor skin conditions
2) Post-traumatic arthritis
3) Varicose veins
4) Medically unfit

Criteria For Retaining PCL
1) Structurally intact Posterior cruciate ligament
2) Fixed flexion deformity of less than 150
3) Varus of less than 100
4) Valgus of less than 100

Criteria For Sacrificing PCL
1) Fixed flexion deformity (FFD) of more than 15^0
2) Valgus or varus more than 10^0
3) Structurally contracted PCL or Lax PCL
4) Technical inability to properly balance PCL

During the prospective study period, 44 knees were replaced in 42 patients. Of them, 3 patients with 4 total knee replacement lost follow-up. Others had regular follow up and were taken into study. The final study was on 40 knees in 39 patients which included 1 bilateral and 38 unilateral cases.The patients who did not turn for follow-up are omitted from the study. This included 3 patients with 4 knees.
Initial Preoperative BMI of the patients recorded during the admission as per guidelines. The scoring system formulated by the American knee society(KS) used to evaluate the patients before and after surgery. Both knee scores and functional scores calculated with each amounting to 100 points.Preoperative full height lower-limb weight-bearing radiograph from hip to ankle taken in all patients who underwent knee replacement surgery, and mechanical axis was drawn and the varus\valgus deformity was calculated. Radiological grading as suggested by Kellegren and Lawrence was used to evaluate and grade from I to IV as follows The results were analyzed statistically using SSPS -17 (Statistics Package for Social Sciences) software and using
1) chi-square for discrete variables
2) 't' test for continuous variables
3) Bivariate correlation to find out the measure of the agreement was done

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 1, 2021, Pages. 2448 - 2461
Received 15 December 2020; Accepted 05 January 2021.

All the cases were investigated and comorbid medical conditions were evaluated brought under control before surgery. Presence of any skin lesions, varicose veins were ruled out prior to surgery. All the 40 cases were operated upon by 2 different teams of orthopedic surgeons during the period of study. All the cases were done under tourniquet control using a pneumatic tourniquet. Anesthesia by either Ligament balancing and bone cuts were performed depending on the severity of the deformity. After checking stability with trial implants, appropriate implants were fixed with cement and checked for stability. Tourniquet removed, hemostasis achieved and wound closed in layers.

Post operative Evaluation

Standard postoperative protocol followed as advised by the American knee society. All the patients were given temporary immobilization using a knee brace for first 48 hours. First look of the wound and removal of the drain were done on the 2nd POD. During the instant post-operative period, a bolster was kept under the ankle to prevent flexion. From POD1 Quadriceps strengthening exercises were encouraged. Active knee mobilization was started on the 2nd or 3rd POD as per the patient compliance.Supportive ambulation using a walker was allowed on the 2nd POD. Patients discharged after suture removal on the 12th postoperative day and reviewed at 6th week, 3rd month, 6th month, 1 year.Post-operative follow up was done monthly during the initial three months. All patients were evaluated post-operatively for the range of movements, relief of pain and scoring did as per Knee Society Knee Score, Knee Functional Score was done in all patients after an average of 3 months from the date of surgery and at the end of 1 year.

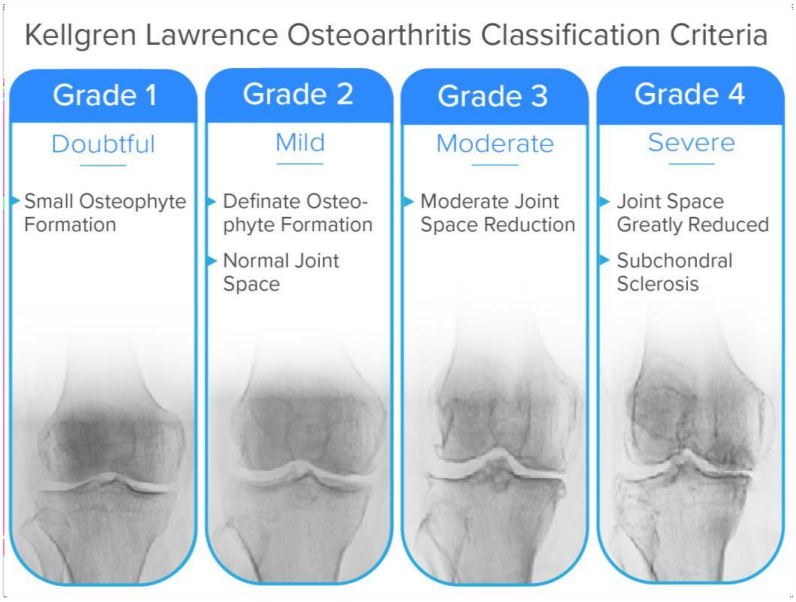


Fig 32: KL Grading for Arthritic Knee

Age Group Range :

Range - 52 years to 75 years
Mean - 63.11 years

Age Group Ratio

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 1, 2021, Pages. 2448 - 2461
Received 15 December 2020; Accepted 05 January 2021.

