

Analysis of factors affecting range of motion after Total Knee Arthroplasty

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Abstract: This study was done to analyze the various factors affecting range of motion in total knee Arthroplasty. Various factors such as age, sex, body mass index, disease, different prosthesis and designs, pre-op factors such as pre-op flexion, fixed flexion deformity, coronal plane deformity, were assessed to find out its effect on post-op range of motion. Post-op factors such as coronal plane alignment, joint line position change, change in antero-posterior diameter of femoral component and extension lag were assessed and its co-relation to post-op range of motion. One of the important aspect of the study was the surgeon was a single surgeon and hence surgeon factors remained a constant. A total of 75 knees were operated were studied upon, 8 were rheumatoid and 67 were primary osteoarthritis of the knee joint, with a minimum follow up period of 2 years. The average pre-op flexion was 87.678 and the average post-op flexion was 105.538. 86.15% of our patients had more than 100 degrees of flexion. 69.2% of our patients with a average pre-op flexion of less than 90 degrees had an average post-op flexion of 103.763. 30.8% of patients with average pre-op flexion between 90-100 degrees had a average post-op flexion range of motion of 109.55. Patients with pre-op fixed flexion deformity had a post-op range of motion of 97.5 degrees. The average post-op flexion range of motion in 10 of our obese patients was 95 degrees, and in the non-obese group it was 107.454. The 8 patients with rheumatoid arthritis had an average post-op flexion of 96.25 degrees, whereas the patients in the osteoarthritis group had an average post-operative flexion of 107.462 degrees. Post-op flexion with change in joint line position was not significant. Patellar resurfacing was not done in any of the patients.

Keywords: Total Knee Arthroplasty, knee joint, range of motion

I. Introduction

Range of motion is an important measure of outcome after total knee Arthroplasty, as is an important part of most knee scoring systems. It has been demonstrated that 67 degrees of knee flexion is needed for the swing phase of the gait, 83 degrees to climb up stairs, 90 degrees to descend stairs, and 93 degrees to rise from a chair¹. The minimal flexion of the knee necessary for usual daily living is generally agreed to be at 90 degrees.² It has been shown that the amount of knee flexion significantly influences the total Hospital for Special Surgery Score, Knee Society Scoring System, the stair climbing score, and the walking ability score of the patient.³ While patients hope that their knee range will improve after total knee Arthroplasty, this may or may not happen. A large review of total knee Arthroplasty of different designs performed before the end of 1985 found that 46% of patients could not flex their knees beyond 90 degrees after their surgery.⁴

Even in some of the recent literature, reports during the late 1990's and early 2000's suggest that there exists a loss of average knee flexion after total knee Arthroplasty. However, with the advancement in the prosthesis research, total knee Arthroplasty has become much more effective in increasing the post-operative flexion range of motion in the recent years.³ Patients with severe arthritis of knee joint often require Total Knee Arthroplasty (TKA) to reduce pain, improve stability, and restore function. Total Knee Arthroplasty has become a highly successful joint reconstruction procedure of late in the last decade or so. Surgical outcomes, patient satisfaction, and implant survival have improved steadily since its inception and the procedure has become widely accepted over the last decade.^{5,6,7,8,9, and 10}

Although Arthroplasty have shown to be successful in the younger population, ideally the more suitable patients are more than 60 years of age, so that an uncomplicated Arthroplasty would more than likely last for the rest of the Patients life. Survivorship for cemented Total Knee Arthroplasty ranges between 91% and 99% at 10 years^{5,8} and between 91% and 96% at 15 years.^{5,10} Improvements in quality of life, increased mobility after knee replacement may reduce social isolation and have other benefits, such as improved cardiovascular fitness and overall health of the individual.

Hence, the purpose of this study was to analyze the various factors, which could probably affect the post-operative flexion range of motion including prosthesis types, designs, patient's disease, co-morbid conditions, prosthesis positioning, pre-operative flexion range of motion etc.

II. Aim

To analyze the various factors affecting the range of motion after Total Knee Arthroplasty in arthritis knee.

III. Materials And Methods

This is a prospective study done on patients who underwent Total Knee Arthroplasty from April 2010. Patient of both the sexes were included in this study and a total of 75 knees were analyzed. All the knees received a Cruciate Retaining, Cruciate Substituting or Deep-dish design. The various prosthesis used in the study were, PFC (Depuy), Genesis II (Smith and Nephew) and Optetrak (Exactec).

