

## Original Research Article

# Factors determining the range of motion in primary total knee arthroplasty

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## ABSTRACT

**Background:** Total knee arthroplasty (TKA) is one of the most successful surgical procedure with over 90% survival rate at 10 to 15 years. It provides a stable, pain free range of motion (ROM) for day to day activities. The aim of this study is to evaluate various factors determining ROM after TKA.

**Methods:** 348 patients with 390 knees treated with TKA using cruciate retaining (CR) and posterior stabilized (PS) prosthesis were included and analysed. Mean follow up period was 18 months. Patients were analysed for factors like age, sex, diagnosis, body mass index (BMI), pre-operative exercises, ROM, deformity, posterior femoral condylar offset (PFCO), posterior tibial slope (PTS), post-operative rehabilitation and implant design (CR vs PS). Statistical analysis of above factors on knee ROM was done. Patients were assessed pre-operatively, at 6 weeks, 3, 6, 12 and 18 months post-operatively.

**Results:** Age and sex did not affect the final ROM. The mean knee ROM improved from 86.87° to 96.95°. Factors like BMI, deformity had negative correlation and Pre-operative diagnosis, exercises, knee scores, good preoperative ROM, PFCO, PTS had positive correlation on ROM.

**Conclusions:** Pre-operative exercises, diagnosis, ROM, deformity, BMI, PFCO and PTS were important factors which influence ROM in TKA. Patient selection and preoperative counselling are important for good clinical outcome.

**Keywords:** Total knee arthroplasty, Range of motion, Body mass index, Posterior femoral condylar offset, Posterior tibial slope

## INTRODUCTION

Total knee arthroplasty (TKA) is one of the most successful surgical procedures with over 90% survival rate at 10-15 years.<sup>1-4</sup> It provides a stable, pain free range of motion (ROM). The ROM attained after TKA is an important functional outcome that affects day to day activities. In literature various authors described the factors influencing ROM after TKA. Of all the various factors preoperative exercises, diagnosis, ROM, deformity, body mass index (BMI), posterior femoral

condylar offset (PFCO), posterior tibial slope (PTS), and post-operative physiotherapy are important.<sup>5</sup> The aim of this study was to evaluate various factors determining the ROM after TKA.

## METHODS

The study was carried out in BIRRD (T) Hospital, Tirupati, Andhra Pradesh, India between January 2018 to October 2019, a total of 390 TKA's were followed on 348 patients (390 knees; bilateral 42) at our institute

using press fit condylar (PFC) sigma (56 cruciate-retaining (CR), 63 posterior-stabilized (PS)) and Exactech Optetrak (150 CR, 121 PS) prosthesis. A prospective study of these cases was done. 408 patients (458 knees; bilateral 50) were included in the study of which 60 patients (68 knees; bilateral 8) lost to follow up. The patients were assessed clinically and radiologically using the knee society scoring system.

### Inclusion criteria

Patients with severe arthritis, age between 40–80 years and those with minimum follow up of 18 months at the time of evaluation.

### Exclusion criteria

Patients with unicompartmental knee replacement, those with mega prosthesis for peri-articular knee tumour's, patients with revision TKA, rotating platform, high flexion and hinged TKA and those who are medically unfit for surgery.

All knees exposed with standard medial parapatellar approach. Wound closure was done in 40-50° of knee flexion. Radiographs of both weight bearing antero-posterior and lateral views were taken pre and postoperatively and were assessed for PFCO, PTS and deformity. Post op rehabilitation was done for every patient. Knee ROM, total knee society score (TKSS) were evaluated preoperatively and at 6 weeks, 3, 6, 12 and 18 months post-operatively.

### Statistical analysis

Our study was performed using statistical package of social science version 20 (SPSS). Paired t-test was used for statistical testing of the variation in mean scores in comparing preoperative to post-operative ROM,  $p < 0.05$  was considered to be statistically significant. Unpaired t-test was used for subgroup analysis with significant at 95% level of confidence. ANOVA was used for various subgroup analysis for comparison between pre and postoperative improvement in ROM. The data were reported as mean $\pm$ SD and frequency.