TABLE 1: Distribution of patients Age-wise

AGE(YEARS)	NUMBER 'n'	PERCENTAGE (%)
51 – 60	10	25%
61 – 70	14	37.5%
71 – 75	16	37.5%
TOTAL	40	100%

The age of the patients who underwent total knee arthroplasty(TKR) in our series ranged from 52 to 75 years; the mean was 63.11 years. More than 70% of the patients belonged to 61-75years.

Sex Ratio

TABLE 2: Distribution of patients based on sex

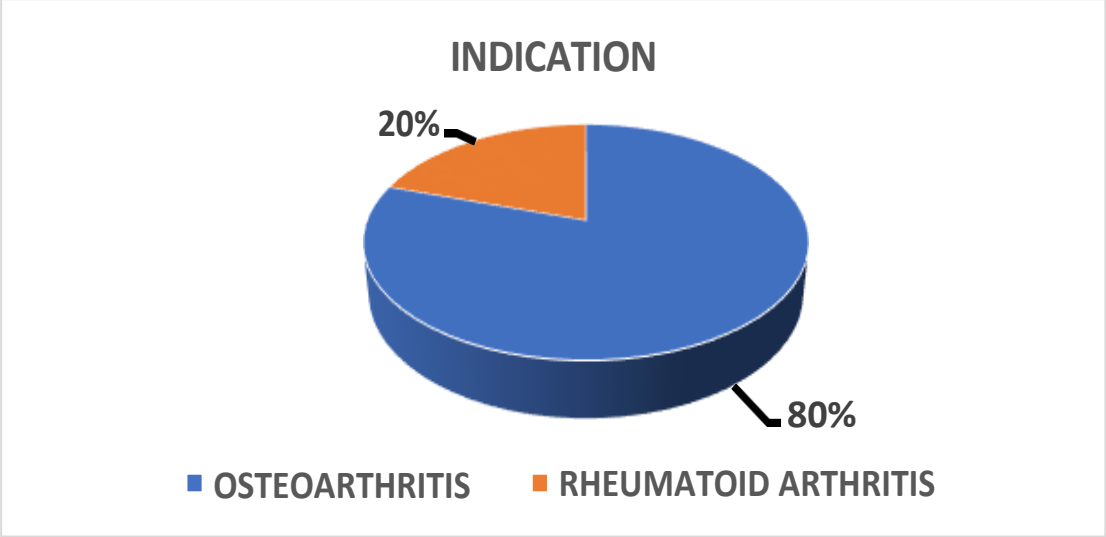
SEX	NUMBER ('n')	PERCENTAGE (%)
MALE	15	37.5%
FEMALE	25	62.5%
TOTAL	40	100%

Indications

TABLE: 3 Distribution of patients based on Indication.

DISEASE	NUMBER ('n')	PERCENTAGE (%)
OSTEOARTHRITIS	32	80%
RHEUMATOID ARTHRITIS	08	20%
TOTAL	40	100%

CHART 1: Distribution of Indication.



Side:

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 1, 2021, Pages. 2448 - 2461
Received 15 December 2020; Accepted 05 January 2021.

TABLE 4: Distribution of patients based on the side

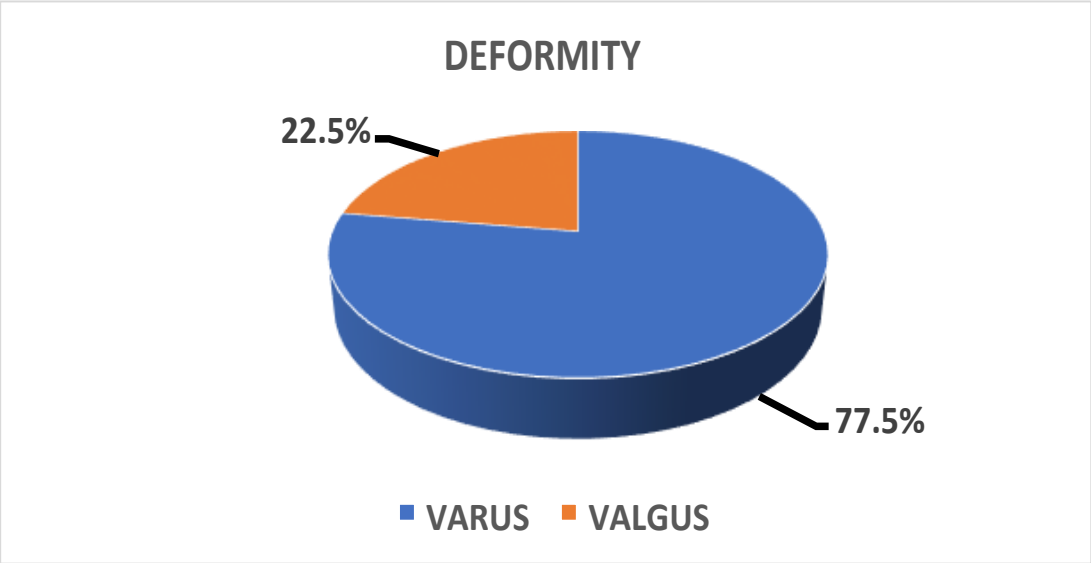
SIDE	NUMBER ('n')	PERCENTAGE (%)
LEFT	22	45%
RIGHT	18	55%
TOTAL	40	100%