3.1 Inclusion criteria

- Patients with Osteoarthritis and Rheumatoid Arthritis were included in the study.
- Fixed bearing - posterior cruciate ligament substituting, posterior cruciate ligament retaining and deep-dish design implants were included in the study.

3.2 Exclusion criteria

- Knees that used Rotating Platform, high flexion knee and hinged prosthesis and revision total knee Arthroplasty were excluded from the study.

3.3: Factors Analyzed

- Age
- Sex
- Body mass index
- Disease
- Prosthesis
- Cruciate Retaining Versus Cruciate Substituting Versus Deep Dished Design
- Pre-operative flexion range of motion versus Post-operative flexion range of motion
- Pre-operative fixed flexion deformity versus Post-operative flexion range of motion
- Pre-operative coronal plane deformity versus Post-operative flexion range of motion
- Post-operative coronal plane alignment versus post-operative flexion range of motion
- Joint line position change versus post-operative flexion range of motion
- Change in antero-posterior diameter of femoral component versus post-operative flexion range of motion
- Post-operative extension lag versus post-operative flexion range of motion

3.4 Clinical evaluation

The following were observed and recorded clinically:

- Pre-operative flexion range of motion
- Pre-operative fixed flexion deformity
- Pre-operative coronal plane deformity
- Post-operative flexion range of motion/ deformity
- Extension lag

3.5 Radiological evaluation

X – rays of each patient were taken pre-operatively and post-operatively. Standard antero-posterior weight bearing X – rays and standard lateral X – rays were taken.

Following important aspects were noted in the X – rays:

- Pre-operative coronal plane deformity
- Post-operative coronal plane deformity
- Joint line position change
- Change in AP diameter of the femur pre-operative and post-operative comparison

3.6 Factors constant

- Single surgeon
- Surgical technique
- Surgical approach – mid vastus approach
- Post-operative rehabilitation protocol

3.7 Post-operative protocol

- Post – Op day 1: DVT prophylaxis with LMW heparin, in bed mobilization.
- Post – Op day 2: Wound inspection and drain removal, mobilize the patient to make them stand/ walk with walker support, CPM, quadriceps and hamstring exercises. Active flexion extension exercises started.
- Daily CPM till flexion range of motion reaches 90 – 95 degrees
- Post – op day 5, 8 11: wound inspection.
- Post – op day 14-suture removal.

3.8 Follow up

All patients were followed up at 6weeks, 3months, 6 months, 1 year, 2 years and yearly after that. Pre-operative clinical and radiological evaluation and post-operative clinical and radiological evaluation was compared.

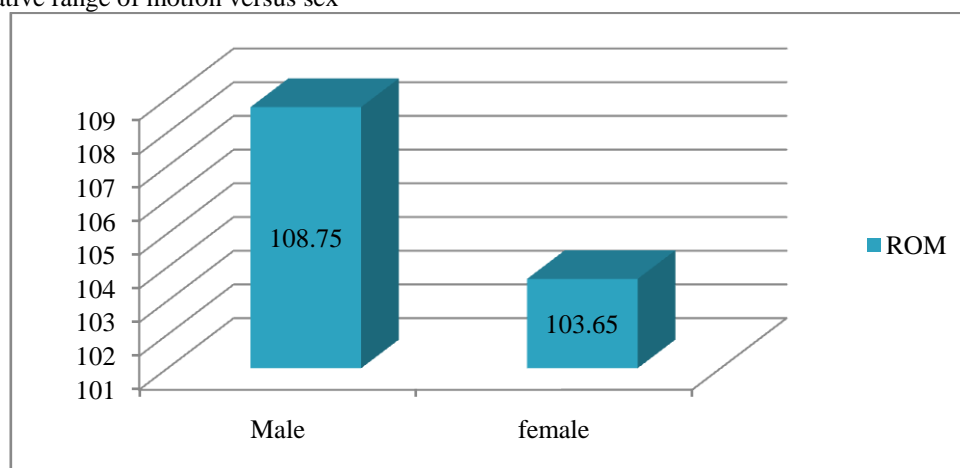
IV. Results

Patients were analyzed based on the various factors listed above and the following results were obtained

4.1 Post-operative range of motion versus sex

The average flexion range of motion of 34 males was 108.75 degrees whereas the average flexion range of motion of 41 females was found to be 103.65 degrees. The ‘t’ test was not significant i.e. range of motion was not influenced by the sex of the patient.