## RESULTS

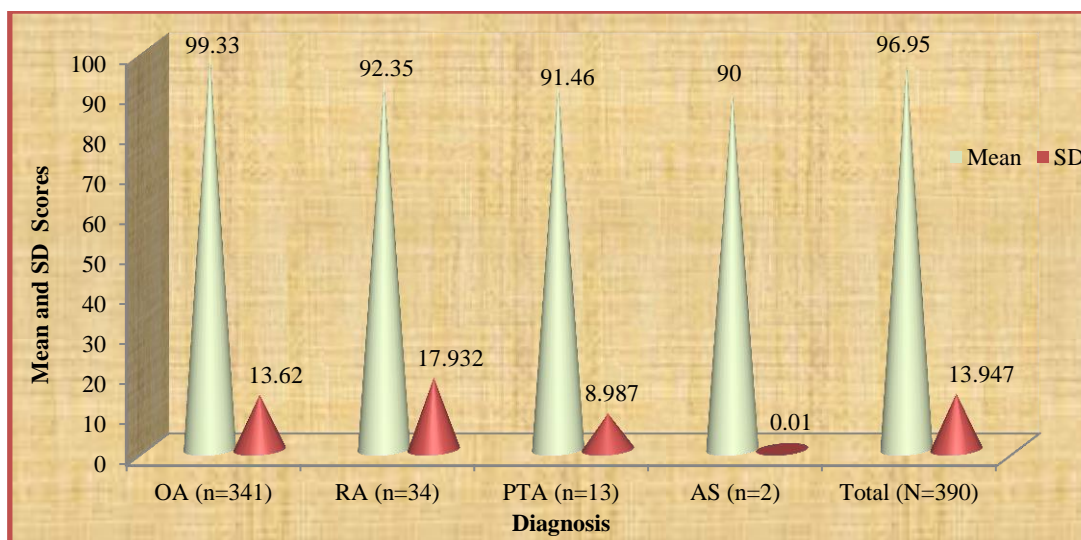
This is a prospective study performed in 348 patients (390 knees). Mean age at the time of surgery was 61.5 yr (38–77 years). 42 knees <50 yrs, 122 between 51–60yrs, 171 between 61–70 yrs, 55 between 71–80 yrs (Table 1). There were 167 females and 181 males (Table 2). The indication for surgery was primary osteoarthritis in 341 knees, rheumatoid arthritis 34, post traumatic arthritis 13 and ankylosing spondylitis 2. The patients in the OA category had good postop ROM ( $p < 0.01$ ) (Figure 1). Mean BMI was 27.23 kg/m<sup>2</sup> (21–37). Highest BMI 37.34 kg/m<sup>2</sup> and lowest BMI 21.32 kg/m<sup>2</sup>. The patients who had BMI <30 shown good post-op ROM which is significant ( $p < 0.01$ ) (Table 3). There were 143 knees who did pre-operative exercises and 247 knees without exercises, the patients who had done pre-operative exercises had good postop ROM, which shows statistically significant difference ( $p < 0.05$ ) (Table 4). Mean pre-operative ROM was 86.87° with highest of 120° and lowest of 50°. The mean post-operative flexion was 96.95° with highest of 130° and lowest of 40° (Table 5). The highest preoperative fixed flexion deformity (FFD) was 20° and highest post-operative FFD was 15°. The knees with greater deformity had less ROM which is significant ( $< 0.05$ ) (Table 6). The mean pre-operative PFCO was 3.42 cm with highest being 4.5 cm and lowest being 2.5 cm. The mean postoperative PFCO was 3.48cm with highest being 4.88 cm and lowest being 2.14 cm. The knees having less difference in pre-op and post-op PFCO and vice-versa had good ROM which is significant ( $< 0.001$ ) (Table 7). The mean preoperative PTS was 8.4° with highest being 16° and lowest being 2°. The mean postoperative PTS was 5.45° with highest being 12° and lowest being 0°. Knees within 3-5 mm PTS had good postop ROM which is significant ( $p < 0.05$ ) (Table 8). The mean preoperative knee score was 26.81, with highest being 51 and least being 9. After TKA the mean knee scores was 167.34 with highest being 189 and least being 121 which improved significantly (Table 9). There were 206 CR and 184 PS knees. Among those PS knees had a good post-op ROM which is significant ( $< 0.05$ ) (Table 10).

