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The understanding of distal femur cut in total knee arthroplasty: Preset 5° valgus cut angle and variability of alpha angle

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Abstract

Introduction: Total knee Arthroplasty (TKA/TKR) is frequently performed surgery in patients with osteoarthritis, above 50 years age. TKR decreases pain, increases patient ability to walk independently. This decreases dependency on others in elderly age. This will help them to carry-out daily activities of living, at times daily activities of earning in that old age.

Aim: To study variability of alpha angle post-operatively in knee, with same preset 5° valgus cut angle.

Null Hypothesis: We propose that preset 5° valgus cut angle (distal femur cut) will have same alpha angle of 95° in all knee post-operatively.

Materials and methods: Patients admitted into BIRRD (T) Hospital for TKR during the March 2017 to March 2018 were included into study, after satisfying inclusion and exclusion criteria. Radiological evaluation was done pre and post-operatively. Varus (pre and post-operative), alpha angle and other angles were calculated. Results were tabulated and statistical evaluation done.

Results: Sixty-two patients were included in the study. Average age was 60 years. There were twenty six male and thirty six female patients. Average pre-operative Varus was 183° and post-operative correction obtained was 177°. Average alpha angle was 94.9°, beta angle 89.4°. Alpha angle varied from 90°-99° while beta angle varied 80°-94° in our study.

Conclusion: Preset 5° valgus distal femur cut cannot determine alpha angle. Alpha angle is dependent upon many factors like entry-point of intramedullary guide, over-reaming of entry point, isthmus diameter of femur, cutting difference of medial and lateral condyles in distal femur cut. Null hypothesis remains rejected.

Keywords: Preset 5° valgus cut, TKR, TKA, distal femur cut, alpha angle

Introduction

In post-Arthroplasty knee, a balanced tension throughout range of movement must be biggest and end achievement ^[1]. Extension and flexion gaps must be rectangular i.e, medial and lateral soft tissue balanced tension. During the procedure of TKR, whatever be the technique used (either gap balancing or measured resection technique), ultimately it must lead to correction of deformity and maintenance of equal soft tissue tension on medial and lateral side ^[1]. Though burden of revision TKR is almost half than revision THR, but it is steadily rising around world with increase of primary arthroplasties every year ^[2]. Revision TKR might have surpassed Revision THR by 2007 ^[3]. Polyethylene wear, aseptic loosening, followed by infection play a major role in revision surgeries of TKR. But malalignment or malposition of implant at about 10% will also contribute to Revision TKR ^[4]. We thought preset 5° valgus distal femoral cut during Arthroplasty will be represented as alpha angle of 95° post-operatively. But on random short study we found variability of alpha angle. This has led to the start of the study to find out whether same preset 5° valgus and post-operative alpha angle do have any relation or not. We propose null hypothesis preset 5° valgus cut angle and alpha angle 95° go hand in hand post-operatively

Aim

To know the variability of alpha angle post-operatively in Arthroplasty knee with same preset 5° valgus cut.

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Materials and Methods

The study was a retrospective analysis of patient who underwent total knee Arthroplasty in BIRRD (T) hospital, Tirupati. All patients who underwent Arthroplasty during period of March, 2017 to March, 2018 were included into the study after fulfilling inclusion and exclusion criteria.

Inclusion criteria

1. Age greater than 50 years.
2. Patients with primary TKR
3. Uncomplicated TKR

Exclusion Criteria

1. Age less than 50 years
2. Patients with secondary TKR i.e. revision TKR
3. Complicated TKR with medullary stems, medial and lateral wedge supports
4. Patients with constrained implant, MCL tear

Ours is a charity Institute, we do TKR at free of cost. For better utilization of limited resources, for greater good, we restrict procedure for population above 50 years. We do perform TKR for patients below 50 years in specific conditions like Rheumatoid arthritis etc.

This study does not involve direct interaction with patients. All the measurements were taken from the x-rays stored in our Database of our institute. Pre-operative and, post-operative anatomical axis, alpha angle, beta angle, tibio-femoral anatomical valgus angle were calculated.

Observations and Results

There were 62 patients included into the study. There were 26 males and 36 female patients. Average age of patients in the study was 60.3 ± 9.2 years. Average female and male patient age were 58.5 ± 9.5 , and 62.8 ± 8 years respectively.