Deformity

TABLE 5: Distribution of patients based on the type of deformity

DEFORMITY	$<10^0$ ('n')	$>10^0$ ('n')	TOTAL ('n')	PERCENTAGE(%)
VARUS	09	22	31	77.5%
VALGUS	05	04	09	22.5%
TOTAL	14	26	40	100%

CHART 2: Distribution of Deformity.



Kellegren and Lawrence Scoring

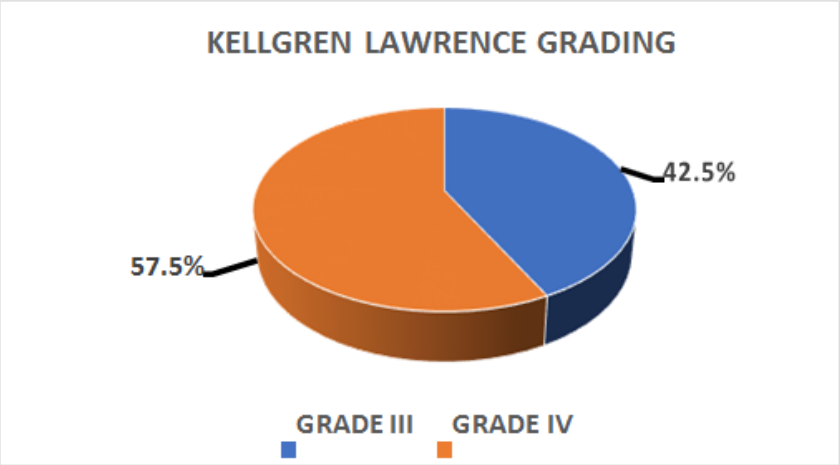
The severity of the arthritis was assessed with the Kellegren and Lawrence scoring system which showed that 61% (n=16) of our patient had grade IV arthritis while admission.

TABLE 6: Distribution based on KL Grading of knees

GRADE	NUMBER ('n')	PERCENTAGE (%)
I	NOT INCLUDED	NOT APPLICABLE
II	NOT INCLUDED	NOT APPLICABLE
III	17	42.5%
IV	23	57.5%
TOTAL	40	100%

CHART 3: Distribution of KL Grade.

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 1, 2021, Pages. 2448 - 2461
Received 15 December 2020; Accepted 05 January 2021.

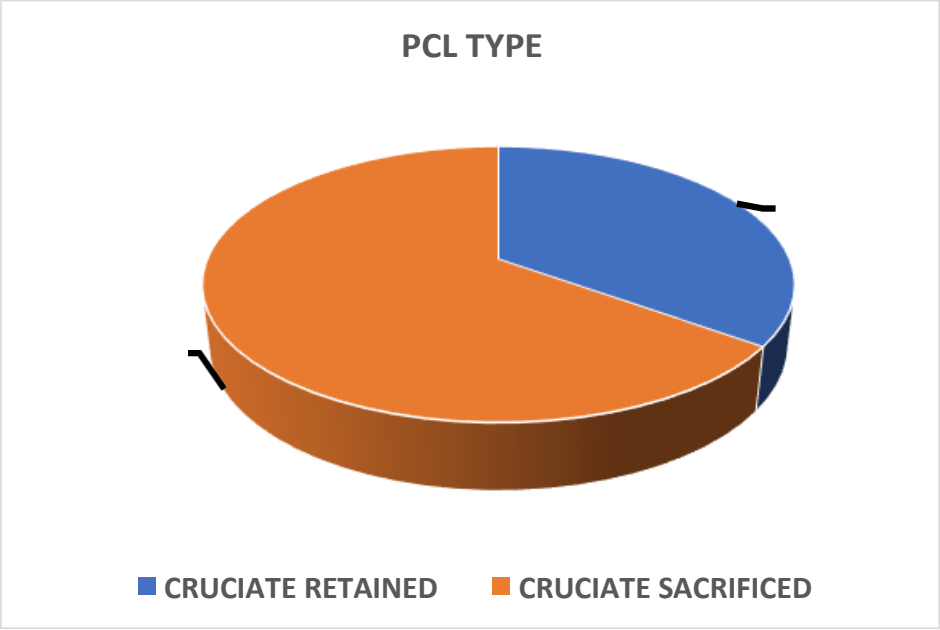


PCL was retained in 14 patients who had minimal deformities with no flexion contracture pre-operatively and PCL was sacrificed in 26 patients. PCL retaining prosthesis was applied for all the 14 whom PCL was retained. Bone cement was applied in all 40 cases.

