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A Prospective Comparative Study of Functional Outcome of Cruciate Retaining Total Knee Replacement Using Standard Bearing Insert Versus Anterior Stabilising Insert Of Tibial Component

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AIM -
The aim of this study is to compare the functional outcome of patients undergoing cruciate retaining Total Knee replacement with standard bearing insert versus anterior stabilizing insert for a follow up period of 1 year and results evaluated by WOMAC and Functional Knee Score questionnaire.

I. Introduction

Total knee replacement has an established place in treatment of degenerative knee disease and is considered to be an effective intervention to relieve pain and improve mobility[1]. There is no consensus regarding preservation or removal of posterior cruciate ligament in primary total knee arthroplasty[2]. Depending on the surgeon's preference, the posterior cruciate ligament can be retained or sacrificed and a posterior stabilizing prosthesis with a cam can be used[3,4,5].

The functionality of a preserved posterior cruciate ligament with a cadaveric study reveals normal posterior cruciate ligament strain in only 37% of cruciate retaining total knee replacement[6].

Proponents of posterior cruciate ligament retaining in total knee replacements state that posterior cruciate ligament retention preserves more normal knee kinematics, is associated with fewer patellar complications, reduces shear forces at bone- tibial-implant interface and the posterior cruciate ligament has an important proprioceptive function[7,8,9,10]. The disadvantages of posterior cruciate sacrificing total knee replacements are, patellar clunk syndrome[11,12], increased polyethylene wear[13], and additional bone resection[14].

In posterior cruciate ligament retaining total knee replacement, the surgeon must carefully assess the posterior cruciate ligament and if found to be absent or incompetent, then an increases level of constraint may be achieved by use of a posterior cruciate ligament sacrificing implant[7,15].

BIOMECHANICS –
The shaft of the Femur is placed in a slight oblique direction (90 valgus to the mechanical axis) in such a way that the femoral condyles are towards the vertical axis of the body and hence the lateral condyle of the femur is more in line with the femoral head. To maintain the distal end of femur in a horizontal plane the medial condyle extends far distally than the lateral condyle[22,23].

The articular surface of the lateral femoral condyle is smaller than the articular surface of the medial femoral condyle. When the femur is examined through an inferior view, it can be seen that the lateral tibial surface ends before the medial condyle.

The Knee Joint is a double condyloid Joint with freedom of angular motion in three planes namely sagittal, transverse and frontal planes

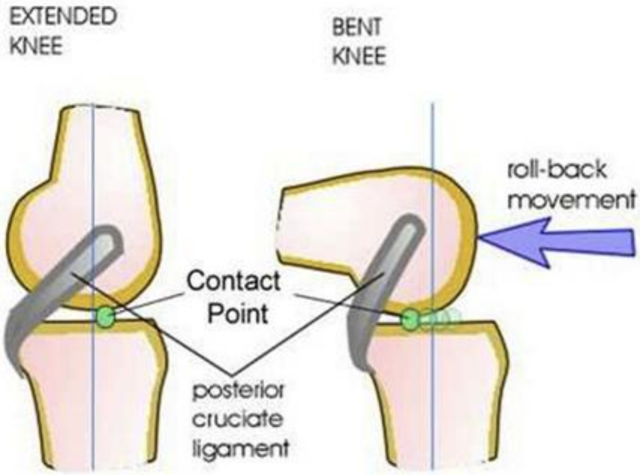
1. Sagittal Plane: The primary movement occurring in the knee joint is Flexion/Extension, the axis for this movement can be simplified as a horizontal line passing through the femoral medial and lateral epicondyles. Though the transepicondylar axis represents the axis for flexion and extension, this axis is not truly fixed but keeps shifting during range of motion which is because of the incongruent large articular surface of femur and small tibial condyle creating a problem when the femur flexes on the fixed tibia.

The first 25° of knee flexion occurs primarily as rolling of the femoral condyles on the tibia bringing the femoral condyles posteriorly on the tibial condyle. When flexion is continued, the rolling of the femoral condyle is accompanied by a simultaneous anterior glide that creates a nearly pure spin of the femur on the posterior Tibia with little linear displacement of the femoral condyles after 25° of flexion. Extension of the Knee from Flexion is essentially a reversal of this motion[35,36,37].

