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ORIGINAL RESEARCH

To compare postoperative alignment Using Fixed *versus* Individual Valgus Correction Angle in Primary Total Knee Arthroplasty and factors affecting VCA

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ABSTRACT

Aim: This study aimed to compare postoperative alignment using fixed versus individual valgus correction angle (VCA) in primary total knee arthroplasty (TKA) and analyze factors affecting VCA. **Material and Methods:** This prospective randomized controlled trial was conducted at the Department of Orthopaedics, Noida International Institute of Medical Sciences (NIIMS) Greater Noida, from September 2023 to September 2024. A total of 100 knees from 52 patients were included, with 50 knees in each group: Group A (individual VCA) and Group B (fixed VCA). Patients were selected based on strict inclusion and exclusion criteria and underwent TKA using the modified Insall's technique. Preoperative and postoperative hip-knee-ankle (HKA) radiographs were analysed. Statistical analysis was conducted using SPSS 26.0, and a p-value <0.05 was considered significant. **Results:** The mean age of the study population was 64.04 ± 9.41 years, with the majority (38.4%) aged 60–69 years. Females constituted 84.6% of the cohort. The mean BMI was 30.33 ± 5.32, with 53.8% classified as obese. The mean VCA was 6.9°, with 41% of patients having VCA values between 6–6.9° and 37% >7°. Postoperative alignment was significantly better in the individual VCA group (MAD: 1.61 ± 1.63°) compared to the fixed VCA group (MAD: 3.3 ± 1.60°, p = 0.000). Group B had a higher proportion of patients with alignment deviation ≤1° (48%) compared to Group A (12%). **Conclusion:** Individual VCA resulted in significantly better postoperative limb alignment compared to fixed VCA. Factors such as height, weight, BMI, and hip medial offset influence VCA and should be considered during preoperative planning to optimize outcomes in TKA. Tailored VCA measurement ensures precise alignment, particularly in patients with unique anatomical variations.

Keywords: Total knee arthroplasty, valgus correction angle, limb alignment, osteoarthritis, individual VCA

INTRODUCTION

Osteoarthritis is one of the most common chronic health conditions and a leading cause of pain and disability among adults worldwide.[1] In India it is the most frequent joint disease with a prevalence ranging from 22% to 39%. [2]Orthopaedic surgeons began performing total knee arthroplasty (TKA) in the 1970s. Today it is a commonly performed surgical procedure for osteoarthritis that is beneficial to majority of patients and is cost effective.[3,4] TKA is a surgical procedure in which a diseased or damaged knee joint is replaced with an artificial joint. It is routinely performed to relieve the disabling pain associated with severe arthritis when nonsurgical treatment options, have been ineffective. The objective of TKA include pain relief, returning to activities of daily living, restoring mechanical alignment, preserving the joint line, balancing the ligaments, and restoring a normal Q angle.[3] Before performing TKA the alignment of the lower extremity is measured and during surgery accurate bone-cuts are taken, soft tissue is released from concave side of deformity and proper alignment is achieved. Release of the medial ligament and capsule, elimination of the osteophytes are important steps in ligament balancing in varus knee deformity.[5] Accurate restoration of limb alignment is the foundation of the long-term success of TKA, and limb malalignment is associated with the early failure of TKAs.[6] Implant mal-alignment following primary TKA has been reported to be the

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primary reason for revision in about 7% of revised TKAs and it has been linked to decreased implant survival, inferior patient reported outcomes, and long-term complications including accelerated wear, premature mechanical loosening of the implant and patellofemoral problems.[7] During surgery the alignment of the limb is restored by appropriately placed bone cuts augmented by soft tissue release. The neutral alignment of the limb can be achieved by perpendicular cuts made to the tibia and femoral mechanical axis. The resection of the tibia is done perpendicular to its anatomical axis which corresponds to the mechanical axis. On the femoral side, however, because the anatomical axis does not correspond to the mechanical axis and hence the cut has to be made at an angle which varies from patient to patient. The goal is to restore the mechanical axis of the limb within 3 of normal. An intramedullary alignment guide is currently the most commonly used method for performing distal femoral resection, and most surgeons routinely use the fixed 5° or 6° coronal plane valgus correction angle (VCA) in distal femoral resection for all patients, assuming little or no variation in the femoral mechanical-anatomic angle(FMA) among patients.[8] According to literature routine 5° or 6° VCA is safe for an uncomplicated primary TKA. However the use of the same resection for all patients implies that they all have the same FMA angle. There are a number of published papers that indicate that this is not the case and FMA angle could vary between 2° and 9°. This led to a change of our practice to adjust the femoral distal valgus resection angle to the individual patient's FMA angle.[9]