TABLE:7 Distribution based on the type of procedure

TYPE	NUMBER ('n')	PERCENTAGE (%)
CRUCIATE RETAINING(CR)	14	35%
CRUCIATE SACRIFICING(CS)	26	65%
TOTAL	40	100%

CHART:4 Distribution of procedure



Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 1, 2021, Pages. 2448 - 2461
Received 15 December 2020; Accepted 05 January 2021.

RESULTS

All the 40 cases which had regular follow up were taken up for the study and the average follow up was from a minimum of 12 months to 30 months. Among the 40 cases which received total knee replacement, for 14 knees the procedure was done using a cruciate retaining prosthesis retaining the Posterior cruciate ligament (PCL) and in the rest 26 knees, it was sacrificed. Total knee arthroplasty was performed on 32 knees for osteoarthritis and 8 for rheumatoid arthritis. Out of which 31 knees had varus and 9 knees had a valgus deformity.

American knee society (KS) scoring and the functional knee (FS) score was used to compare the functional outcome between the posterior cruciate-retaining (CR) and the cruciate-sacrificing (CS) groups.

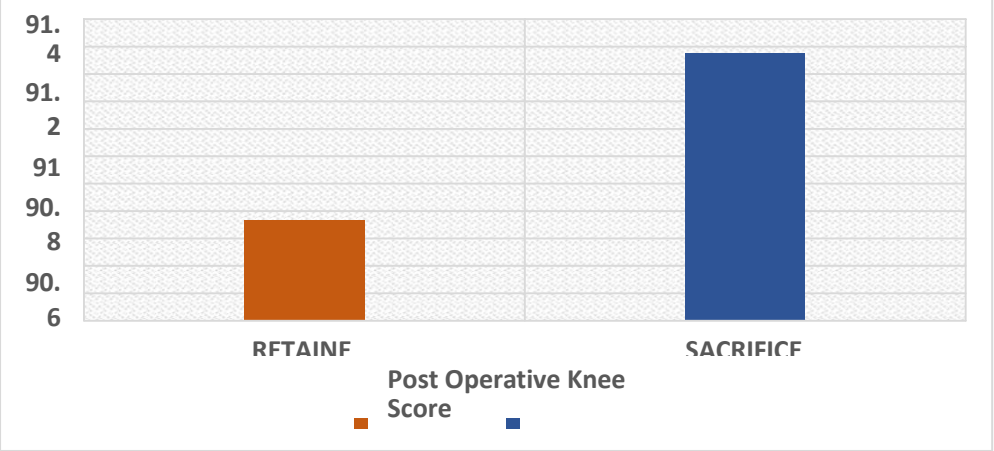
Knee Society Score

All patients evaluated by the scoring system proposed by The American Knee society. Details of the format are given below in annexure.

TABLE 8: Comparison of Knee society score (KS).

GROUP		KNEE SCORE(KS)
PREOPERATIVE		41.75
POST- OPERATIVE	RETAINED	89.93
	SACRIFICED	91.15

CHART 5: Knee society score comparison.



The average knee score was 91.15 for Posterior Cruciate Sacrificed group and 89.93 for the Cruciate Retained group of patients, as compared with the pre-operative score of 41.75.

Functional Score

All patients evaluated by scoring system proposed by The American Knee society – Functional score. Details of the format is given below

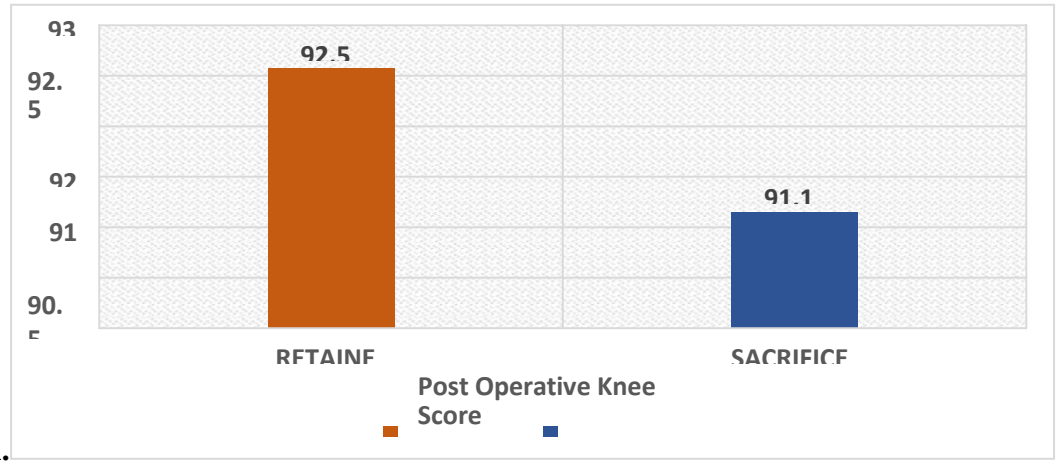
TABLE 9: Comparison of Functional Knee Score (FS)

	FUNCTIONAL SCORE(FS)
PREOPERATIVE	47.92

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 1, 2021, Pages. 2448 - 2461
Received 15 December 2020; Accepted 05 January 2021.