**Table 1: Age distribution of patients.**

Age (years)	N	Mean $\pm$ SD	Minimum	Maximum	F-value (p-value)	Significance
<50	42	97.62 $\pm$ 8.208	80	110	0.096 (0.962)	P>0.05 (not significant)
51-60	122	96.56 $\pm$ 15.254	40	130		
61-70	171	97.19 $\pm$ 13.774	40	130		
71-80	55	96.55 $\pm$ 15.180	50	130		
<b>Total</b>	390	96.95 $\pm$ 13.947	40	130		

**Table 2: Distribution of patients according to sex.**

Groups (sex)	N	Mean $\pm$ SD	Range	T value	P value
Male	181	96.85 $\pm$ 14.777	50–130	0.624	0.533 (not significant)
Female	167	95.90 $\pm$ 13.397	40–130		



**Figure 1: Graphical representation of diagnosis vs. ROM.**

Note: This indicates that the OA patients possess high mean value on the dimension of ROM, however the AS patients showed least mean value (m=90.0) compared to other patients. The ANOVA test result reveals that p value is <0.01 (at 99% level of confidence). Which indicates there is significant difference between diagnosis and ROM (p<0.01).

**Table 3: Distribution of patients according to BMI.**

BMI	N	Mean±S.D	F value (p value)	Significance
18.5-24.99 (normal)	82	99.39±11.900	6.176* (0.001)	P<0.01 (significant)
25-9.99 (over weight)	270	96.89±14.061		
30-34.99 (obese)	32	95.31±12.696		
>35 (morbid obesity)	6	75.00±22.583		
<b>Total</b>	390	96.95±13.947		

\*significant at 0.001 level.

**Table 4: Pre-operative exercises.**

Pre-operative exercises	N	Mean±SD	Std. error mean	T value (p value)	Significance
With pre-op exercises	143	98.18±14.948	1.250	2.505* (0.013)	P<0.05 (significant)
Without pre-op exercises	247	95.23±8.313	0.529		

\*significant at 0.05 level.

**Table 5: Pre and postoperative ROM.**

	N	Mean±SD	Std. error mean	T value	Significance
Pre-op ROM	390	86.87±12.209	0.618	15.313* (0.000)	P<0.001 (significant)
Post-op ROM	390	96.95±13.947	0.706		

\*significant at 0.001 level.

**Table 6: Deformities in study participants.**

Deformity	N	Mean±SD	F value (p value)	Significance
Varus <25	182	100.48±10.348	2.780* (0.027)	P<0.05 (significant)
Varus >25	108	96.20±14.123		
Valgus <20	42	98.21±13.922		
Valgus >20	15	92.67±15.523		
FFD >15	43	97.91±15.970		

\*significant at 0.05 level.

**Table 7: Posterior femoral condylar offset.**

Posterior femoral condylar offset (mm)	N	Mean±SD	F value	Significance
Postop-preop (0-2)	102	108.76±12.833	24.644*	P<0.001 (significant)
Postop-preop (2-5)	94	95.91±14.220		
Postop-preop (>5)	42	90.66±15.970		
Preop-postop (0-2)	69	104.14±13.246		
Preop- postop (2-5)	55	94.11±15.058		
Preo- postop (>5)	28	87.46±14.268		
<b>Total</b>	390	96.90±13.947		

\*significant at 0.001 level.

