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Dr. Anudeep Peddineni
Post-Graduate Resident,
Department of Orthopedics,
BIRRD (T) Hospital, Sri
Padmavathi Medial College for
Women, SVIMS, Tirupati,
Andhra Pradesh, India

Dr. Kiran Bharath
Department of Orthopedics,
BIRRD (T) Hospital, Sri
Padmavathi Medial College for
Women, SVIMS, Tirupati,
Andhra Pradesh, India

Dr. Vamsi Chandra Raju
Post-Graduate Resident,
Department of Orthopedics,
BIRRD (T) Hospital, Sri
Padmavathi Medial College for
Women, SVIMS, Tirupati,
Andhra Pradesh, India

Dr. Avinash B
Assistant Professor, Department
of Orthopedics, BIRRD (T)
Hospital, Sri Padmavathi Medial
College for Women, SVIMS,
Tirupati, Andhra Pradesh, India

Dr. Sandeep Krishna Avulapati
Assistant Professor, Department
of Orthopedics, BIRRD (T)
Hospital, Sri Padmavathi Medial
College for Women, SVIMS,
Tirupati, Andhra Pradesh, India

Corresponding Author:
Dr. Anudeep Peddineni
Post-Graduate Resident,
Department of Orthopedics,
BIRRD (T) Hospital, Sri
Padmavathi Medial College for
Women, SVIMS, Tirupati,
Andhra Pradesh, India

Gama angle in sagittal plane of post-operative total knee replacement - variations in patients: A retrospective radiological analysis

**Dr. Anudeep Peddineni, Dr. Kiran Bharath, Dr. Vamsi Chandra Raju,
Dr. Avinash B and Dr. Sandeep Krishna Avulapati**

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Abstract

Introduction: Total Knee Replacement (TKR) though appears as bone surgery, but success depends on correct pre-operative analysis, better execution of bone cuts and soft tissue balancing. Radiological evaluation shows differences between patients, even though same instrumentation and technique were used in surgery. There appears variation in Gama angle in femur, posterior slope in tibia.

Aim and Objectives: To analyze variability of Gama angle in patients after post TKR surgery.

To find out the reasons of variability of Gama angle, posterior slope and sagittal femoral bowing

Materials and Methods: A retrospective study carried out in Department of Orthopedics, BIRRD (T) Hospital. All the surgeries were carried out by single surgeon were included into the study after satisfying inclusion and exclusion criteria. The study involves radiological evaluation, without direct interaction of patient. Patients were evaluated for basic radiological measurements in coronal and sagittal planes. Results were tabulated and evaluated.

Results: Seventy-two patients were included into study. There were 30, 42 male and female patients respectively. 54 patients with unilateral and 18 patients bilateral TKR were carried. Average age of patient was 61 years. Average Gama angle in femoral side, posterior slope in tibia and femoral sagittal femoral bowing was 4°, 85.4° and 5.5° respectively.

Conclusion: There exists positive co-relation in femoral bowing, posterior slope in tibia and Gama angle in femur in sagittal plane radiologically.

Keywords: Gama angle, posterior slope, sagittal femoral bowing, total knee replacement

Introduction

Total knee replacement in India is a costlier surgery, which is not available to 60% population, wherein 70% of Indian are from rural background, with low socio-economic status and primary health care facilities are less. Most of people who present to our hospital are from rural background. These people present with Grade III/ IV osteoarthritis with varus deformity at highest. We do have valgus deformity also but a smaller number of cases. TKR in these patient offers pain relief, increased mobility, decreased dependence on other for daily activities of life and living.

Some of the acceptable radiological findings across studies shows size of femoral implant should be identical to contralateral unaffected femur ^[1]. Distal femoral cut must be perpendicular to anatomical axis of femur to prevent anterior cortical notching ^[1]. Posterior slope of 0-7 stabilizes knee and prevents slipping of tibia back under femur in flexion ^[1, 2]. In sagittal plane acceptable tibial posterior slope is 0-7, whereas any angle outside these parameters shows malalignment ^[2]. Similarly normal acceptable femoral implant alignment is 0-3 where >3 is considered flexion and <0 is considered as extension ^[2].

When started our analysis we found that there are variations in these values. Also, further in literature does not adequate analysis and relationship between these parameters. Hence forth we started our study to find variability and relationship between these parameters.

Aim and Objectives

Aim: To analyze the variability of Gama angle in sagittal plane in post TKR patients

Objectives

1. To analyze the reason for variability
2. To find out co-relation between sagittal parameters in post TKR patients

Materials and Methods

This is a retrospective study carried out in department of orthopedics, BIRRD (TO Hospital, Tirupati. This study requires radiological evaluation of patient's data. All the cases

carried out by single surgeon were included into the study. All the X-rays are stored into our central data base are accessed after fulfilling the inclusion and exclusion criteria.