FEMORAL ROLL BACK

Normal Knee:

As the normal knee flexes, femoral rollback occurs. The lateral femoral condyle, having a larger radius of curvature, rolls back farther posterior than the medial femoral condyle. This rollback is guided by the posterior cruciate ligament (PCL). The asymmetric rollback results in the tibia internally rotating relative to the femur during flexion[23,33,34,35].



If the TKR is posteriorly unstable, paradoxical anterior slide of the femur on the tibia occurs and normal knee kinematics does not get exhibited. This paradoxical anterior slide of the femur on the tibia during flexion may be a cause of instability

1. Difficulty with climbing stairs and inclines (particularly going down),
2. Pain when the knee is flexed and loaded, such as with recreational athletic activities
3. Paradoxical anterior femoral slide on the tibia may be a cause of intermittent effusions as the femur repetitively stresses and irritates the anterior capsule of the knee.
4. In addition, anterior sliding of the femur can cause earlier impingement of the posterior polyethylene on the back of the femur, thus preventing high flexion from occurring.

To achieve a high-flexion, symptom-free knee, normal kinematics must be understood. It is not satisfactory to achieve deep flexion knee arthroplasty if it is posteriorly unstable and functionally symptomatic due to altered knee kinematics[23,33,34,35].

PCL RETAINING

Native PCL promotes posterior displacement of femoral condyles similar to a normal knee.[23,33].

ANTERIOR STABILISING

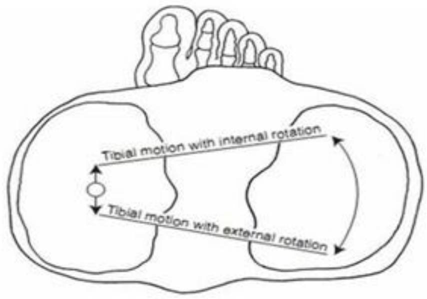
Deep dished insert helps in femoral rollback and prevents the anterior translation of tibia.[23,33]

2. Transverse Plane:

Rotational movements of the knee is described as angular relative motions of the tibia on the femur, internal and external rotation takes place around a longitudinal axis that runs close to or through the medial tibial intercondylar tubercle and, the medial condyle acts as the pivot point while the lateral condyles moves through a bigger arc of motion, regardless of the direction of rotation. During rotational movements, the menisci will distort in the direction of movement of its respective femoral condyle to maintain its relationship with the femoral condyles as they do in flexion and extension.

In this way, the menisci continue to reduce the friction and distributes forces without restricting motion of the femur. Axial rotation is permitted by incongruity of the articular surface and laxity of ligaments. Hence rotational movement of knee depends on the degree of flexion of the knee at that particular point. At full extension the ligaments are taut tibial tubercles are lodged in the notch and menisci are firmly interposed between the articular surfaces, which makes any rotation hardly possible[38,39].

Internal and External rotation of the knee joint



Roatory Movements of the Knee Joint

3.Frontal Plane:

Abduction and Adduction takes place around an Antero-Posterior axis, it is the lowest among the three and the maximum range of 130° is possible at 20° of knee flexion and 8° only at full extension any excess movement indicates ligamentous laxity. The true flexion/extension axis of the knee joint is not exactly perpendicular to the axis of femur and tibia but is inclined obliquely because of the mismatch of the medial and lateral femoral condyles. Hence the foot which is placed laterally from the midline in knee extended position comes towards midline when knee is flexed. This combination of movements occurring in sagittal and frontal plane is termed "coupled motion".[37] Therefore flexion gets coupled with varus motion whereas extension gets coupled with valgus motion .

II. Materials And Methods

60 patients were selected for this study and divided into two groups of 30 each , of which one group was operated upon with anterior stabilizing insert and another with standard bearing insert of cruciate retaining total knee arthroplasty.