**Table 8: Posterior tibial slope.**

Posterior tibial slope (mm)	N	Mean±SD	F-value (p value)	Significance
0-3	101	94.94±14.755	4.410* (0.005)	P<0.05 (significant)
4-5	129	100.69±12.191		
6-7	97	97.73±13.388		
>7	63	94.44±16.537		
<b>Total</b>	390	96.95±13.947		

\*significant at 0.05 level; (p<0.05).

**Table 9: Pre and postoperative TKSS.**

TKSS	N	Mean±SD	Std. error mean	T value (p value)	Significance
Pre TKSS	390	26.859±9.990	0.50587	46.089*	P<0.001 (significant)
Post TKSS	390	167.340±59.573	3.017	(0.001)	

\*significant at 0.001 level. TKSS: Total knee society score.

**Table 10: CR versus PS.**

CR vs. PS	N	Mean±SD	Std. error mean	T value (p value)	Significance
CR	206	95.18±13.408	0.934	1.918*	P<0.05 (significant)
PS	184	98.37±14.431	1.064	(0.051)	

\*significant 0.05 level; (p<0.05). PS: posterior-stabilized, CR: cruciate-retaining.

### Complications

8 patients had stiff knee with ROM less than 50 degrees, 4 with infection for which two stage revision done in all cases after 6 months, 1 had cellulitis treated conservatively, 1 with MCL avulsion treated with brace, 1 had tibial base plate subsidence but asymptomatic, 1 with medial laxity with graft failure and screw breakage and 1 with patellar clunk syndrome. Delayed wound healing was noted in 3 cases of average 20 days.

### DISCUSSION

Post-operative knee ROM is crucial for patient satisfaction. The success is based on pain relief and restoration of function. TKA is the standard treatment for severe dysfunction, aiming to make the knee pain free as well as stabilize the knee with an appropriate ROM. A number of studies explained the factors determining the

ROM after TKA which include appropriate ligament balancing, wound closure with knee in 40 to 50° of flexion and postoperative rehabilitation.<sup>6-11</sup> Laubenthal et al describe that in day to day life an individual requires 67° of flexion to walk, 83° to climb stairs, 90° to walk down stairs, 105° to get up from a chair.<sup>12</sup> The purpose of this study is to evaluate the factors determining knee ROM after TKA.

### Sex

Our study is similar with the reports of Sancheti et al, Schurman et al, Harvey et al, Kotani et al, that sex had no correlation in affecting the knee joint ROM.<sup>8,13-15</sup>

### Age

Schurman et al divided 25 patients with pre-operative ROM <78° into 2 groups: one group <62 years and the

other >62 years. Younger group showed a mean postoperative ROM of 83°, and the older group had a mean value of 100°, showing that the age is a factor in determining ROM.<sup>14</sup> Franklin et al reported older age groups have a poorer outcome when compared to younger.<sup>35</sup> Kotani et al, Horikawa et al, Harvey et al and Anouchi et al, reported no correlation between age and postoperative ROM.<sup>8,15-17</sup> In our study we also found no age-related effect on post-operative ROM.

### **Diagnosis**

Harvey et al reported that patients having rheumatoid arthritis (RA) had more post-operative ROM compared to OA.<sup>8</sup> Ritter and Stringer observed that the knee flexion increased in RA patients, but statistically insignificant.<sup>18</sup> Kotani et al described that the pre-operative diagnosis had no influence on post op ROM.<sup>15</sup> Sancheti et al, and in our study there was significant difference in post-operative ROM between the OA and RA groups with OA group having more post-operative ROM.<sup>15</sup>

### **BMI**

Obesity has an adverse effect on post-operative ROM due to soft tissue impingement between femur and tibia, which restricts flexion of the knee.<sup>19-20</sup> Study by Kotani et al, Farahini et al concluded that there was no relationship between BMI and post-operative flexion.<sup>15,21</sup> Shoji et al concluded that obese patients had poor ROM.<sup>19</sup> Lizaur et al reported that BMI was significantly correlated ( $r=0.25$ ,  $p=0.023$ ) with post-operative ROM.<sup>20</sup> In our study, BMI was strongly correlated with post-operative ROM.