Inclusion criteria

1. Patients who underwent TKR under single surgeon

exclusion criteria

1. Patient who underwent bilateral TKR

Table 1: Shows Parameters evaluated in X ray

Anterior – posterior X-ray	Lateral X - Ray
Pre- operative knee alignment Post-operative knee alignment Alpha angle (femoral implant angle) Beta angle (tibial implant angle) Valgus angle	Gama angle (implant Vs anatomical femoral angle) Sagittal femoral bowing angle Implant – tibial posterior slope angle

Results were tabulated and statistical analysis was done.

Observation and Results

There were seventy-two patients included into the study. There were 42 females and 30 male patients in all. There were 29, 25, 18 patients operated left, right and bilateral sides respectively. In our Institute we do bilateral with a gap of

minimum of 6-12 months apart based on severity of osteoarthritis of knee. Average age of patients was 61 years, with females operated at an early age than males (59 years vs 64 years).

Table 2: showing TKR with differentiation in unilateral, bilateral, side and sex of patients

Total number of patients = 72					
Unilateral - 54				Bilateral - 18	
Left = 29		Right = 25			
Male	Female	Male	female	Male	Female
12	17	9	11	9	9

We have pre-operative knee alignment of 183.61° (S.D ± 7.98) with range of 157° - 197° . We have 8 valgus knee and 39 varus knees. While there are 43 knees with in normal range of

175° - 185° [3]. Post-operatively, we have correction alignment 177.22° (S.D $\pm 3.98^{\circ}$), with range of 168° - 187° .

Table 3: Various sagittal parameters evaluated in patients

Variable in sagittal plane	average	Standard deviation (S.D)	No of values in Mean + 2 (S.D)	Values greater than Mean + 2 (S.D)	Values lesser than Mean + 2 (S.D)
Gama Angle	4.02°	3.93°	85	5	0
posterior tibial slope	85.25°	2.85°	87	1	2
Sagittal femoral bowing angle	5.53°	1.96°	88	2	0

Discussion

Indians have shortest, bowed femurs. This shortness and bowing are increased in Indian female population. The maximum point of curvature is placed more distally in femur. This is in contrast to western, African and American Indians who have long femur and proximal point of curvature in them [5]. Mean sagittal bowing in femur is measured by radius of curvature in a study. The more radius of curvature will have the less sagittal bowing and vice versa. The average sagittal curvature in Indian population was found to be 109.34cm (S.D ± 25 cm). They found that more radius of curvature in male population (112.72cm in males Vs 103.26cm in females) [6].

In sagittal plane, the acceptable alignment of implant is 0° - 3° . Any angle less than 0° will be considered as extension, angle greater than 3° as flexion. As per studies it shows extension of

femoral implant results in notching of anterior cortex of femur, further resulting in supracondylar peri-prosthetic fractures at a later date. Similarly in implant alignment in flexion can be result in impingement on poly in anterior and intercondylar anterior edge [4]. Sagittal alignment of implant also depends upon diameter of reamer, design of implants, sagittal femoral bowing, entry point of intramedullary guide, length of intramedullary guide [4].

Use of long and short intramedullary rod can also result in sagittal alignment of implant as shown figure no. 1. Use of long intramedullary can result in translation of distal femur guide anteriorly. This can result in extension of implant less than 0° . But due to anterior referencing of sizer which prevents anterior notching of femur. Similarly use of short intramedullary guide, it results in flexion of implant as shown in figure No. 1.

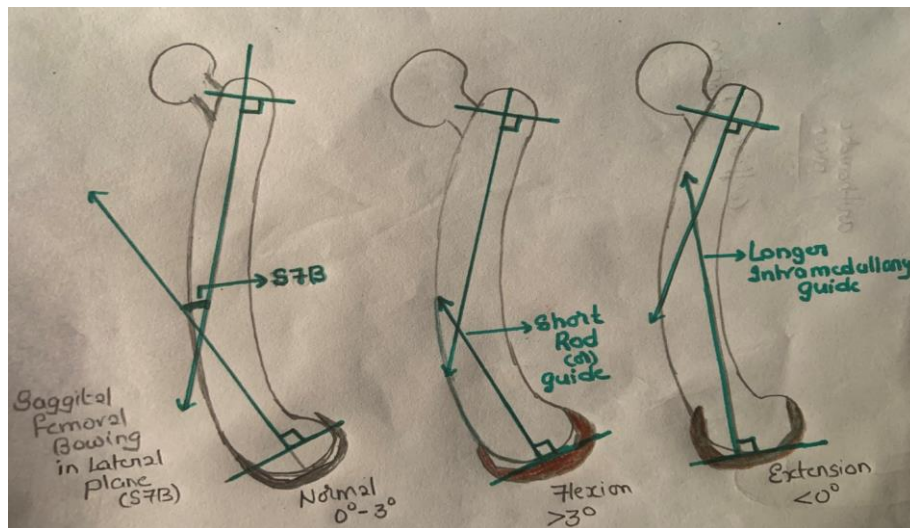


Fig 1: measurement of Sagittal femoral bowing, use of short and long intramedullary guide, alignment of femoral implant accordingly.