Post-operative range of motion versus sex

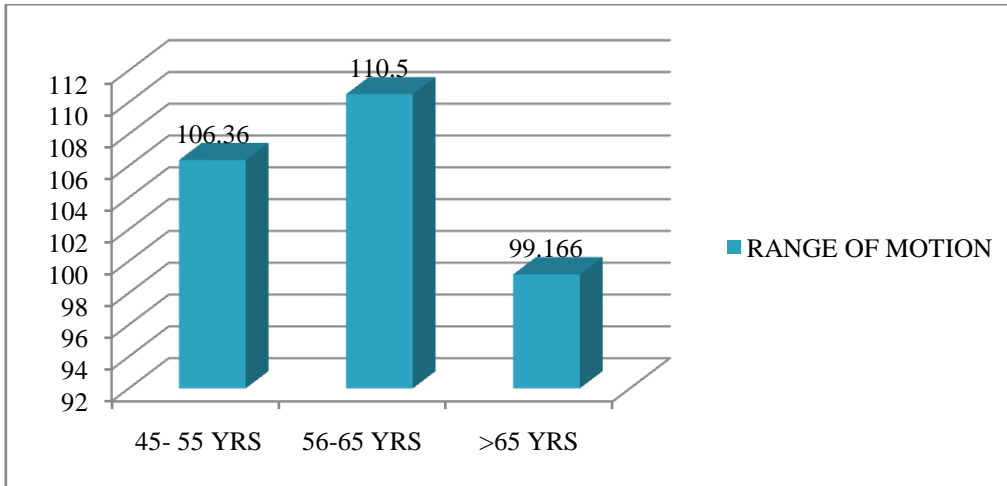


4.2 Post-operative range of motion versus age

The average range of motion of patients in the age group of 45 to 55 years was 106.36 as compared to an average of 110.5 degrees in the age group of 56- 65 years and 99.166 degrees in the above 65 years age group.

The ‘t’ test was significant suggesting a co-relation in age and post-operative flexion range of motion

Post-operative range of motion versus age

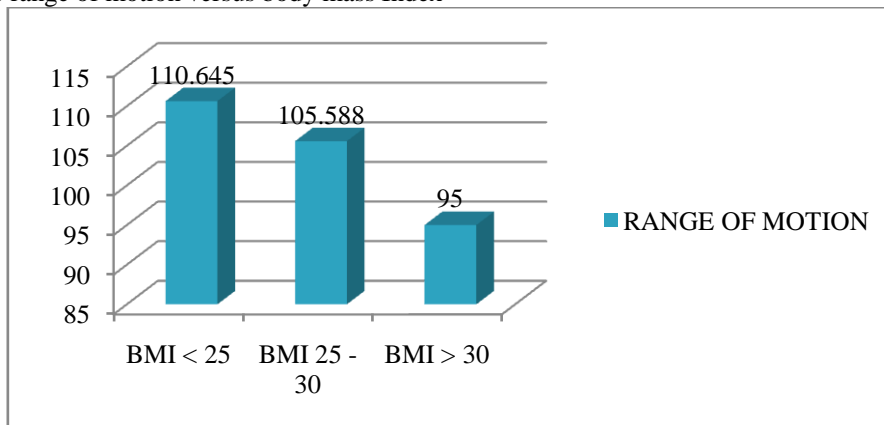


4.3 Post-operative range of motion versus Body mass Index

The average range of motion for the patient group with BMI < 25 was found to be 110.645 degrees, for the patient group of BMI 25 – 30 was 105.588 degrees and for the group who had a BMI > 30 was found to be 95 degrees.

The ‘t’ test was significant suggesting that range of motion was affected by BMI.