POST- OPERATIVE	**RETAINED**	92.57
	SACRIFICED	94.80

CHART 6: Functional Score



comparison.

The Functional knee score was 94.80 for Posterior Cruciate Sacrificed group and 92.57 for the Cruciate Retained group of patients as compared to the pre-operative score of 47.92

Pain Score

In total, all the patients in both groups had excellent improvements in the knee scores. The pain score in the Posterior cruciate sacrificing was on average 48.26 and that of Cruciate Retained group was 46.428 out of total score 50, higher is better. Preoperative pain score mean was 36.12

TABLE 10: Comparison of Pain Score

GROUP	MEAN PAIN SCORE
RETAINED (CR)	46.428
SACRIFICED (CS)	48.26

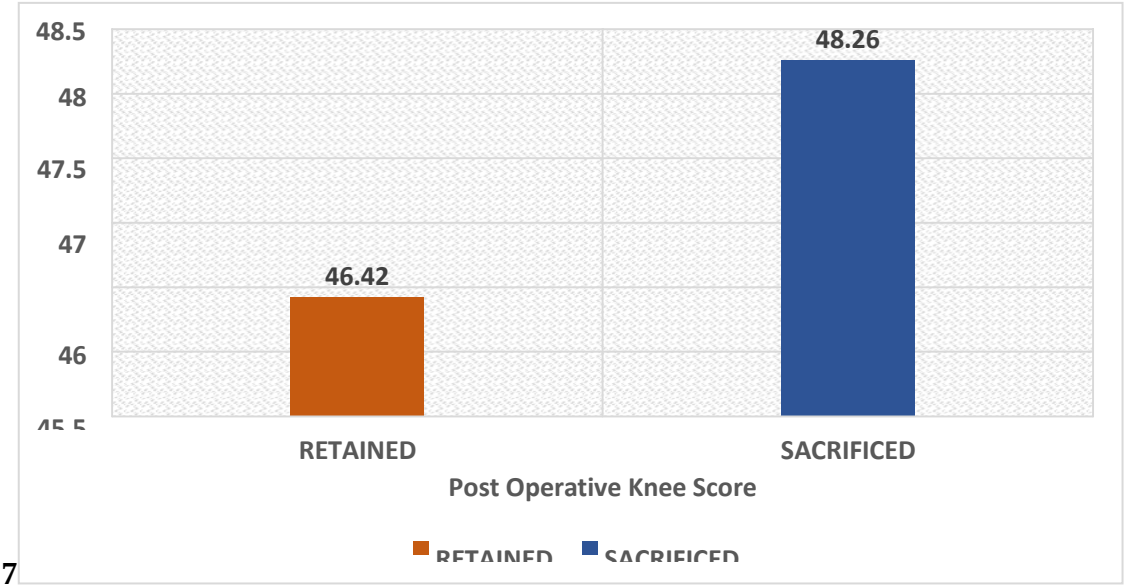


CHART:7

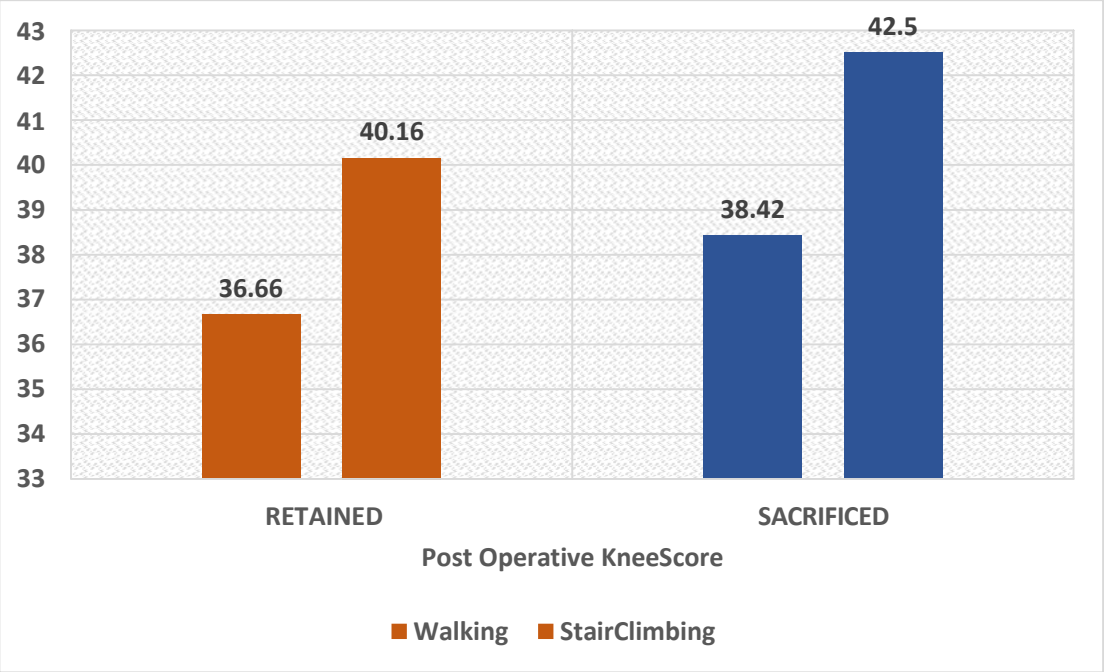
Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 1, 2021, Pages. 2448 - 2461
Received 15 December 2020; Accepted 05 January 2021.