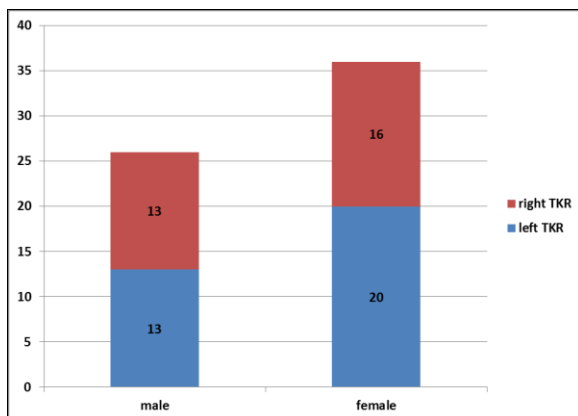


Fig 1: Bar-chart showing male and female with side of TKR

Table 1: Showing pre-operative Varus deformity and Post-operative Anatomical Axis in the study

| Quantity Measured | male | Female | Total |
|---------------------------------------|-----------------------------|-----------------------------|---------------------------|
| Average pre-operative Varus Deformity | $182.3^\circ \pm 9.3^\circ$ | $183.1^\circ \pm 7.4^\circ$ | $182.8 \pm 8.2^\circ$ |
| Post-operative Anatomical Axis Angle | $177.3^\circ \pm 3.9^\circ$ | $176.7^\circ \pm 3.5^\circ$ | $177^\circ \pm 3.7^\circ$ |

Average correction of deformity was $5.7^\circ \pm 7.6^\circ$ with range (-14.9° to 22.7°). Average alpha angle was $94.9^\circ \pm 2.0^\circ$. Entry point during surgery was 3mm medial and 7-10mm above PCL insertion was common for all the patients.⁵ Preset valgus of 5° valgus cut angle was also common.

Discussion

We start our discussion with a simple question “Why alpha angle of all Post-operative cases will not be the same as 95° , though there is same preset 5° valgus cut angle was used during Arthroplasty?”

On further literature research we found that [5, 6, 9].

1. Entry point for intramedullary guide is not center of trochlea (shown in Table no. 2). It is 3-4mm medial to center of trochlea. A straight line passing through anatomical center of femur and isthmus center passes medial to center of trochlea. This point is more anatomical center than center of trochlea [5, 6].
2. Distal femur resection angle is dependent upon the entry point for intramedullary guide i.e, distal femur cut will be more valgus when placed at center of trochlea as well as more lateral to centre of trochlea [6, 9].
3. Widening Entry point of Intramedullary guide with 10-12 mm drill was recommended for prevention of Fat Embolism Syndrome with intramedullary guides [9]. This will contribute for variability of alpha angle. \tan^{-1} angle shows variability (table No.2) at the entry point. This gives good amount of freedom in antero-posterior and lateral views for intramedullary rod.
4. This distal femur cut is also dependent on accuracy of central positioning of intramedullary rod in the center of femoral canal [6].
5. Wide femoral canal allows toggling of intramedullary rod. This can result in 1° - 2° error in both varus and valgus.
6. Proximal position of rod past the center of Isthmus will determine valgus or varus cut as shown in Table No 2 and 3
7. Entry point of intramedullary rod is 6-10mm proximal to PCL insertion [5]. Femoral bowing can also result in changes of angle. Increased bowing of femur in Antero-posterior view, with same preset 5° valgus cut angle can result in Varus cut [9]. Hence pre-operative ortho-scanogram is required to calculate valgus angle and entry point of intramedullary guide.
8. Femoral valgus cut angle is increased in short femur ($>4^\circ$), decreased in long femur ($<4^\circ$) [17].
9. Fixed Valgus Cut Angle will result in alignment of knee outside of ideal 0° - 3° HKA axis in significant manner [18].
10. Grazing of the anterior cortex proximally by intramedullary guide may result in flexion of implant and vice versa results in extension position of implant. (these finding are depicted in Figure No.5)

From the above reasons, we infer that that alpha angle for Post TKR patients will not be the same even though there is preset 5° valgus instrumentation.

We have pre-operative varus deformity of $182.8^\circ \pm 8.2^\circ$ which was corrected by $5.7^\circ \pm 7.2^\circ$. Our correction i.e. $177^\circ \pm 3.7^\circ$ is comparable with $176.1^\circ \pm 2.16^\circ$ in Francesco Benazzo *et al.* study [7].⁷ We do have other findings comparable with other studies given in tables no 4 and 5. The defect in tibia was major contributor to varus deformity of knee than that of femoral defect [5]. In our study we found preset 5° valgus cut of distal femur will not itself contribute to restoration of mechanical axis and stability of implant. The other reasons for this can be soft tissue balancing, tibial cut, antero-posterior cut of femur. Our Institute being a tertiary care and charity hospital, we do have patients with grade IV osteoarthritis, and varus and valgus deformities. Knee Arthroplasty, we practice it as a procedure of minimal bone

resection with maximal soft tissue balancing [8]. Alignment of knee was obtained after appropriate femur and tibial cuts, and soft tissue balancing [9]. The longevity of implant life is dependent up on lesser constraint and good soft tissue balancing. We (BIRRD Hospital) follow these steps in sequence for maintaining soft tissue balancing, during the procedure. These steps are followed for each and every case. Our main aim during the Arthroplasty procedure is to have minimal bone-cuts, good soft-tissue balancing, less constraint instrumentation with optimal correction of deformity. We call this as "BIRRD Protocol" and we take pride in following it. Soft tissue balancing (BIRRD Protocol) is as follows. (Figure no.2)