Post-operative range of motion versus body mass Index

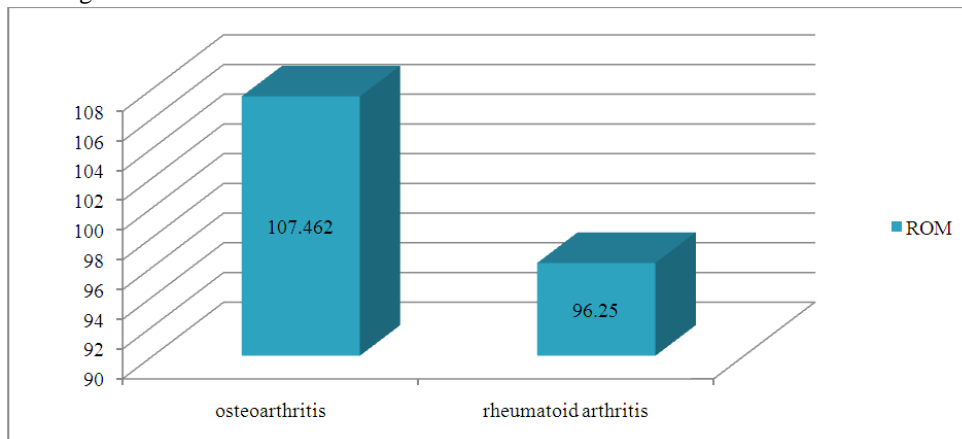


4.4 Post-operative range of motion versus Disease

The average post-operative flexion range of motion in the osteoarthritis group was 107.462 degrees, whereas in the rheumatoid arthritis group it was 96.25 degrees.

The ‘t’ test values were significant, indicating that there is a co-relation between the disease and post-operative flexion range of motion.

Post-operative range of motion versus Disease



4.5 Post-operative range of motion versus Prosthesis

PFC design: 14 knees were of the cruciate substituting design and the average post-operative flexion range of motion was found to be 103.92 degrees.

The average post-operative flexion range of motion in 17 knees of the posterior stabilizing implant was found to be 103.75 degrees.

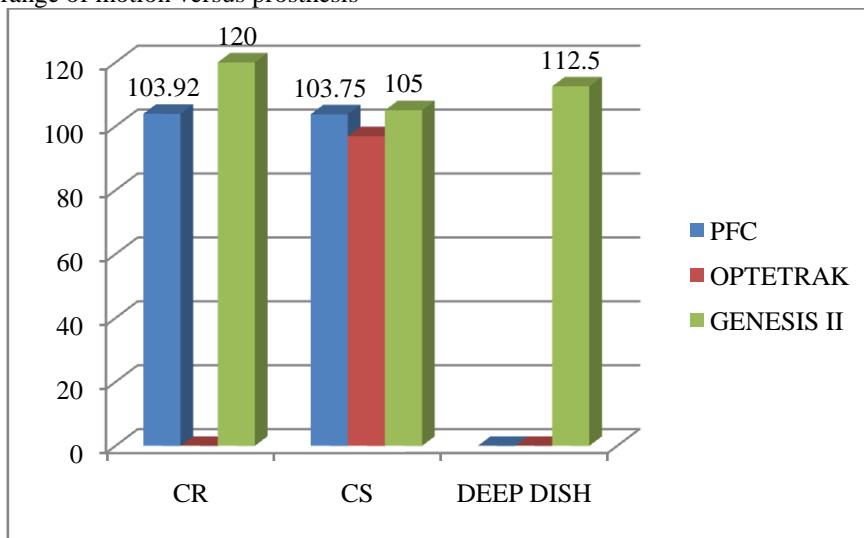
OPTETRAK design: A total of 16 knees were done and all were the posterior stabilizing design. The Average post-operative flexion range of motion was 96.875 degrees.

GENESIS II design: 2 knees of the cruciate retaining type had an average post-operative flexion range of motion was 120 degrees.

Six knees of the posterior stabilizing design had an average post-operative flexion range of motion was 105 degrees.

20 knees of the cruciate resecting deep-dish design had an average post-operative flexion range of motion of 112.5 degrees.

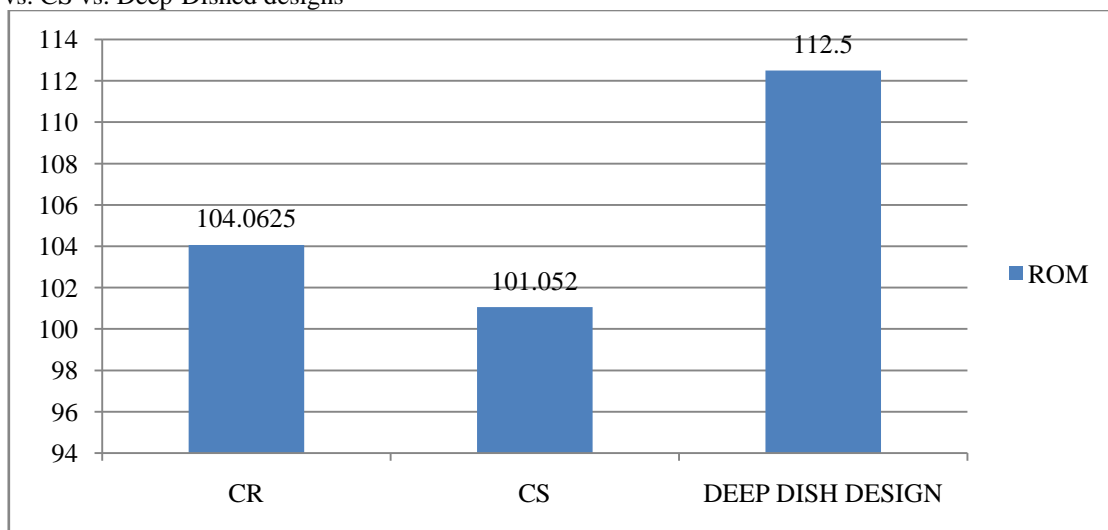
Post-operative range of motion versus prosthesis