Table 4: shows correlation between the different variables through Pearson and Spearman's calculator

Variables	Pearson's calculator	Spearman's calculator
Between Gama angle and posterior slope implant on tibia	$R = -0.2141$ $R^2 = 0.458$ $P = 0.0458$ $p < 0.05$ negative weaker correlation	$R_s = -0.0158$ $P (2 \text{ tailed}) = 0.03388$ By normal standards association is significant
Between Gama angle and femoral sagittal bowing	$R = 0.2275$ $R^2 = 0.0158$ $P = 0.031$ $p < 0.05$ positive correlation	$R_s = 0.167$ $P (2 \text{ tailed}) = 0.1145$ By normal standards association is not significant
Between Posterior slope of implant on tibia and femoral sagittal bowing	$R = 0.06103$ $R^2 = 0.0082$ $P = 0.3988$ $p < 0.05$ not significant	$R_s = 0.06103$ $P (2 \text{ tailed}) = 0.5677$ Not significant

We found positive co-relation (Pearson's) between Sagittal femoral bowing and Gama angle of femoral implant post-operatively. This association is not significant by normal standards in Spearman's test. Pearson's shows Weaker negative co-relation between Gama angle and posterior tibial slope of implant post-operatively. Similar results were found

in Spearman's co-relation test, negative association is significant by normal standards. Insignificant weakly positive relation exists between sagittal femoral bowing angle and posterior tibial slope of tibial plate on tibia in Pearson's test, but this is not significant in Spearman's test

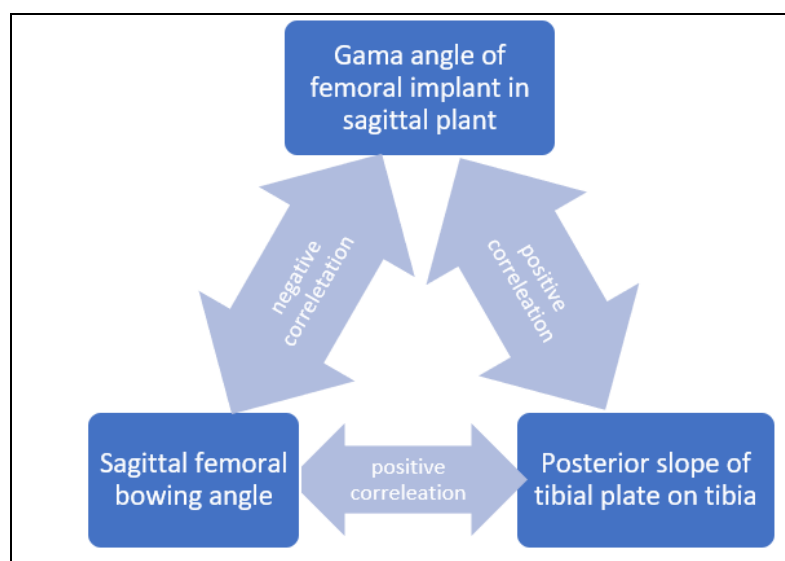


Fig 2: Flow chart representing the relationship between Gama angle of femoral implant in sagittal plane, sagittal femoral bowing angle of distal femur and posterior slope of tibial plate on tibia

Table 5: comparison of femoral sagittal flexion angle of implant in various studies and our study

Studies	Sagittal flexion angle	No of patients in the study
Boldt, Jacobi <i>et al.</i> [7, 9]	2°	1133
Miza- Uchi <i>et al.</i> [8]	4.5°	76
Pravin DP <i>et al.</i> [7]	6.32° + 6.8°	185
Our Study	4.02° + 3.93°	72

We found our study values are similar to other studies as shows in comparison in table no 5.

Finally, our observations are the following

1. Indian population have sagittal bowing more than European and other populations. They have more sagittal bowing in lower end of femur.⁵ We measured the same as 5.53° (S.D ± 1.96°) in our study.
2. Femoral implant position in sagittal plane is dependent upon Sagittal femoral bowing. This is in inclination with femoral articular surface in Indian population.
3. Use of long intramedullary guide results in anterior translation of distal femur cut. Using anterior reference point in our TKR lead to no notching of anterior surface of femur. There might be slight extension noted in femur implant in sagittal plane sometimes noted.
4. Using of short intramedullary guide always aligns femoral implant in flexion. This is in alignment with articular surfaces of femur.

Conclusion

We conclude that gama angle of femoral implant in sagittal plane is variable.

This is dependent upon many factors like sagittal femoral bowing, posterior slope of tibial implant on tibia, use of long and short intramedullary guide

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