ORIGINAL ARTICLE

# SAFE ZONE OF JOINT LINE ELEVATION FOR THE TREATMENT OF KNEE FLEXION CONTRACTURE PREVENTING MID-FLEXION INSTABILITY IN TOTAL KNEE REPLACEMENT

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**Background:** In osteoarthritic knee, flexion deformity is caused by synovial inflammation, posterior femoral and tibial osteophytes tenting onto the capsule, ligamentous contracture and hamstring shortening. This study aimed to evaluate the safe zone of joint line elevation for the treatment of flexion knee contracture preventing mid-flexion instability in total knee replacement. **Methods** 51 knees with varus osteoarthritis undergoing TKA were evaluated. 39 knees with flexion contracture < 15°and 12 knees with flexion contracture >15°. 2-mm joint line elevation was performed in just 4 knees with >15° flexion contracture. The extension and flexion gaps were measured with traditional spacer block. Stability in coronal plane (varus & valgus stress) was assessed at 0,30,60 & 90 degrees. Sampling Technique was non probability consecutive. SPSS 23 was used for statistical analysis. **Results:** The study comprises 51 patients undergoing total knee replacement (TKA) for osteoarthritis, with a notable gender distribution (84.3% women, 15.7% men) and a mean age of 60.24±8.54 years. Of these, 41.2% had both knees affected, and joint elevation was performed in 23.5% with flexion contracture >15°. No instability was found in cases with joint line elevation. Flexion contracture analysis revealed asymmetry across sides, yet no statistically significant differences. Detailed comparisons show variability in flexion contracture and range of motion, emphasizing the complexity of side-specific outcomes. The study underscores the importance of tailored evaluation and intervention for flexion contracture >15° to optimize postoperative results. **Conclusions** This study has shown that in patients with varus osteoarthritis of the knee and flexion contracture > 15°, a 2-mm joint line elevation is safe to treat knee flexion contracture and is not associated with mid-flexion laxity. Level of evidence IV Cross sectional study.

**Keywords:** Total knee arthroplasty (TKA); Joint line elevation (JLE); Mid-flexion instability (MFI); Posterior stabilized (PS) knee

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## INTRODUCTION

In osteoarthritic knee, flexion deformity is caused by synovial inflammation, posterior femoral and tibial osteophytes tenting onto the capsule, ligamentous contracture and hamstring shortening.[1,2] Based on the degree of deformity, Lombardi *et al*.[3] divided flexion deformity into three groups. Mild contracture, or Grade I, has a deformity that is less than 15°. Moderate contracture, or Grade II, has deformities ranging from 15–30°. Severe contracture with a deformity more than 30° is referred to as Grade III.

Total knee arthroplasty (TKA) success depends on the soft tissue balance of the knee whereas instability is one of the most frequent reasons why TKA fails early or late.[4] Soft tissue balance in the mid-flexion range is not well-considered intraoperatively, despite soft tissue balance at 0° and 90° being evaluated. A study involving stability in the mid-flexion range was first published in 1990.[5] In most daily activities, the knee is loaded in both mid-flexion and near full extension, particularly when walking on slopes or climbing and descending stairs. Mid-flexion laxity can cause chronic synovitis, pain, and an unsteady sensation when walking.[4] Unlike other forms of instability, such as global instability, flexion instability, and hyperextension instability, mid-flexion instability (MFI) is a distinct clinical entity where the TKA remains stable at standard intervals (such as full extension and 90° of flexion), but becomes unstable during flexion at a point greater than 0° but less than 90°of flexion.[6]

Additional bone cuts in the distal femur are occasionally made during TKA in order to prevent flexion contracture. Prior cadaver studies demonstrated that laxity at mid-flexion following total knee arthroplasty (TKA) was caused by additional bone cuts in the distal femur and joint line elevation.[7]

It was postulated that in patients with osteoarthritis of the knee, the joint line elevation following total knee arthroplasty causes mid-flexion laxity. This study aimed to evaluate the safe zone of joint line elevation for the treatment of knee flexion contracture preventing mid-flexion instability in total knee replacement.

## MATERIAL AND METHODS

This cross-sectional study was conducted on patient with Varus knee osteoarthritis admitted in Orthopaedic Department, Ghurki Trust and Teaching hospital, from 13th December 2023 to 12th March 2024. We assessed 51 patients with Varus osteoarthritis undergoing total knee arthroplasty (TKA) using a fixed-bearing PS TKA prosthesis (Zimmer Biomet LPS, USA).

All of the patients provided informed consent, and the institutional review boards of our hospitals approved this study.