4.6 Post-operative range of motion comparison between cruciate retaining versus cruciate substituting versus cruciate resecting deep-dished design

The average post-operative range of motion in cruciate retaining design of all the prosthesis combined together was 104.0625 degrees, 101.052 degrees in cruciate substituting – posterior stabilized design and 112.5 degrees in deep-dish design. Deep-dish designs used were primarily only from Genesis II design from Smith and Nephew.

CR vs. CS vs. Deep-Dished designs



4.7 Pre-operative range of motion versus post-operative range of motion

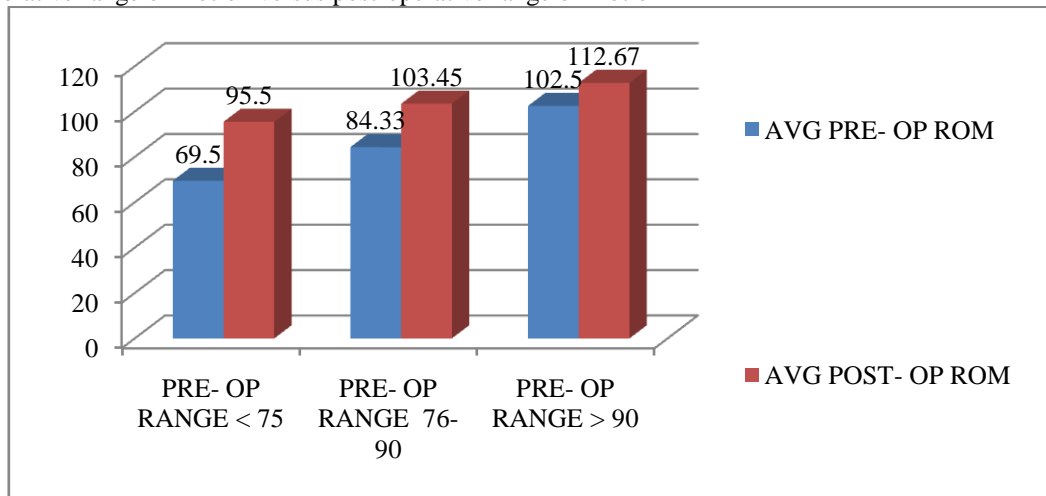
The mean pre-operative flexion range of motion of 20 patients, who had a pre-operative flexion range of motion of < 75 degrees, was 69.5. Their mean post-operative flexion range of motion was 95.5 degrees. The percentage increase in the mean post-operative flexion was 37.41%.

The mean pre-operative flexion range of motion of 33 patients, who had a pre-operative flexion range of motion between 76- 90 degrees, was 84.33. Their mean post-operative flexion range of motion was 103.45 degrees. The percentage increase in the mean post-operative flexion was 22.672%

The mean pre-operative flexion range of motion of 22 patients, who had a pre-operative flexion range of motion >90 degrees, was 102.5. Their mean post-operative flexion range of motion was 112.67 degrees. The percentage increase in the mean post-operative flexion was 9.92%

The patients with a good pre-operative flexion range of motion had a better post-operative flexion range of motion.