MATERIAL AND METHODS

The study was conducted at the Department of Orthopaedics, Noida International Institute of Medical Sciences (NIIMS) Greater Noida from August 2022 to March 2023. It was a prospective randomized controlled trial designed to evaluate postoperative limb alignment in patients undergoing total knee arthroplasty (TKA). This was a prospective randomized controlled trial. Patients included in the study were those admitted to NIIMS, Hospital Greater Noida for primary TKA due to Grade IV osteoarthritis (OA) with clinical and radiographic findings consistent with severe OA. A total of 100 knees were studied, with 50 knees in each group (Group A: Individual valgus correction angle, Group B: Fixed valgus correction angle). Data collection was conducted between September 1, 2023, and September 30, 2024.

Inclusion Criteria

1. Patients with Grade IV OA planned for primary TKA.
2. Patients who provided written informed consent for the procedure.
3. Patients of Indian nationality.

Exclusion Criteria

1. Fixed flexion deformity >30°.
2. Pre-existing extra-articular deformity of the femur or tibia.
3. Patients with prior history of hip or ipsilateral lower limb surgery.

Methodology

All patients underwent pre-anesthetic evaluation and clearance before surgery. TKA was performed using a modified Insall's technique with the Stryker Scorpio Knee System (Stryker, Mahwah, New Jersey, USA). Preoperative and postoperative full-length, standing hip-knee-ankle (HKA) radiographs were taken using a standardized radiographic technique and stored in the hospital's Picture Archiving Communications System (PACS). Postoperative radiographs were taken with knees in ≤5° flexion contracture to minimize measurement errors. The lower extremities were fully extended, with patella and tibial tuberosities facing the X-ray source. The overlap of the proximal tibia and fibula was ≤60%, ensuring no limb rotation. Parameters such as femoral length, preoperative mechanical axis, femoral neck–shaft angle, coronal femoral bowing angle, and distal femoral valgus resection angle were recorded and analyzed.

Group Allocation

Patients were randomly assigned to two groups using an odd-even method:

- **Group A:** Individual valgus correction angle.
- **Group B:** Fixed valgus correction angle (5°).

The senior surgeon performed all surgeries, ensuring consistency across groups.

Outcome Measures: Postoperative scanograms were evaluated to compare limb alignment between the two groups. Factors influencing valgus correction angle (VCA) were also analyzed. Patients were randomly assigned to the two groups upon hospital admission using an odd-even numbering method.

Statistical Analysis

Data were analyzed using SPSS 26.0 software. Continuous variables were expressed as mean ± standard deviation (SD) and compared using t-tests. Categorical variables were expressed as proportions and analyzed using chi-square tests. A p-value <0.05 was considered statistically significant.

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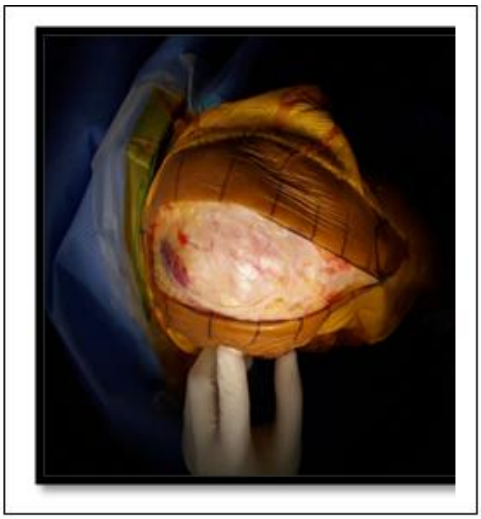