INCLUSION CRITERIA
- Age between 45 to 80 years
- Patients undergoing primary total knee replacement
- Varus and valgus deformity knees
- Patient with no extra articular deformities

EXCLUSION CRITERIA
- Infected knee joints, ankylosed knee joints, revision arthroplasty
- Patients with Neuro vascular deficits
- Unfit medically for surgery
- Who did not consent for surgery

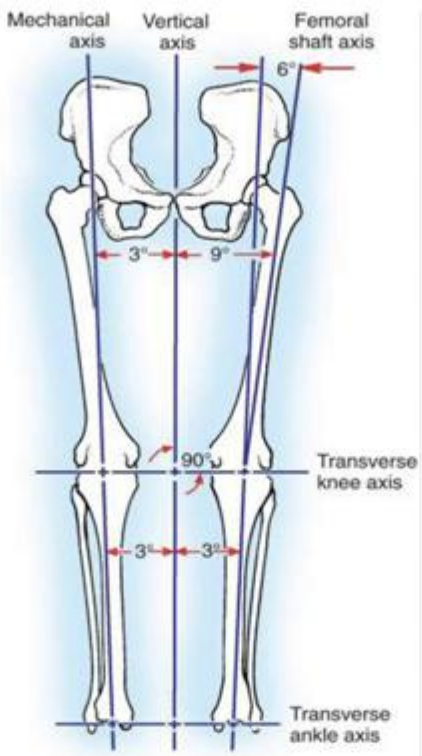
CRITERIA FOR RETAINING POSTERIOR CRUCIATE LIGAMENT –
- Structurally intact posterior cruciate ligament
- Fixed flexion deformity of less than 15 degrees
- Varus of less than 10 degrees
- Valgus of less than 10 degrees

CRITERIA FOR ANTERIOR STABILIZING INSERT
- PCL intact but attenuated
- Anteroposterior instability
- Flexion/extension mismatch

Duration of study was 1 year during which scoring was done according to WOMAC and Functional knee scoring and were evaluated pre operatively, 6 weeks post op, 3 months post op, 6 months post op and at 1 year post op.

Pre op evaluation –

Pre operatively standard anteroposterior and lateral radiographs were taken of knee joints and also weight bearing full lower limb radiographs were taken to evaluate the anatomic and mechanical axis of lower limbs.



Mechanical axis refers to the angle formed by a line drawn from

the centre of the femoral head to the medial tibial spine and a line drawn from the medial tibial spine and the centre of the ankle joint. This line is also called as Maquet's line This should not be confused with the weight bearing axis which runs from the centre of femoral head to centre of ankle**.** Because the hips are more widely separated than the knees and ankles, mechanical axis is in 3° valgus from the true vertical axis of the body. Mechanical axis of the femur : is drawn by connecting the centre of the femoral head and the centre of the knee. Mechanical axis of the tibia: is drawn by connecting the centre of the knee to the centre of the ankle[18,22].

The anatomical Axis refers to a line drawn along the length of the intramedullary canal of either the femur or the tibia.
Anatomical axis of femur: Line drawn from the proximal femur to the centre of distal femur or centre of knee joint. The anatomical axis of the femur makes an angle of 5˚ to 7˚ with the mechanical axis.

Antaomical axis of tibia: Line drawn from the centre of tibia to centre of ankle. The anatomical axis of the tibia corresponds to the mechanical axis of the lower limb.
The anatomical axis of the tibia thus subtends an angle of 3˚ with the vertical axis, while for the anatomical axis of the femur with the vertical axis the angle subtended is from 8˚ to 10˚(90).

Anatomic tibiofemoral angle: The angle formed when the line that forms the femoral shaft axis is extended through the distal femur to form an angle between the femoral shaft axis and the tibial shaft axis . The angle is represented by numbers that supplement the normal angle of alignment (e.g., 3°, 6°, etc.) and indicates the extent of anatomic misalignment or deformity.

Mechanical tibiofemoral angle:
The angle formed when the line that forms the mechanical axis of the femur is extended through the distal femur to form an angle between the mechanical axis of the femur and the tibial shaft axis .As with the anatomic tibiofemoral angle, this angle is represented by numbers that supplement the normal angle of alignment (e.g., 3°, 6°, etc.) and indicates the extent of mechanical misalignment or deformity.

PHYSIOLOGICAL VALGUS ANGLE : The angle formed between the anatomical and mechanical axis of femur is called the knee physiologic valgus angle.

MEASUREMENT OF THE OVERALL VALGUS OR VARUS DEFORMITY OF THE KNEE
If the femoral head is visible :
1. Locate the centre of the knee and centre of the femoral head.
2. Draw a line connecting these two points.
3. Locate (or approximate) the centre of the ankle.
4. Draw a line connecting the centre of the knee to the centre of the ankle.
5. Measure the angle between the 2 lines. A measurement of 0°/180° implies no deformity; otherwise, the observed angle is the angle of varus or valgus present (valgus if foot is lateral, varus if foot is medial).