Pre-operative range of motion versus post-operative range of motion



4.8 Pre-operative fixed flexion deformity versus post-operative range of motion

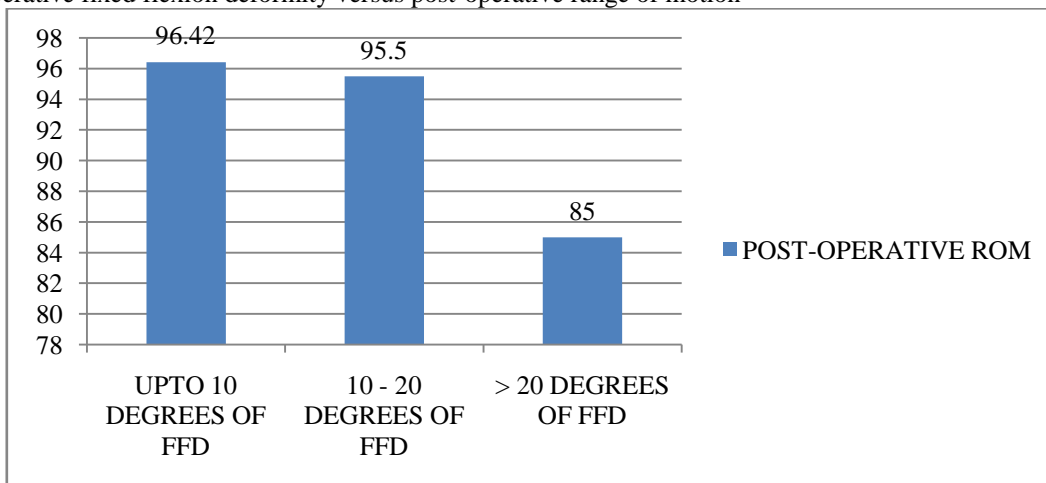
The mean post-operative flexion range of motion of 14 patients who had a fixed flexion deformity of up to 10 degrees was 96.42 degrees.

The mean post-operative flexion range of motion of 10 patients who had a flexion deformity of 10 – 20 degrees was 95.5 degrees.

The mean post-operative flexion range of motion of 4 patients who had a fixed flexion deformity of > 20 degrees was 85 degrees.

The ‘t’ test was significant suggesting co-relation between the two.

Pre-operative fixed flexion deformity versus post-operative range of motion



4.9 Pre-operative coronal plane deformity versus post-operative flexion range of motion

The patients with a valgus of 5 - 10 degrees had a mean post-operative range of motion of 103.33 degrees.

32 patients did not have any significant coronal plane deformity and the mean post-operative flexion range of motion was 109.375 degrees.

28 patients pre-operatively had 5-10 degrees of varus deformity and the mean post-operative flexion range of motion was 105 degrees.

9 patients with a pre-operative varus deformity >10 degrees had a mean post-operative flexion range of motion of 102.222.

The ‘t’ test of significance was negative suggesting no co-relation between pre-operative coronal plane deformity and post-operative flexion range of motion.

Pre-operative coronal plane deformity versus post-operative flexion range of motion

Mal-alignment	No of knees	MEAN POST-OP RANGE OF MOTION
Valgus 5 – 10 degrees	6	103.33
Not significant	32	109.375
Varus 5 – 10 degrees	28	105
Varus > 10 degrees	9	102.222

4.10 Post-operative coronal plane alignment versus post-operative flexion range of motion

Out of the 75 knees, 52 had insignificant coronal plane alignment, 15 knees had a 5 degree of valgus, and 8 knees had 5 degrees of varus alignment. The ‘t’ test of significance did not show any significance in co-relation between post-operative alignment and flexion range of motion.

Post-operative coronal plane alignment versus post-operative flexion range of motion

Post-operative coronal plane Alignment	No of knees	Mean range of motion
Not significant	52	107.307
Valgus 5 degrees	15	103.333
Varus 5 degrees	8	105.00

4.11 Joint line position change versus post-operative flexion range of motion

59 knees did not have any significant joint line position change and the mean flexion range of motion was 105.084 degrees.

None of the cases had any significant depression of joint line of 5 mm or greater.

15 of them had a significant joint line elevation of >5mm and < 10mm, and the mean post-operative flexion range of motion was 102.66 degrees.

1 patient had an elevation of > 10 mm in joint line position change and the post-operative flexion range of motion was 100 degrees.

There was no significant co-relation between post-operative flexion range of motion and joint line position change

Joint line position change versus post-operative flexion range of motion

JOINT LINE POSITION CHANGE	NO OF KNEES	MEAN RANGE OF MOTION
Depression of 5 mm and greater	-	-
Not significant	59	105.084
Elevation of > 5mm < 10 mm	15	102.66
Elevation of > 10 mm	1	100

4.12 Change in antero-posterior diameter of femoral component versus post-operative range of motion

None of them had a decrease in femoral Antero-posterior diameter > 5 mm

49 of them had an insignificant change in the Antero-posterior diameter with a mean range of motion of 104.081 degrees.