A single surgical team carried out each procedure utilizing the same surgical technique. A medial para-patellar approach was used to expose the knees, and the anterior and posterior cruciate ligaments were resected. To make proximal tibial cut, an extramedullary alignment guide was employed. In accordance with the manufacturer's instructions, the tibial bone's surface was cut perpendicular to the frontal plane and inclined 7° posterior in the sagittal plane. An intramedullary alignment guide was used to make cuts in the distal and posterior femur. The distal and posterior femoral bone cuts were made at a distance of 9 mm. The rotation for the posterior femoral condyle resection was set at 3° in order to produce a rectangular flexion gap that was the same size as the extension gap. Osteophytes surrounding the tibia and femur were meticulously excised. Following this, a step-by-step release of the medial soft tissues was carried out, which included (1) removal of medial osteophytes from the proximal tibia and distal femur, (2) the release of the medial collateral ligament's deep layer and posteromedial capsule from proximal tibia. (3) meticulous excision of osteophytes on the posterior aspect of femur (4) restoration of posterior capsular recess. The superficial layer of the medial collateral ligament and the semimembranosus were not released.

Then the extension gap at 0° and the flexion gap at 90° was measured with the traditional spacer block.

The extension gap was tight in the knees with flexion contracture > 15° whereas it was equal and rectangular to flexion gap in rest of the knees. 2mm joint line elevation was done by additional distal femoral cut (Figure-1) and meticulous release of posterior capsule was made again.

Extension gap was measured again with the spacer block and posterior soft tissue was released if needed for symmetrical, rectangular and equal gaps, no further distal femoral cut was made. Chamfer cuts were revised and trial femoral and tibial components were implanted. A polyethylene trials were inserted according to measured size. The joint gap laxity in coronal plane after implantation was assessed by varus and valgus stress test at 0°, 30°, 45°,60° & 90° (Figure-3 to 7).