Fig.1 showing anterior midline incision over knee

Fig.2 showing knee arthrotomy using medial parapatellar

Fig.3 showing Tibial preparation using extra medullary *technique*

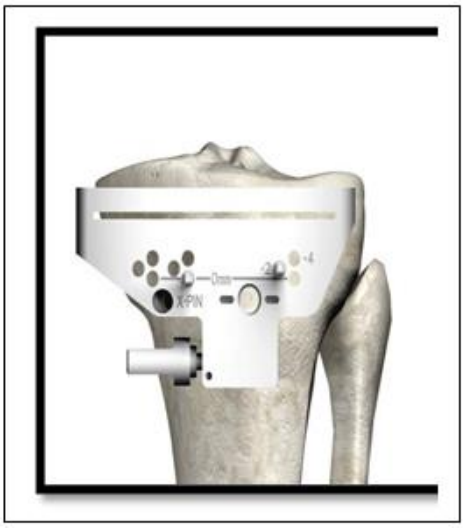

Fig.4 showing Tibial Resection Guide

Fig.5 showing preparation of Tibial base plate

Fig.6 showing technique of Tibial Keel Punching

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Fig.7 showing Femoral alignment guide insert into intercondylar drill hole

Fig.8 showing method of distal femoral resection

Fig.9 showing attachment of A/P sizer with stylus on Femur

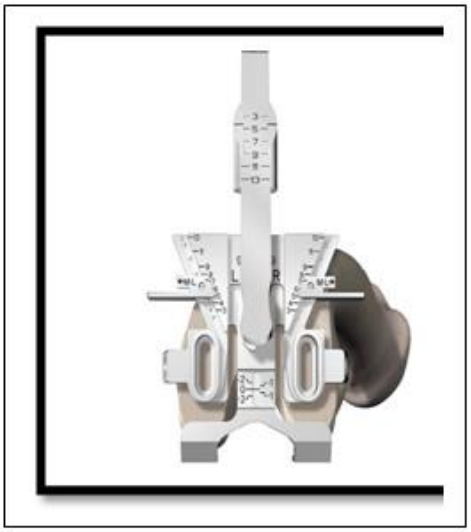

Fig.10showing A/P sizer with Stylus with modular handle

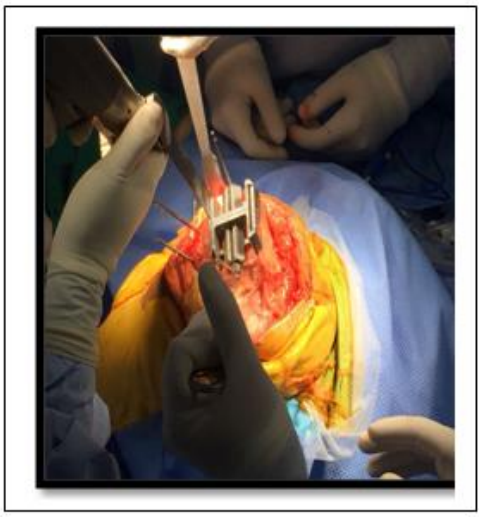

Fig.11 showing 4:1 femoral cutting block

Fig.12 showing notch preparation using Saw technique

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RESULTS

Patient Demographics and Distribution

Age Distribution: The age of the patients ranged from 39 to 85 years, with a mean age of 64.04 ± 9.41 years. The majority of patients (38.4%) were in the 60–69 age group, followed by 50–59 years (28.8%) and 70–79 years (21.2%). A small proportion of patients (5.8%) were above 80 years, and only 2% were below 40 years. This distribution indicates a higher prevalence of total knee arthroplasty (TKA) in older adults, consistent with the progression of osteoarthritis with age.

Gender Distribution: The study population comprised 44 females (84.6%) and 8 males (15.4%), with the difference in gender distribution being statistically significant ($p = 0.003$). This highlights a higher prevalence of osteoarthritis in females, potentially due to hormonal influences and higher life expectancy.