1. Release of medial, posterior medial, posterior capsule from tibia. This needs to be done, step by step with assessment of gap in flexion and extension during the procedure [9].
2. Release of posterior osteophytes of femur after antero-posterior cut of femur.
3. Release of posterior capsule of femur.
4. Removal of medial, posterior-medial and posterior osteophytes of tibia followed by femur [9].
5. Assessment of tightness of PCL ligament.

Correction of deformity was good. We had deformity range of -14.9° valgus to 22.7° of varus. Post operatively we had average correction of $5.7^\circ + 7^\circ$. Average alpha and beta angle were 94.9° and 89.4° respectively which are comparable with other studies. With state of art theatre facilities available in our hospital we have lowest rate of infection. With good post-

operative pain relief and prompt physiotherapy team, we do mobilize the patients immediately on the day of surgery.

Finally we infer that alpha angle is dependent on

1. Pre-operative factors

- Femoral bowing
- Femoral length
- Anatomical alignment of femur

2. Per-operative factors

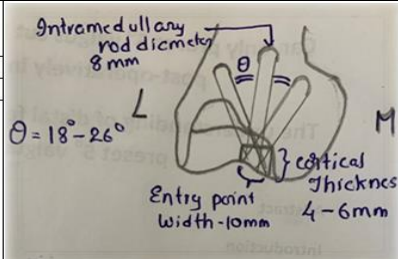
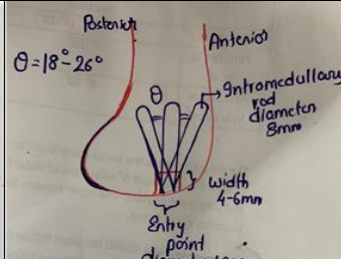
- Position of Entry point of intramedullary guide
- Widening of entry point
- Intramedullary Guide diameter
- Freedom of movement at entry point for intramedullary
- Freedom of intramedullary guide at isthmus of femur
- Position of intramedullary guide in femoral canal
- Position of implant on femur

3. Post-operatively

- Anatomical and mechanical axis alignment post-operatively

The placement of the entry point and the position of intramedullary guide in femoral canal can determine the final orientation of the femoral component in coronal plane (valgus/varus) and in sagittal plane (neutral/flexion/extension). This results in variability of alpha angle post-operatively.

Table 2: variability of (\tan^{-1}) angle at the entry point of femur with intramedullary guide diameter of 8mm and entry canal diameter of 10mm

| Cortical thickness at entry point | (\tan^{-1}) angle over Antero-posterior and lateral views | | |
|-----------------------------------|---|---|--|
| 4mm | 26° |  |  |
| 5mm | 21° | | |
| 6mm | 18° | | |

This \tan^{-1} angle represents freedom for variability of alpha angle at the isthmus of femur

Table 3: Showing angle variability in case scenarios with preset valgus angle 5° with intramedullary guide of 8mm at isthmus of femur

| Length of femur Versus Isthmus diameter of femur | (Isthmus diameter of femur) 13.63mm \tan^{-1} angle | Variability of alpha angle |
|--|---|----------------------------|
| 287.45mm | 1.08° | 96.08°- 93.92° |
| 184.81mm | 1.74° | 96.74° - 93.26° |

Measurements drawn with findings correlated with Xiu Yun Su *et al.*, [10] Rajendran H S R *et al.*, [11] and James E Mc Grory *et al.* [6].