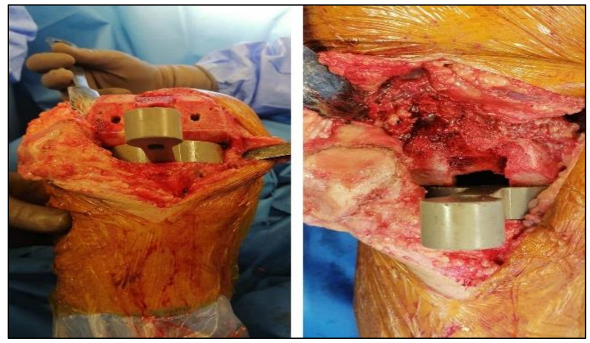

**Figure-1: Additional distal femoral cut**

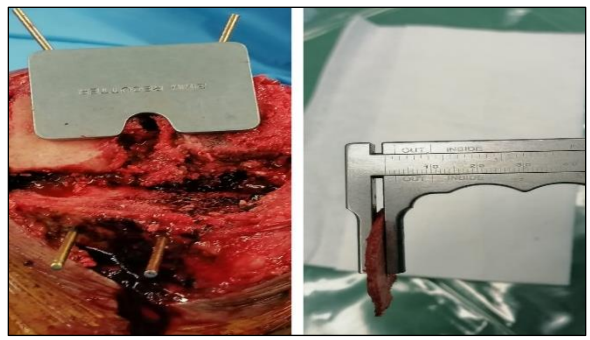

**Figure-2: Measurement of extension gap**

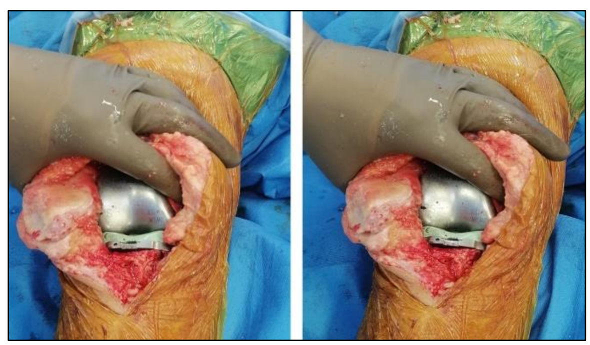

**Figure-3: 0 degree**

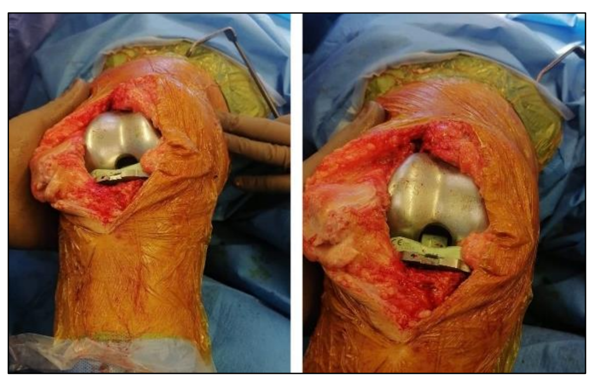

**Figure-4: 30 degree**

**Figure-5: 45 degree**

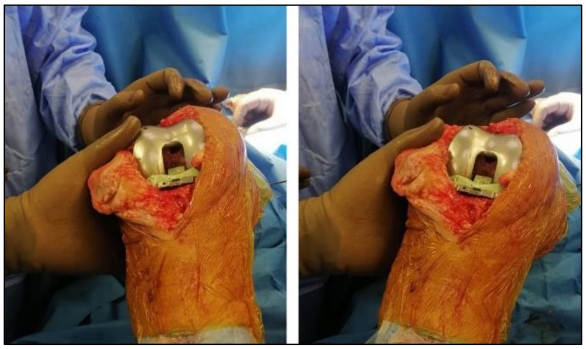

**Figure-6: 60 degree**

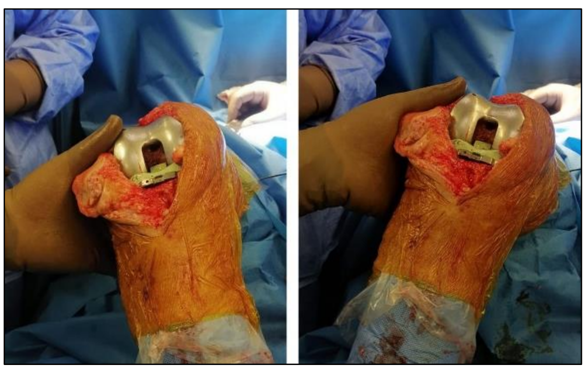

**Figure-7: 90 degree**

## RESULTS

The study includes a cohort of 51 patients receiving total knee replacement (TKA) who had osteoarthritis; women make up a significant majority of patients (84.3%) compared to men (15.7%). The age distribution has a mean of 60.24±8.54 years and ranges from 41 to 80 years. A significant proportion of the patients (41.2%) had involvement of both knees. There were 13 left-side and 17 right-side affected knees. A 2mm joint elevation treatment was performed in about 23.5% of the patients. Following surgery, every patient was able to bear their weight. The patients' varied ages and levels of side involvement are highlighted by the demographic and clinical profile, which also provides insight into the characteristics of patients having TKA for osteoarthritis.

Joint line elevation was done in 12 (23.5%) cases out of 51 with flexion contracture >15$^{o}$. Out of 12 patients, joint stability in coronal plane was assessed at 30 $^{o}$, 45 $^{o,}$ and 60 $^{o}$ of flexion among these cases and no instability was found.

In the 0–15$^{o}$ flexion contracture category, the majority of cases were observed on the left side (84.6%), as compared to the right side (76.4%), and bilaterally (71.4%). In the 15–20$^{o}$ category, the distribution was less uniform, with the highest percentage on the bilateral side (23.8%) as compared to the right side (11.8%) and the left side (7.7%). For cases with a flexion contracture greater than 20$^{o}$, the majority occur on the right side (11.8%), compared to the left side (7.7%), and bilaterally (4.8%). *p*-values are above .05 for all the sides in each of the mentioned flexion contracture classifications; hence no statistically significant differences exist for these cases. Hence, there is no definitive conclusion that the affected side has a significant disparity of flexion contracture and range of motion. (Table-2)

Table-3 further illuminates a detailed comparison of flexion contracture and range of motion parameters based on the affected side. The mean flexion contracture values of the right knee were high as compared to the left knees as the right side has a mean of 9.44 ±8.68 than the left side of 7.59±6.74 and in bilateral cases, the right side has a mean of 9.19±8.70 and the left side has a mean of 6.52±6.67. These figures reveal the variability and asymmetry in flexion contracture across different sides.

In terms of range of motion, the lower range (0–30°) demonstrates similar variability. The right side has a mean of 6.94 ±8.53°, the left side has a mean of 5± 6.72°, and in bilateral cases, the right side has a mean of 6.86±SD 8.42°, while the left side has a mean of 4.31± 6.40° The variability in the lower range of motion is highlighted by these numbers, especially in situations involving both sides.