Unilaterality/Bilaterality: Among the 52 patients, 48 (92.3%) underwent bilateral TKA, while 4 (7.7%) underwent unilateral procedures (3 right-side, 1 left-side). This demonstrates a predominance of bilateral knee involvement, common in advanced osteoarthritis.

Weight Distribution: The weight of the patients ranged from 47 to 126 kg, with a mean weight of 74.27 ± 14.35 kg. The most common weight group was 60–69 kg (28.8%), followed by 80–89 kg (25%) and 70–79 kg (23.1%). Only 3.8% of patients weighed between 90–99 kg, while 5.8% weighed over 100 kg.

Height Distribution: The height of patients ranged from 137 to 170 cm, with a mean height of 156.36 ± 7.95 cm. The majority of patients (42.3%) fell into the 150–159 cm range, followed by 160–169 cm (30.7%). Only 5.8% of patients were taller than 170 cm, and 21.2% were below 150 cm.

BMI Distribution: Patients were categorized based on BMI. The mean BMI was 30.33 ± 5.32, with the majority (53.8%) classified as obese (BMI >30). About 34.6% were overweight (BMI 25–29.9), and a small percentage (9.6%) had a normal BMI (18.5–24.9). Only 2% were underweight (BMI <18.5).

Offset (MO) Distribution

Patients were grouped based on their MO values. The most common range was 5–5.9 cm (47%), followed by 4–4.9 cm (28%). A smaller percentage (24%) had an MO ≥6 cm, while only 1% had an MO <4 cm.

Valgus Correction Angle (VCA) Distribution

The majority of patients (41%) had a VCA between 6–6.9 degrees, while 37% had a VCA >7 degrees. About 18% were in the 5–5.9 range, with minimal representation in the 3–3.9 (1%) and 4–4.9 (3%) ranges. No patients had a VCA <3 degrees.

Comparison of VCA by Gender

The mean VCA in male patients was 7.07 ± 0.98, slightly higher than in females (6.74 ± 2.05). However, the difference was not statistically significant ($p = 0.31$).

Postoperative Alignment Using Fixed vs. Individual VCA

The mean axis deviation (MAD) in the fixed VCA group was 3.3 ± 1.60 degrees, significantly higher than in the individual VCA group (1.61 ± 1.63 degrees, $p = 0.000$). This indicates that the individual VCA technique achieved better postoperative alignment.

Demographic Comparison Between Groups

Both groups (fixed and individual VCA) were comparable in demographic characteristics. Group A (fixed) had slightly younger patients (62.7 ± 10.9 years) compared to Group B (individual, 65.4 ± 7.6 years). Mean BMI was higher in Group B (31.4 ± 5.9) compared to Group A (29.4 ± 4.5). Despite these differences, both groups had similar gender distributions and limb involvement.

Distribution of Patients by MAD Angle

Group B (individual VCA) had a higher proportion of patients with a MAD angle ≤1 degree (48%) compared to Group A (12%). Additionally, Group B had fewer patients with a MAD angle >3 degrees (18%) than Group A (62%), reinforcing the superiority of the individual VCA technique in achieving better limb alignment.

Table 1. Patient Demographics and Distribution

Parameter	Category	Frequency (N)	Percentage (%)	P-value
Age Distribution	<40	1	2	
	40-49	2	3.8	
	50-59	15	28.8	
	60-69	20	38.4	
	70-79	11	21.2	
	>80	3	5.8	
	Total	**52**	**100**	
Gender Distribution	Males	8	15.4	0.003*
	Females	44	84.6	

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	Total	**52**	**100**	
Unilaterality/Bilaterality	Bilateral	48	92.3	
	Left	1	1.9	
	Right	3	5.8	
	Total	**100**	**100**	
Weight Distribution	<60	7	13.5	
	60-69	15	28.8	
	70-79	12	23.1	
	80-89	13	25	
	90-99	2	3.8	
	>100	3	5.8	
	Total	**52**	**100**	
Height Distribution	<150	11	21.2	
	150-159	22	42.3	
	160-169	16	30.7	
	>170	3	5.8	
	Total	**52**	**100**	
BMI Distribution	<18.5	1	2	
	18.5-24.9	5	9.6	
	25-29.9	18	34.6	
	>30	28	53.8	
	Total	**52**	**100**	