Post operative radiographs

The mechanical axis cannot be accurately measured using short AP radiographs of the knee. In such cases, the component positions can be assessed with reference to the anatomical axes of the femur and tibia instead. The femoral angle (the medial angle between the femoral anatomical axis and a tangent to the distal ends of the femoral condyles) should be about 95°. The tibial angle (the medial angle between the tibial anatomical axis and a line along the tibial base plate) should be about 90°. The overall femorotibial angle is the sum of the femoral and tibial angles, and should be about 185°. In other words, the replaced knee should be in about 5° valgus. It should be emphasized that this is only a surrogate measure for the mechanical axis[40].

In the lateral view, the sagittal alignment of the femoral and tibial components can be assessed. The femoral component may be in extension, neutral position, or flexion. If the femoral component is in too much extension, the risk of notching the anterior femoral cortex is increased. However, if the femoral component is in excessive flexion, knee extension may be blocked in TKA prosthesis designs that do not permit too much hyperextension.

Checking the posterior slope in lateral view is also important. We had a fixed posterior slope of 3° in our prosthesis. Excessive posterior slope may cause flexion instability while inadequate posterior slope or anterior slope may cause tightening of the collateral ligaments with knee flexion, thus limiting knee flexion.

The size of the components is also an important aspect; ideally, the components should duplicate the patient's anatomy if possible. With regard to the femoral component, it should be flush with the margins of the femoral condyles medially and laterally in the AP radiograph. Any overhang is better tolerated on the lateral side. In the lateral view, the anterior flange should be flush with the anterior femoral cortex, and the posterior condyles of the prosthesis should be in line with the patient's own posterior condyles. If the femoral component is too big, a gap may be seen between the anterior flange and anterior cortex of the femur. It may overfill the PF joint and create a tight flexion gap, both of which are associated with limited knee flexion. If the femoral component is too small, its anterior flange may cause notching of the anterior femoral cortex, or the posterior condyles may not fill up the flexion gap adequately, leading to flexion instability. On the tibial side, the margins of correct-sized components should be flush with the medial, lateral, anterior, and posterior cortices in both AP and lateral views. An undersized tibial component exposes the cancellous bone and, poses the risk of subsidence. An oversized tibial component may result in soft tissue irritation, and may affect ligament balance and limit motion[40].

III. Observation And Results

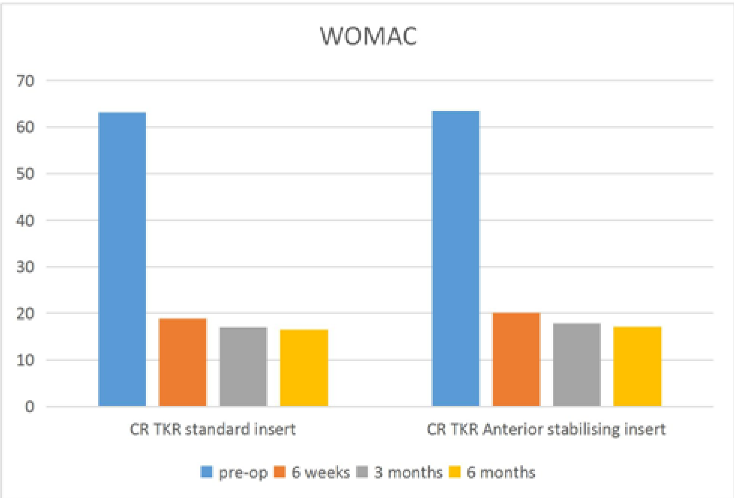
There were 57 varus knee and 3 valgus knee in total, there were total of 30 females and 10 males in this study, 8 left knees, 12 right knees and 20 bilateral cases were dealt.

Standard insert cruciate retaining pateints were 30 and anterior stabilizing cruciate retaining insert were 30.