Walking and Stair Climbing

TABLE:11

GROUP	WALKING	STAIR CLIMBING
RETAINED	36.66	40.16
SACRIFICED	38.42	42.50

CHART 8: Comparison of Walking and Stair Climbing



Range of Movements

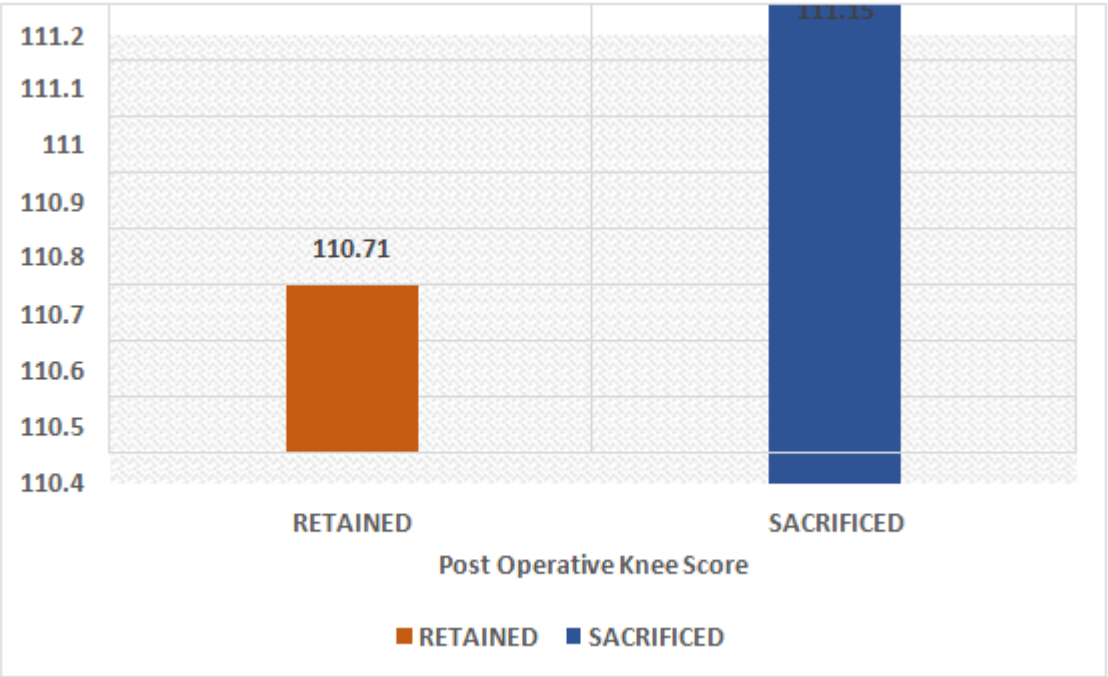
The mean range of movements in both groups had a great improvement with postoperative ROM of 111.150 and 110.710 in PCL sacrificing and retaining groups respectively compared to preoperative ROM of 74.50.

TABLE 12: x

GROUP	MEAN ROM (in Degrees)
RETAINED	110.71^0
SACRIFICED	111.15^0

CHART 9: ROM comparison between two groups

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 1, 2021, Pages. 2448 - 2461
Received 15 December 2020; Accepted 05 January 2021.



DISCUSSION

Total knee arthroplasty(TKR) for arthritic patients in whom all non- operative methods and options have been tried and failed, is an excellent procedure if done in appropriately selected patients.As total knee arthroplasty(TKR) functions and operates within normal anatomical and mechanical boundaries as it is a surface replacement within the existing soft tissue cover. Impaired function after total knee arthroplasty(TKR) is due to the nature 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 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 incision exposure. This means aspects other than the incision size and trauma to quadriceps while exposure are responsible for impaired functionality after total knee arthroplasty(TKR).

Various factors are associated with the onset and progression of osteoarthritis[46-52]. These include genetic factors, age, sex, obesity, occupation, abnormal loading of the joint in kneeling, squatting and cross- legged sitting. The mean age of our patients who had osteoarthritis is lesser than the data available from the western population. The earlier onset of osteoarthritis in individuals with a 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 the knee joint during heavy physical activity, particularly kneeling, squatting and cross-legged sitting.[46-52] Eckstein et al in his study on the Vivo cartilage deformation during different types of physical and house activity noted that the pattern of patellar cartilage deformation corresponds to the range of motion(ROM) involved in a particular activity.