Table 2: Distribution of the Patients According to Median Offset (cm)

Median Offset (cm)	Frequency (N)	Percentage (%)
<4	1	1
4-4.9	28	28
5-5.9	47	47
>6	24	24
Total	**100**	**100**

Table 3: Distribution of the Patients According to VCA Angle (Degrees)

VCA Angle (Degrees)	Frequency (N)	Percentage (%)
<3	0	0
3-3.9	1	1
4-4.9	3	3
5-5.9	18	18
6-6.9	41	41
>7	37	37
Total	**100**	**100**

Table 4: Comparison of Mean Values of VCA (FMA Angle) According to Gender

Gender	Mean ± SD	P-value
Males	7.07 ± 0.98	0.31
Females	6.74 ± 2.05	

Table 5: Comparison of Postoperative Alignment Between Fixed vs. Individual Valgus Correction Angle in TKA

Group	Mean Axis Deviation Angle (Mean ± SD)	P-value
Fixed	3.3 ± 1.60	0.000*
Individual	1.61 ± 1.63	

Table 6: Demographic Data of the Patients in the Two Groups

Reference Indexes	Group A (Fixed)	Group B (Individual)
Number of Knees	50	50
Male/Female	11/41	5/47
Age (years)	62.7 ± 10.9	65.4 ± 7.6
Right/Left	50	50

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Mean Height (cm)	156.5 ± 8.65	156.2 ± 7.5
Mean Weight (Kg)	71.8 ± 10.7	76.7 ± 17.1
BMI	29.4 ± 4.5	31.4 ± 5.9
MAD Angle	3.3 ± 1.6	1.61 ± 1.63

Table 7: Distribution of Patients According to MAD Angle (Degrees)

MAD Angle (Degrees)	Group A (Fixed)	Group B (Individual)
≤0 to ≤1	6 (12%)	24 (48%)
<1 to ≤2	5 (10%)	14 (28%)
<2 to ≤3	8 (16%)	3 (6%)
>3	31 (62%)	9 (18%)
Total	**50**	**50**

DISCUSSION

In the present study the mean age of patients was 64.08 years. The peak incidence was seen in the 6th decade. The findings in the present study are similar to the study done by Michael D. et al (64.4), Nam D. et al (62.4).[10]

In the present study the mean value of Height (cm) was found to be 156.36±7.95. Correlation coefficient Height and VCA was found to -0.17 which means there was negative correlation between Height(Femur length) and VCA. Similar findings were observed by Drexler M et al that the patient's height had a significant negative correlation to VCA (P=0.031).[11]

In the present study the mean value of BMI was found to be 30.33±5.32, out of which majority of patient i.e 53.8 %. lie in the BMI group >30 which is similar to findings of Angela H.D. et al (31.8) and Denis N. et al.[12]

In our study 52 patients (100 knees) were included of Indian population. The mean VCA of study population was found to be 6.9° out of which 37 % of the patients had VCA > 7°. The majority of the patients i.e. 41% lie in the range of 6 to 6.9°.

Mullaji et al. also showed similar results, the percentage of limbs with a VCA>7° was 44.9% and the percentage of limbs with a VCA<5° was 10.9% among 503 Indian patients.[13]Bardakos N et al did a study on174 knees of Caucasian population and found average VCA 5.6° ± 1.0° with a range of 2° to 9°. [14]

In our study 44 (84.6%) of patients were females and 8 (15.4%) were males. The retrospective study by Vaishya R et al included 78 total knee replacement patients, which had 19 males (24.35%) and 59 females (75.6%). So the random sex distribution of our study was comparable with the above study in Indian patients.[15]

The mean value of VCA in male patients was found to be 7.07±0.98 and mean value of VCA in female patient was found to be 6.74±2.05;p value between both groups was 0.31,which was not statistically significant. Hsu et al did not detect a significant difference in VCA between male and female in Brazilian population.[16]

The function and durability of total knee replacement is determined by a combination of patient, implant, and surgeon-related factors. One of the important variables controlled by the surgeon is proper positioning of the individual components and the resulting overall alignment of the lower extremity. Preoperative alignment did not have an impact on implant survival. Rather, postoperative alignment was the chief predictor of failure and revision surgery, regardless of the preoperative alignment in varus, valgus, or neutral. The results from this study reaffirm the fundamental principle that a well-aligned TKA has better longevity than one placed in varus or valgus.