Increase of more than 5mm and less than 10 mm of femoral Antero-posterior diameter was observed in 20 patients and the mean range of motion was 105.00 degrees.

Increase of more than 10 mm of femoral Antero-posterior diameter was observed in 6 patients and the mean range of motion was 95.333 degrees.

Change in antero-posterior diameter of femoral component versus post-operative range of motion

CHANGE IN AP DIAMETER OF FEMUR	NO OF KNEES	MEAN RANGE OF MOTION
Decrease of > 5 mm	-	-
Not significant	49	104.081
Increase of > 5mm and < 10 mm	20	105.00
Increase of > 10 mm	6	95.333

4.13 Post-operative extension lag versus post-operative flexion range of motion

Nine patients had an extension lag of 5 to 10 degrees. However, these patients had a mean flexion range of motion of 120 degrees.

V. Discussion

In our study, all the patients were operated by the same surgeon with a similar surgical technique and approach were applied. The post-operative protocol followed were identical for all the patients including physiotherapy and rehabilitation. 13 factors were examined in our study to determine the factors affecting the range of motion.

5.1 Range of motion versus age:

Patients were divided in groups ranging from 45- 55 yrs, 56- 65 yrs and >65 yrs. In our study, there was a significant decrease in range of motion in the age group >65 yrs with a sample size of 24 was comparable to the study done by Alejandro Lizaur et al, in which there was a significant decrease in range of motion in patients above 65 years of age.

5.2 Range of motion versus sex

There was no significant difference in the range of motion between the male group and female group, the average range of motion in males was 108.75 degrees and 103.65 in females. Our study is comparable with the results obtained by B.S.K reddy et al in which they had an insignificant co-relation between post-operative range of motion and sex of the patient.

5.3 Range of motion versus body mass index

There was a significant decrease in range of motion in patients with a body mass index > 30 degrees. This finding in our study was similar to that found in Alejandro Lizaur et al, which showed a significant co-relation between post-operative flexion range of motion and body mass index ratio.

5.4 Range of motion versus disease

The 2 groups of osteoarthritis and rheumatoid arthritis were compared. There was a significant reduction in post-operative range of motion in patients with rheumatoid arthritis as compared to the osteoarthritis group comparable with studies done by Schurman DJ et al 1998.

5.5 Range of motion versus prosthesis

Three different types of prosthesis were compared, PFC, genesis II, Optetrak with posterior cruciate ligament retaining implants, posterior cruciate ligament substituting PS types, and deep dish designs. All the deep dish designs were only from Genesis II.

Posterior cruciate ligament retaining implants were used from depuy PFC and genesis II smith and nephew

Cruciate substituting PS implants were used from all the three manufacturers.

There was not much of a significant difference between the various groups as suggested by the spearman's co-efficient test for comparison.

5.6 Range of motion in posterior cruciate ligament retaining implants versus posterior stabilized versus cruciate resecting deep-dished designs

The mean range of motion in knees with posterior cruciate ligament retaining prosthesis was 104.0625 degrees, in posterior cruciate ligament substituting type was 101.052 degrees, and 112.5 degrees in posterior cruciate sacrificing deep dish design.

There was no significant difference in the range of motion in the three types of designs as suggested by the 't' test. Our study results were similar to that done by B.S.K Reddi et al, and K.Y Chiu et al suggesting no significant difference between posterior cruciate ligament retaining and substituting designs. There have not been comparison studies on cruciate resecting deep dish designs.

5.7 Pre-operative range of motion versus post-operative range of motion

The mean post-operative range of motion in patients with a pre-operative flexion range of motion of < 75 degrees was 95.5 degrees. The mean increase in range of motion was 37.41%.

The mean post-operative range of motion in patients with a pre-operative flexion range of motion between 75-90 degrees was 103.45 degrees. The mean increase in range of motion was 22.672%.

The mean post-operative range of motion in patients with a pre-operative flexion range of motion > 90 degrees was 112.67 degrees. The mean increase in range of motion was 9.92%.

The above findings suggest that an increased pre-operative flexion range of motion had a better post-operative flexion range of motion.

However the percentage increase in post-operative flexion range of motion was more in patients with a decreased pre-operative flexion range of motion.