Table 4: Showing Tibio-femoral valgus angle in various studies Post-operatively in comparison with our study

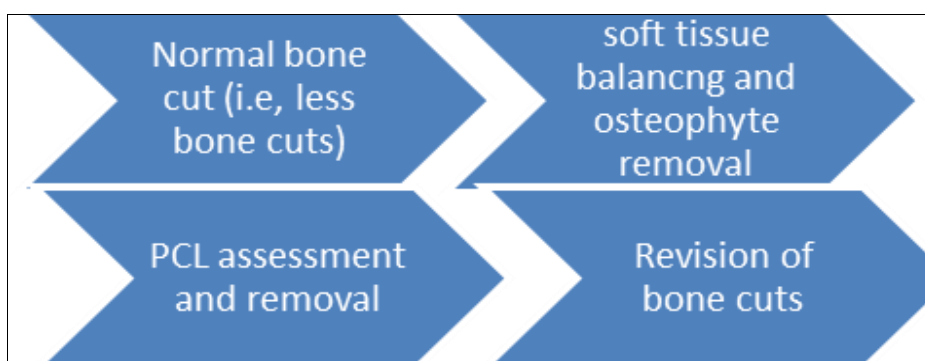
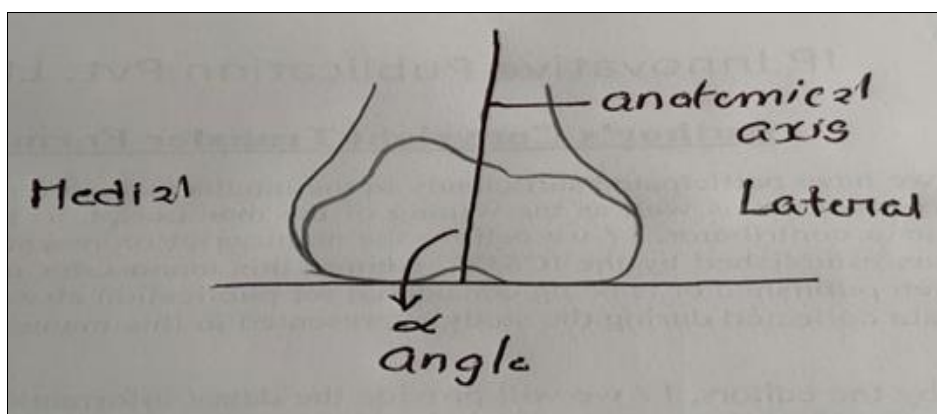
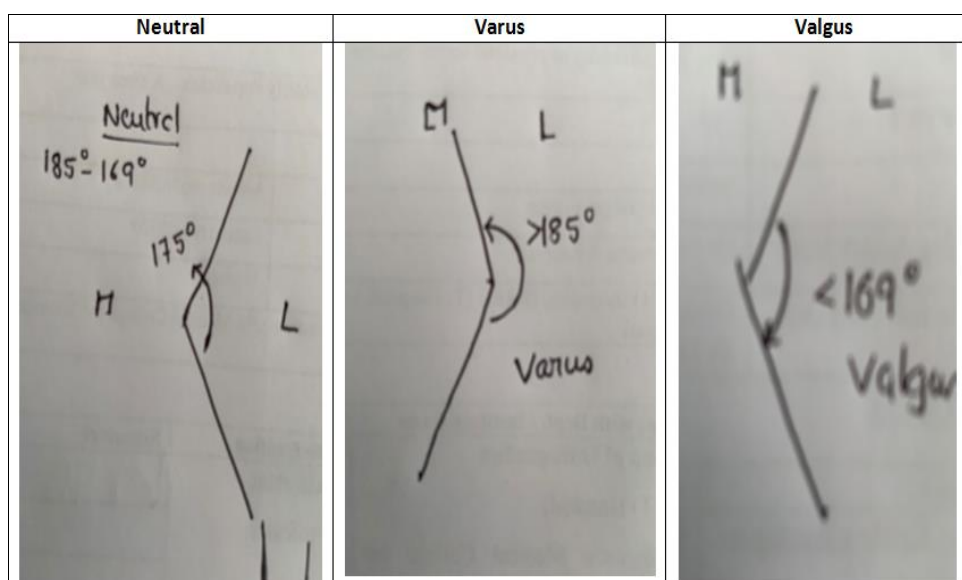
| Study | Tibio-femoral valgus angle the zone | Sample size of study | Percentage within the range |
|-------------------------------------|---|----------------------|-----------------------------|
| Our study | $4.13^\circ + 2.5^\circ$ (4° - 10°) | 62 | 42% |
| Petersen TL <i>et al.</i> [12] | 4° - 10° | 50 | 74% |
| Mahaluxmi Vala J <i>et al.</i> [13] | 4° - 10° | 673 | 74% |