WOMAC score mean for all patients were –

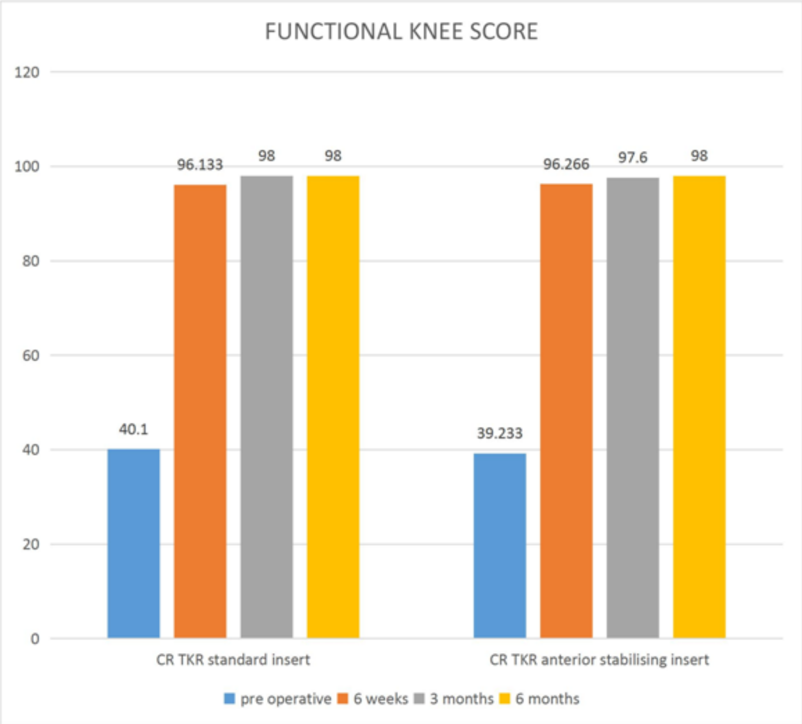
Time of recording score	Standard bearing insert	Anterior stabilizing insert
Pre op	63.133	63.5
6 weeks post op	18.9	20.1
3 months post op	17.066	17.933
6 months post op	16.566	17.233
1 year post op	16.566	17.233

WOMAC score improvement more in anterior stabilizing at 6 weeks, but p value is >0.05 so statistically insignificant.



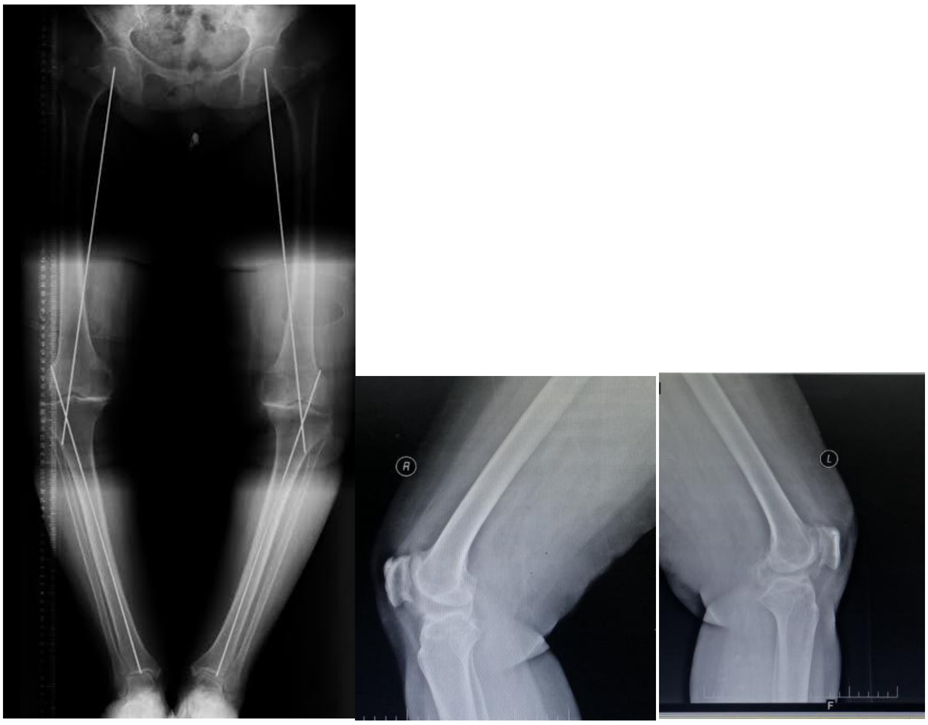
Functional knee score for all patients –

Time of recording score	Standard bearing	Anterior stabilizing
Pre op	40.1	39.233
6 weeks	96.133	96.266
3 months	98.00	97.6
6 months	98.00	98
1 year	98.00	98



PRE OPERATIVE CLINICAL IMAGES

PRE OPERATIVE RADIOGRAPH



POST OPERATIVE RADIOGRAPH

POST OPERATIVE CLINICAL IMAGES

This was the protocol for both anterior stabilizing insert and standard tibial insert cruciate retaining total knee replacement .