Out of 40 patients, 23 had complete obliteration of joint space at the time of presentation which corresponds to GRADE IV, due to lack of awareness about the nature of the disease and about

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 1, 2021, Pages. 2448 - 2461
Received 15 December 2020; Accepted 05 January 2021.

the availability of the various treatment modalities including surgery. Low socioeconomic status and illiteracy may be one of the responsible factors for this.

Retention of posterior cruciate ligament (PCL) 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. Retaining the posterior cruciate ligament (PCL) results in a central contact area of the femur over tibia that helps to distribute load evenly on the tibial component. In our study, flexion and standing view radiographs are taken postoperatively for all patients. PCL retained cases exhibits increased femoral rollback when compared to the PCL sacrificed knees. In patients with valgus or varus deformity, PCL can cause an imbalance between the flexion and extension spaces as it can be contracted in coronal plane deformities which make cruciate retention difficult. In a study by Scott and Volatile(1988) showed that with a severe fixed angular deformity in spite of appropriate soft tissue release, the Posterior Cruciate Ligament (PCL) acts as a tether and impedes proper medial and lateral balancing on the concave side of the deformity[53].In our experience, this has occurred with every knee that has presented with angular deformity of >15 degrees and required medial and lateral release.

Various scoring system are in vogue to assess the outcome of Total Knee Arthroplasty namely The American Knee Society (KS) Score, Function Knee Society (FS) Scoring, Western-Ontario, and McMaster OA index (WOMAC), The Hospital for Special Surgery Rating System Knee injury and Osteoarthritis Outcome Score (KOOS), Oxford 12-item Knee Questionnaire.

We have used the scoring system as advocated by the American knee society. According to this system only three main parameters pain, stability, range of motion judged. Appropriate deductions should be done for Fixed Flexion contracture. And also deducted for extension lag and misalignment of the limb post-operatively. The maximum score of 100 is given when the knee is pain-free with 1250 of motion, <5mm of Antero- posterior instability and 50 of varus\valgus stability. The functional score considers walking distance and stair climbing with deductions for walking aids. The maximum functional score of 100 is given to patients who can walk up and down the steps and can walk for unlimited distance.

Although some advocate retaining the posterior cruciate ligament in all patients and others argue for Posterior cruciate ligament (PCL) sacrifice and substitution in all patients Laskin et al 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 15 degrees, where surgical exposure is challenging and balancing soft tissues are difficult.

Analyzing the functional outcome, it was found that all the patients in both the CR and CS groups had significant improvement in their knee score and the functional knee score. On comparison between the two groups, in those patients in whom the cruciate ligament (PCL) was sacrificed had an average knee score of 91.15 and a Functional Knee Score of 94.80, whereas in whom the posterior cruciate ligament was retained the knee score was 89.93 and the functional score was 92.57. The total Knee

Scores statistical analysis(SPSS) showed a significant difference in the p-value(0.04) in favor of Cruciate Sacrificing(CS) Prosthesis signifying that Cruciate Sacrificing(CS) implant has better functional results. The functional knee society also showed a marked improvement in all patients. But Statistically, there was no significant difference All patients in the study in both the groups had marked improvement in pain score from their pre-operative level, Cruciate sacrificed(CS) had marginal better scores when compared to the retained(CS) group in pain score, with an

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 1, 2021, Pages. 2448 - 2461
Received 15 December 2020; Accepted 05 January 2021.

average of 48.26 in CS group as compared to 46.43 in CR group. Statistical analysis revealed no significant difference in a p- value for all the variables of pain score.

We were able to achieve flexion of 1000 to 1200 in all our patients. Statistically, there was not much difference between CR and CS groups. The mean scores were 110.710 for the retained (CR) group and 111.150 for sacrificed (CS) group which showed minimal better results in the sacrificed group. Our results are comparable with Hirsch et al., who in his study compared two groups in regard to ROM and found that patients in the PCL-retaining group had 102 degrees of motion, while the PS design averaged 112 degrees. Bolanos et al. in his study found no substantial difference in the range of motion, level walking and stairs between CR and PS [56].Antero-posterior and medio-lateral instability do not show any differences in both groups. Posterior migration of tibia on flexing the knee is very well obvious radiologically in sacrificed (CS) group indicating Posterior cruciate ligament's function as to resist translational displacement. But better improvement in flexion from preoperative to most recent follow-up assessment seen in patients in the posterior cruciate sacrificed (CS) group compared to the retained (CR) group. In addition, a significantly greater improvement in stair climbing and the mean functional score in cruciate sacrificed arthroplasty groups.

In 1993 Ranawat and colleagues reported a 94% 15-year survival of 112 PCL sacrificed prostheses [42]. Rand evaluated a series of cruciate sparing arthroplasties and found a 96% survival at 10 years [43].Charles Engh has observed that before any technique is to be adopted or recommended there must be a minimum follow up of ten years [55]. Ours is a small series with a maximum follow-up of only 18 months, we cannot draw any conclusion from our findings.