Examining the upper range (90–140°), the right side has a mean of 89.49 ±55.75°, the left side has a mean of 77.02± 61.81°, and in bilateral cases, the right side has a mean of 91.18 ±55.27°, while the left side has a mean of 79.61±58.50°. These upper-range figures indicate the variability in achieving higher degrees of flexion across different sides, with bilateral cases once again displaying considerable diversity. Table-2 & 3 offers a thorough understanding of the complex connection between range of motion and side-specific flexion contracture and requirement of joint line elevation. To address the particular difficulties presented by flexion contracture >15° and achieve the best possible postoperative results, the values place a strong emphasis on the significance of tailored evaluation and intervention techniques.

**Table-1: Demographic & Clinical Profile of a patient with More than 15-degree Flexion Contractures in Total Knee Replacement (n=51)**

| Parameters | N | % | M±SD (Years) |
|---|---|---|---|
| **Gender** | | | |
| Male | 8 | 15.7 | |
| Female | 43 | 84.3 | |
| **Age (years)** | | | 60.24±8.54 (41-80) |
| **Side** | | | |
| Left | 13 | 25.5 | |
| Right | 17 | 33.3 | |
| B/L | 21 | 41.2 | |
| **2mm Joint Elevation** | | | |
| Yes | 12 | 23.5 | |
| No | 39 | 76.5 | |
| **Full weight Bearing** | | | |
| Yes | 51 | 100 | |
| No | --- | --- | |
| | | **Flexion Contracture** | |
| **Joint Elevation** | | **0-15º** | **>15º** |
| Yes | | --- | 12 |
| No | | 39 | --- |
| | | | |
| **Mid-flexion Instability (In Coronal plane)** | | | |
| 30º | | No | No |
| 45º | | No | No |
| 60º | | No | No |

**Table 2: Comparison of Flexion Contracture & Range of Motion based on the side affected**

| Flexion Contracture | Side | | | |
|---|---|---|---|---|
| | **Rt** | **Lt** | **B/L** | ***p*-value** |
| 0-15º | 13(76.4) | 11(84.6) | 15(71.4) | |
| 15-20º | 2(11.8) | 1(7.7) | 5(23.8) | *>.05* |
| >20º | 2(11.8) | 1(7.7) | 1(4.8) | |

**Table-3: Comparison of mean range of motion based on side affected**

| Variables | Side | | |
|---|---|---|---|
| **Range of Motion** | **Rt** | **Lt** | **B/L** |
| **Lower Range** | 6.94 (8.53) (0-30)º | 5 (6.72) (0-30)º | Rt: 6.86 (8.42) (0-30)º<br>Lt: 4.31 (6.40) (0-30)º |
| **Upper Range** | 89.49 (55.75) (90-140)º | 77.02 (61.81) (90-140)º | Rt: 91.18 (55.27) (0-140)º<br>Lt: 79.61 (58.50) (0-140)º |

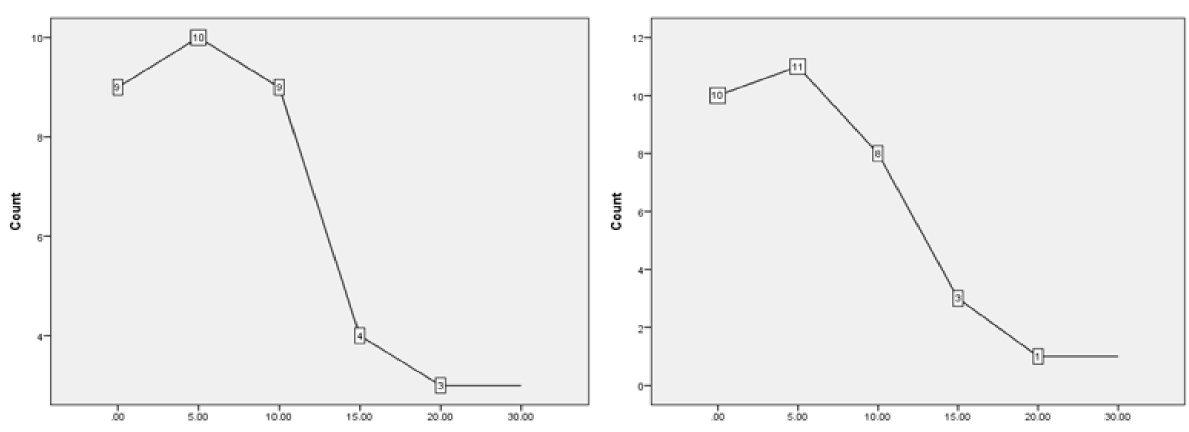


**Figure-8: Flexion Contracture**

## DISCUSSION

The primary objective of our study is that patients with varus knee osteoarthritis and flexion contracture >15° have tight extension gap and does elevation of joint line increase joint gap laxity in mid-flexion. In all patients, we utilized a posterior stabilized (PS) knee, and we assessed the impact of joint line elevation on knee joint laxity during mid-flexion.