There was no conflict of interest in this study.

IV. Discussion

Total knee arthroplasty is a surgical procedure to replace the weight-bearing surfaces of the knee joint for pain relief and disability correction. It is most commonly performed for osteoarthritis and also for other knee diseases such as rheumatoid arthritis and psoriatic arthritis . In patients with severe deformity from advanced rheumatoid arthritis,post traumatic arthritis or long standing osteoarthritis the procedure is beneficial.

The pioneer of knee replacement surgery was Leslie Gordon Percival Shiers ; his original papers were published in the Journal of Bone and Joint Surgery in 1954. Shiers refused to patent his invention and demonstrated the operation throughout the world, inviting other surgeons to improve upon his original idea. Followinng John Charnleys's success with hip replacement in the 1960s attempts were made to design knee replacement implants. Frank H. Gunston and Leonard Marmor were the pioneers in North America. Marmor's design allowed for unicompartmental operations but did not always last well. In the 1970s, the "Geometric" design and John Insall's Condylar Knee design found favor. The history of knee replacement is the story of continued innovation to try to limit the problems of wear, loosening and loss of range of motion.

Most common indication for total knee replacement is osteoarthritis. Various factors are associated with the onset and progression of clinical osteoarthritis. These include genetic factors, age, sex, obesity, occupation, abnormal loading of the joint as in kneeling, squatting and cross legged sitting.

The mean age of our patients who had osteoarthritis and got TKR done was 58. It is much higher than the data available from the western population. 50 % of our patients were well within the normal range of body mass index of <25 kg/m2 .

The earlier onset of osteoarthritis in individuals with normal range of BMI is explained by the habit of kneeling, squatting and cross legged sitting practiced by the population in this part of the world.

33.3% of our patients had Grade IV osteoarthritis with complete obliteration of joint space at the time of initial presentation.

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

Functional outcome:

Analyzing the functional outcome it was found that all the patients in both the groups had significant improvement in their functional knee score and WOMAC scores. On comparision between the two groups, patients with standard insert had an average functional knee score of 96.133 and a WOMAC of 18.9 at 6 weeks post operative, whereas in patients with anterior stabilising insert, the fuctional knee score was 96.2667 and WOMAC score was 20.1 at 6 week post operative. The results were analysed statistically using SSPS -17 (Statistics Package for Social Sciences) software and using

- chi-square for discrete variables
- 't' test for continuous variables
- bivariate correlation to find out measure of agreement

Range of movements:

We were able to achieve a flexion of 100 to 110 in all our patients and stastistically there was no significant difference between CR standard insert and CR anterior stabilising insert.

Cruciate retaining standard insert ROM

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	ROM	86.0000	30	15.22249	2.77923
	ROM 6 weeks	105.1667	30	5.64516	1.03066
Pair 2	ROM	86.0000	30	15.22249	2.77923
	ROM 3 mths	109.6667	30	4.34172	.79269
Pair 3	ROM	86.0000	30	15.22249	2.77923
	Rom 6 months	109.6667	30	4.34172	.79269

Paired Samples Test

		PairedDifferences			
		Mean	Std. Deviation	t-value	P-value
Pair 1	ROM - ROM 6 weeks	-19.16667	15.87034	-6.615	.0000
Pair 2	ROM - ROM 3 mths	-23.66667	15.91645	-8.144	.0000
Pair 3	ROM - Rom 6 months	-23.66667	15.91645	-8.144	.0000

Cruciate retaining anterior stabilizing insert ROM

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	ROM	86.3333	30	15.86219	2.89603
	ROM 6 weeks	105.8333	30	5.26592	.96142
Pair 2	ROM	86.3333	30	15.86219	2.89603
	ROM 3 mths	108.1667	30	4.04358	.73825
Pair 3	ROM	86.3333	30	15.86219	2.89603
	Rom 6 months	108.1667	30	4.04358	.73825