CONCLUSION

Total Knee Arthroplasty in patients in whom posterior cruciate ligament was sacrificed was found to have a slightly better functional outcome as compared to the retaining group.In the Indian scenario where knee replacement is done at a late stage of osteoarthritis, sacrificing the contracted posterior cruciate ligament has better outcomes as compared to retaining it.It is difficult to retain the cruciate (PCL) as maintaining the normal anatomical configuration and native tension must be reproduced or retained with the help of ligament tensioners. Cruciate sacrificing (CS) stabilized design is a more straight forward technique when compared to retaining (CR) as it needs extensive knowledge and experience of the same before we can expect superior results.Finally, our study is in a small number of cases with short duration and further follow up is necessitated.

Funding: No funding sources

Ethical approval: The study was approved by the Institutional Ethics Committee

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGMENTS

The encouragement and support from Bharath University, Chennai is gratefully acknowledged. For provided the laboratory facilities to carry out the research work.

REFERENCES

[1] Vail TP, Lang JE. Insall and Scott surgery of the knee. 4th ed.

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 1, 2021, Pages. 2448 - 2461
Received 15 December 2020; Accepted 05 January 2021.

[2] Philadelphia: Churchill Livingstone, Elsevier; 2006: 1455-1521.
[3] Comparison of PCL sparing and PCL substituting implants for total knee replacement, ON Nagi, Mandeep S Dhillon, Vinod Kumar, Department of Orthopedics, PGIMER, Chandigarh.
[4] Insall J, Lachiewicz P, Burstein A. The posterior stabilized condylar prosthesis: a modification of the total condylar design. Two to four year clinical experience. J Bone Joint Surg. 1982;64:1317–23.
[5] Insall J, Ranawat CS, Scott WN, Walker P. Total condylar knee replacement. Preliminary report. ClinOrthopRelat Res. 1976;120:149-54.
[6] Bijlsma JW, Berenbaum F, Lafeber FP. Osteoarthritis: an update with relevance for clinical practice. Lancet. 201;377:2115-26.
[7] InsallJN : Presidential address to the knee society : choices and compromises in total knee arthroplasty. ClinOrthop. 1989; 248: 13-14.
[8] Lew WD, Lewis JL: The effect of knee-prosthesis geometry on cruciate ligament mechanics during flexion. J Bone Joint Surg [Am] 1982, 64A:734.
[9] Insall JN, Scott WN: Surgery of the knee. Second edition. Church- ill Livingstone, New York; 1993. wear in total knee replacements. ClinOrthRelat Res 1991, 273:253.
[10] Andriacchi TP, Galante JO: Retention of the posterior cruciate in total knee arthroplasty. J Arthroplasty 1988:S13.
[11] Larsen E., Lund P.M.: Clinical Anatomy. ClinOrthopRelat Res 1986; 213:150-153.
[12] Campbells Operative Orthopaedics, Eleventh Edition
[13] Rockwood and Green Fractures in adults, Eleventh Edition
[14] Whiteside LA, Arima J. The anteroposterior axis for femoral rotational alignment in valgus total knee arthroplasty. ClinOrthopRelat Res 1995; (321):168-172.
[15] Becker MW, Insall JN, Faris PM: Bilateral total knee arthroplasty: One cruciate retaining and one cruciate substituting. ClinOrthop 271:122– 124, 1991.
[16] Wilson S, et al.: Comprehensive gait analysis in posterior-stabilized knee arthroplasty. J Arthroplasty 11:359–367, 1996.
[17] Swany MR and Scott RD: Posterior polyethylene wear in posterior cruciate ligament retaining total knee arthroplasty. A case study. J Arthroplasty 8:439–446, 1993.
[18] Corces A, Lotke PA, Williams J: Strain characteristics of the posterior cruciate ligament in total knee replacement. Orthop Trans 13:527, 1989.
[19] Marmor LE. Marmor modular knee in unicompartmental disease.
[20] Minimum four-year follow-up. The Journal of bone and joint surgery. American volume. 1979 Apr;61(3):347-53.
[21] Freeman MAR, Insall JN, Besser W, Walker PS, HallelT : Excision of the cruciate ligament in total knee replacement. ClinOrthop. 1977;126:209-212.
[22] Bourne MH, Rand JA, Listrup DM: Posterior cruciate condylar total knee arthroplasty :five years results. ClinOrthop. 1988; 234 : 129-133.
[23] Fergussen M: excision of knee joint : recovery with false joint and useful limb, Med Times Gaz 1: 601, 1861

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 1, 2021, Pages. 2448 - 2461
Received 15 December 2020; Accepted 05 January 2021.

[24] Verneuil A: Resultats obtain for France par 1'operation d'esmarch: examen des causes d'insuccess et moyend'yremedier, Gas hebd med chir 10: 97,1863.
[25] Smith-Peterson MN: Arthroplasty of hip : a new method, J Bone Joint Surg 31:269,1939.