The findings in our study is similar to that found in B.S.K Reddi et al, K.Y. Chiu et al, Alejandro Lizaur et al.

5.8 Pre-operative fixed flexion deformity versus post-operative flexion range of motion

The mean post-operative flexion range of motion of patients who had a pre-operative fixed flexion deformity of upto 10 degrees was 96.42 degrees, and those who had a pre-operative fixed flexion deformity of 10-20 degrees was 95.5 degrees.

The mean post-operative flexion range of motion in 4 patients who had a fixed flexion deformity of > 20 degrees was 85 degrees only.

Our study suggested that there was a co-relation between fixed flexion deformity and post-operative flexion range of motion.

The lesser the pre-operative fixed flexion deformity the better was the post-operative flexion range of motion.

The findings in our study was similar to that found in A. Harvey et al, B.S.K Reddi et al.

5.9 Pre-operative coronal plane deformity versus post-operative flexion range of motion

The mean flexion range of motion in patients without a significant varus or valgus deformity was 109.375 degrees. The patients with 5 to 10 degrees of valgus deformity had a mean post-operative flexion range of motion of 103.33 degrees.

The mean post-operative flexion range of motion of patients with 5-10 degrees, and greater than 10 degrees of varus deformity was 105 degrees and 102.222 degrees respectively.

There was no significant co-relation between the pre-operative coronal plane deformity and post-operative flexion range of motion.

5.10 Post-operative coronal plane alignment versus post-operative flexion range of motion

52 knees did not have any significant change on the coronal plane alignment post-operatively and the mean range of motion was 107.307 degrees. 15 knees had 5 degrees of valgus and 8 knees had 5 degrees of varus, the mean post-operative flexion range of motion was 103.333 and 105 degrees respectively.

There was no significant co-relation between the 2 entities.

The study done by us has similar results to that done by H. Farahini et al. and B.S.K Reddi et al.

5.11 joint line position change versus post-operative flexion range of motion

59 knees did not have any significant joint line position change with a mean range of motion of 105.084 degrees. Elevation between 5 - 10 mm had an average flexion range of motion of 102.66 degrees.

There was only 1 knee, which had an elevation of >10 mm in joint line position and had a range of motion of 100 degrees. There was no significance in joint line position change versus post-operative range of motion.

5.12 Change in antero-posterior diameter of femoral component versus post-operative flexion range of motion

The patients in the non-significant group had a mean flexion range of motion of 104.081, and the patients who had an increase of 5 - 10mm in the antero-posterior diameter had a mean of 105.00. However there were 6 patients with an increase of >10 mm in the antero-posterior diameter of the femoral component and the mean range of motion post-operatively was 95.333. The 't' test was significant suggesting a co-relation between antero-posterior diameter and the post-operative flexion range of motion.

VI. Conclusion

Accurate surgical technique, restoration of mechanical axis of weight bearing and soft tissue balancing are fundamentals in achieving successful total knee Arthroplasty.

There was a decrease in post-operative flexion range of motion in patients above the age of 65 years signifying a co-relation between age and post-operative range of motion.

There was no significance with respect to sex of the patient and post-operative range of motion.

There was a significant decrease in post-operative flexion range of motion in patients with an increased body mass index ratio of more than 30 (Obese group).

Range of motion was reduced in the group of Rheumatoid arthritis compared to that of Osteoarthritis.

There was no significant co-relation in the post-operative flexion range of motion and the design of prosthesis.

There was no significant co-relation between range of motion in posterior cruciate ligament retaining vs posterior stabilizing and cruciate resecting deep-dish design.

The mean post-operative flexion range of motion pre-dominantly depended on the pre-operative flexion range of motion. An increased pre-operative flexion range of motion resulted in a better post-operative range of motion.

There was a significant co-relation between post-operative flexion range of motion and pre-operative fixed flexion deformity. An increased pre-operative fixed flexion deformity resulted in a reduced postoperative range of motion.

There was no direct co-relation between pre-operative coronal plane deformity and post-operative coronal plane alignment with post-operative flexion range of motion.

Our study had only one knee with a significant joint line position change of more than 10 mm. even though the range of motion was comparable to the rest, the sample size was small for a conclusion.

There was a significant co-relation between change in antero-posterior diameter of femoral component and post-operative flexion range of motion.

Patients with post-operative extension lag had a good average post-operative motion of 120 degrees.

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