Paired Samples Test

		Paired Differences			
		Mean	Std. Deviation	t-value	p-value
Pair 1	ROM - ROM 6 weeks	-19.50000	16.93548	-6.307	.000
Pair 2	ROM - ROM 3 mths	-21.83333	16.16101	-7.400	.000
Pair 3	ROM - Rom 6 months	-21.83333	16.16101	-7.400	.000

Cruciate retaining standard insert Functional knee score

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	FKS	40.1000	30	9.41880	1.71963
	FKS 6 weeks	96.1333	30	4.09990	.74854
Pair 2	FKS	40.1000	30	9.41880	1.71963
	FKS 3 months	98.0000	30	2.87678	.52523
Pair 3	FKS	40.1000	30	9.41880	1.71963
	FKS 6 months	98.0000	30	2.87678	.52523

Paired Samples Test

		Paired Differences			
		Mean	Std. Deviation	t-value	p-value
Pair 1	FKS - FKS 6 weeks	-56.03333	11.01248	-27.869	.000
Pair 2	FKS - FKS 3 months	-57.90000	9.82730	-32.270	.000
Pair 3	FKS - FKS 6 months	-57.90000	9.82730	-32.270	.000

Cruciate retaining anterior stabilizing insert Functional knee score

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	FKS	39.2333	30	9.23144	1.68542
	FKS 6 weeks	96.2667	30	4.19304	.76554
Pair 2	FKS	39.2333	30	9.23144	1.68542
	FKS 3 months	97.6000	30	2.98964	.54583
Pair 3	FKS	39.2333	30	9.23144	1.68542
	FKS 6 months	98.0000	30	2.87678	.52523

Paired Samples Test

		Paired Differences			
		Mean	Std. Deviation	t-value	p-value
Pair 1	FKS - FKS 6 weeks	-57.03333	9.62211	-32.465	.000
Pair 2	FKS - FKS 3 months	-58.36667	9.57901	-33.374	.000

Pair 3	FKS - FKS 6 months	-58.76667	9.76865	-32.950	.000

Cruciate retaining standard insert WOMAC

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	WOMAC	63.1333	30	5.76992	1.05344
	WOMAC 6 weeeks	18.9000	30	2.52368	.46076
Pair 2	WOMAC	63.1333	30	5.76992	1.05344
	WOMAC 3 months	17.0667	30	1.96404	.35858
Pair 3	WOMAC	63.1333	30	5.76992	1.05344
	WOMAC 6 months	16.5667	30	1.73570	.31689

Paired Samples Test

		PairedDifferences			
		Mean	Std. Deviation	t-value	p-value
Pair 1	WOMAC - WOMAC 6 weeeks	44.23333	5.12387	47.284	.000
Pair 2	WOMAC - WOMAC 3 months	46.06667	5.28455	47.746	.000
Pair 3	WOMAC - WOMAC 6 months	46.56667	5.38634	47.352	.000

Cruciate retaining anterior stabilizing insert WOMAC

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	WOMAC	63.5000	30	5.13776	.93802
	WOMAC 6 weeeks	20.1000	30	2.46842	.45067
Pair 2	WOMAC	63.5000	30	5.13776	.93802
	WOMAC 3 months	17.9333	30	1.48401	.27094
Pair 3	WOMAC	63.5000	30	5.13776	.93802
	WOMAC 6 months	17.2333	30	1.38174	.25227

Paired Samples Test

		PairedDifferences			
		Mean	Std. Deviation	t-value	p-value
Pair 1	WOMAC - WOMAC 6 weeeks	43.40000	5.58693	42.548	.000
Pair 2	WOMAC - WOMAC 3 months	45.56667	5.32841	46.839	.000
Pair 3	WOMAC - WOMAC 6	46.26667	5.11208	49.571	.000

months					

V. Conclusion

In the study among 60 knees there is no significant functional difference in both groups however patients with anterior stabilizing insert group showed better early mobilization increased ROM in initial 2 weeks. The use of cruciate retaining anterior stabilizing insert and standard insert is decided intra operatively on surgeons discretion.

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