Table 5: Showing comparison of alpha, beta and tibio-femoral anatomical axis of our study with various studies

| Study | Alpha angle | Beta angle | Tibio-femoral anatomical axis |
|--------------------------------------|----------------------------|--------------------------|---|
| Our study | $94.9^\circ + 2^\circ$ | $89.4^\circ + 2.7^\circ$ | $4.15^\circ + 2.5^\circ$ |
| Mont MM <i>et al.</i> [14] | 94° - 105° | 84° - 94° | 2.6° (varus)- 4.8° (valgus) |
| Christian Michael <i>et al.</i> [15] | 96.4° | 86.1° | 3.9 (valgus) |
| Volkan Kilincoglu <i>et al.</i> [16] | $96.65^\circ + 2.93^\circ$ | $87.15^\circ + 3^\circ$ | |

Table 6: Showing variability of alpha angle with standard deviation with sample size

| Alpha angle | Sample size |
|------------------------------|-------------|
| 94.9° | 2 |
| 94.9° + 2° (92.9° – 96.9°) | 45 |
| 94.9 + 4° (90.9° – 98.9°) | 58 |
| Out side (<90.9° and >98.9°) | 4 |

**Fig 2:** Showing continuous assessment and procedures followed step by step in our institute (BIRRD protocol)**Fig 3:** Showing measurement of Alpha angle post operatively. Angle drawn with findings in J.Azpeitia Study ^[19].**Fig 4:** Showing Neutral, Varus and Valgus angles used in measurement. Measurements drawn from the findings Atul F Kamath et.al study ^[20]

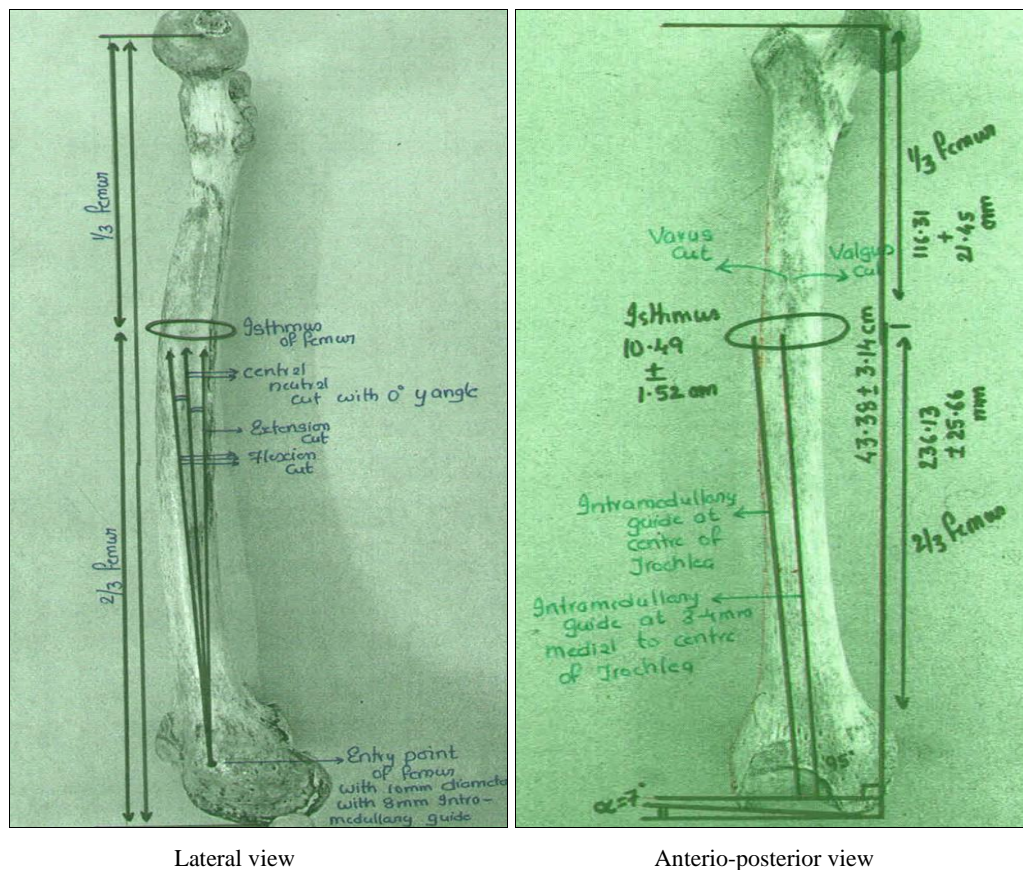


Fig 5: Showing various measurements of femur

Conclusion

We conclude saying that

1. Preset 5° valgus cut angle in femur cannot result in alpha angle of 95 in post-operative knee. [Alpha angle in post-operative knee is result of many factors during surgery].
2. Moreover preset 5° valgus cut angle cannot be the same for all patient femora in general population. This depends up on length of femur and femoral bowing.

Hence null hypothesis remains rejected.

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