### **Preoperative exercises**

Matassi et al analysed that pre-operative exercises are helpful on post-operative recovery after TKA, and helps patients to achieve 90° of knee flexion earlier.<sup>30</sup> Calatayud et al reported that strengthening exercises during pre-operative period minimizes pain and improve ROM and functional recovery after TKA.<sup>31</sup> Our study also showed positive correlation between pre-operative exercises and postop ROM.

### **Preoperative ROM**

In our study like Kurosaka et al, Harvey et al observed that preoperative ROM is an important factor for good postoperative ROM.<sup>22,8</sup> Kotani et al demonstrated positive correlation between preoperative flexion and postoperative flexion at 3 months and 1 year, but no evident correlation at 2 years after surgery.<sup>15</sup>

### **Preoperative deformity**

Kawamura et al concluded that pre-operative coronal deformity had negatively correlation with post-operative ROM.<sup>23</sup> Using a regression tree analysis, Schurman et al

identified that tibiofemoral varus/valgus angle as one of the pre-operative factors that negatively affect post-operative flexion.<sup>8</sup> Our study also observed that deformity has negative correlation with post-operative ROM.

### **Scores**

Anouchi et al described that the pre-operative knee society scores is an important predictor for ROM.<sup>17</sup> They divided patients into 3 groups; pre-operative score <27, 28 to 40, and >40. The patients with pre-operative knee scores below 27 improved 16 points ( $p=0.0001$ ) more than those in the 28 to 40 range and 33 points ( $p=0.0001$ ) greater than those in the greater than 40 group. In our study there is improvement in postoperative knee scores which showed better postoperative ROM.

### **Posterior femoral condylar offset**

Hanratty et al and Kim et al observed that there is no significant correlation between PFCO and final ROM.<sup>24,25</sup> Bellemans et al in an analysis of 150 consecutive PCL-retaining TKA patients, demonstrated a significant correlation between operative restoration of PFCO and maximal postoperative flexion.<sup>36</sup> For every 2 mm decrease in posterior condylar offset, the maximal obtainable flexion was reduced by a mean of 12.2°. In our study also there is significant correlation between PFCO and postop ROM.

### **Posterior tibial slope**

Kim et al observed no correlation between PTS and ROM.<sup>26</sup> Kim et al in a study of 45 knees about 1 yr follow up observed that there is a significant relation between tibial slope and postoperative ROM.<sup>25</sup> Braun et al reported that PTS would cause delay in tibio-femoral impingement and advised 6.5° of PTS to increase ROM.<sup>28</sup> Belleman's et al observed in 21 cadaver simulations of a PCL-retaining TKA using three-dimensional computer programs, reported that a 1° increase in PTS lead to an average increase of 1.7° of flexion.<sup>27</sup> Kansara et al observed that there was no significant relationship between the PTS and ROM in their TKA patients.<sup>29</sup> They divided the patients into two groups according to the use of either a 0° or 5° proximal tibial cutting block and could not find significant intergroup differences in the postoperative ROM. In our study we found a correlation between these two factors which are statistically significant ( $p<0.05$ ).

### **CR versus PS**

Jacobs et al and Bercik et al found that post-operative ROM was better in PS TKA.<sup>32,33</sup> Jiang et al conducted a meta-analysis which showed PS TKA had a better knee flexion postoperatively.<sup>34</sup> Our study also had increased ROM in PS knees compared to CR knees.

Limitations in our study are, patients operated by multiple surgeons at our institute, no comparison group, use of different implant designs, Intraoperative factors like soft tissue balancing, rectangular gaps after bony cuts were not considered.

## CONCLUSION

Pre-operative exercises, diagnosis, ROM, deformity, BMI, PFCO and PTS are the important factors influencing ROM in TKA. Patient selection and pre-operative counselling is important for good clinical outcome.

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