In the present study Mean Axis Deviation of fixed group was 3.3±1.60 and Mean Axis deviation of individual group was found to be 1.61±1.63 and p value was 0.000 which was statistically significant ,which means Post operative alignment using Individual VCA angle was better than using fixed VCA angle

In this study, the mean value of the VCA was 6.9 (range 4-8). This is similar to the results reported by Wang et al (5.1º; 4-8) for a healthy population.[17]

The mean value of Right side MO was 5.27±0.67 and mean value of left side MO was 5.46±0.71.Correlation coefficient of Right MO and right VCA was found to +0.5 and Correlation coefficient of left MO and left VCA was also found to +0.5 which means there was positive correlation between MO and VCA.

Drexler M et al similar to our study observed that MO were significantly correlated with VCA (P < .05) and concluded that patient's height and the hip MO are the 2 main anatomical variables determining VCA. The range of VCA in a Caucasian population without femoral bowing was 4º-8º, a wide range warranting individualized measurement of VCA for every patient to avoid mal-aligning the knee.

Jeffery et al have suggested that there should not be more than 3° of varus or valgus angulation postoperatively (considering 7° as normal valgus angulation at the knee between the anatomical axes of the tibia and femur), as it can lead to increased incidence of loosening of components.[18]

Kinzel et al measured the angle between a perfectly positioned virtual intramedullary rod and the mechanical axis of the femur in 80 patients undergoing TKA.[19] They reported that this angular relationship is highly variable in individual patients, and even under ideal circumstances in atleast 10% of the knees, the postoperative alignment will fall

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outside 2° of the neutral mechanical axis if a fixed angle distal femoral cut is used. They opined that further inaccuracy could be introduced if there is a significant variation in the femoral anatomy.

According to Longstaff LM et aloutcome after TKA is multifactorial. In their multi-surgeon series, other confounding variables exist that may be influential. Poor preoperative function and the existence of other joint abnormalities may impair subsequent postoperative function. Their results have been demonstrated to be independent of these variables as well as age and sex.[20]

Bardakos et al found that 30%-51% of patients required a VCA of <5º or >6º, respectively, and recommended measuring a VCA for each individual patient before TKA using a standing 3-joint view of the lower limb.[14]

In a prospective, randomized study of 124 knees, McGrory et al found that there was no significant difference in the restoration of limb alignment 5º between arbitrarily fixed 5º and individual precise templating on preoperative hip-to-ankle radiographs for distal femoral resection.[21]

Shi et al. found that patients who received individualized VCAs had a better limb alignment (178.1° vs. 175.9°, p < .05) and more patients' alignment deviation within±3° from the neutral axis (77.6% vs. 28.2%, p < .001) compared with those who received fixed VCAs. Six cohort studies (1167 TKAs) had reported MFT angle, the individualized group was closer to neutral than the fixed group with a mean 0.77° difference (95% CI, −1.43 to −0.11; p=.022; I2=71.0%). Moreover, there were more patients postoperative alignment deviation with±3° in the individualized group than the control group.[22]

CONCLUSION

This study demonstrates use of a variable distal femur resection angle improves achievement of a neutral, femoral component alignment, and trends toward improved HKA alignment after TKA. The clinical implications of our findings are that shorter stature patients who undergo TKA and have increased offset in their ipsilateral hip are likely to need a distal resection of 6 degree or more, while tall patients, with decreased hip offset, require a VCA of 5 degree or less. An additional conclusion of our study is that weight and BMI also affect the VCA, a fact which should be considered in pre-operative planning.

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