Vajapey *et al*.[8] conducted a literature review and identified six technique-specific risk factors for MFI that have been evaluated to date. These factors include JLE, alignment technique (mechanical vs. anatomic), femoral component positioning, gap balancing method, posterior condylar offset restoration, and balancing the knee at 0° and 90° of flexion.

The findings of our study were not consistent with those of earlier cadaver studies.[5,7,13] MFI was first described by Martin *et al*.[5] in 1990 when joint line elevation was performed by 5 mm proximal and anterior shifting of femoral component. It was found in computational modelling study by Evangelista *et al*.[9] that the femoral component reduced knee ligament load from 15–75° of flexion when positioned proximally, leading to MFI in spite of well-balanced knee at 0° and 90° of flexion. The flexion-extension axis is altered by joint line elevation, which causes the posterior capsule and collateral ligaments to become slack in the mid-flexion ranges.[5,10] Furthermore, JLE could contribute to MFI by decreasing the distance between the collateral ligaments' attachment sites in mid-flexion.[11]

Preoperative flexion contracture is sometimes compensated for by making a big distal femoral cut, which leads to JLE in primary TKA and MFI.[12] In a cadaveric investigation, Cross *et al*.[13] produced a 10° flexion contracture and resected the distal femur in 2-mm increments. At 30° and 60° degrees of flexion, the authors observed that the coronal plane laxity increased with each successive 2-mm re-cut. Surgeons must thus discover substitute techniques for treating flexion contractures, such as distal femoral augments, osteophyte excision, and capsular release, that do not result in JLE. This result was confirmed by Luyckx *et al*.[7] in a cadaveric examination of ten knees free of flexion contracture.

Nonetheless, there is disagreement in the research about JLE's impact on MFI. In a computational model research, König *et al*.[11] simulated the effects of JLE on MFI and found no increase in MFI with JLE using an ultra-congruent design. When a 2-mm JLE model was implanted, Minoda *et al*.'s[4] investigation of thirty knees with varus osteoarthritis undergoing TKA revealed no variation in joint gap laxity between 30° and 90° of flexion. Similarly, joint line proximalization by 5 mm or distalization by 2 mm did not significantly affect knee stability in the mid-flexion range, according to Matziolis *et al*.'s prospective cohort research.[14] In conclusion, JLE may cause patients with flexion contractures to have greater mid-flexion laxity; however, patients may tolerate 2 mm of elevation well, whereas 4 mm may cause more issues.

There were several advantages in this study. First, this study focused on intraoperative research on patients with varus osteoarthritis, rather than on cadaver knees free of osteoarthritis in a lab setting.[5,7,13] Because most TKA candidates have varus osteoarthritis, it's possible that earlier research utilizing cadaver knees did not accurately reflect the structure of the knee joint in TKA candidates. This study's findings can be used for primary TKA. Second, there were more knee joints in this study than in other cadaver investigations.[5,7,13] Third, there is no need of specially designed tensor device to evaluate mid-flexion instability, one can assess laxity with varus-valgus stress test. Fourth, this method reduces duration of the surgical procedure as compared to other methods like joint line elevation model or tensor device.

There were also limitations in this study. First of all, because only varus knees were examined in this study, valgus knees cannot be directly affected by the findings of this investigation. It is necessary to look into valgus knees more. Secondly, a PS prosthetic was examined in this investigation. According to a prior study, mid-flexion laxity increases following PS TKA compared to cruciate retaining TKA, and it was hypothesized that the PCL affects mid-flexion laxity.[15] The findings of this study, therefore, are not applicable to other kinds of total knee prostheses, particularly cruciate-retaining ligament. Third, this study's joint line elevation was 2 mm. In earlier cadaver experiments, the joint line elevation was set at 4 mm (7) or 5 mm (5). Few surgeons recut the distal femur and elevate the joint line more than 2 mm in primary TKA, despite the possibility that the extent of the elevation could influence the laxity in mid-flexion.

Regarding mid-flexion laxity, surgeons do not have to hesitate make a 2-mm additional bone cut in the distal femur and perform joint line elevation, if a tight flexion gap can be maintained, in PS TKA.

## CONCLUSION

This study has shown that in patients with varus osteoarthritis of the knee and flexion contracture > 15°, a 2-mm joint line elevation is safe to treat knee flexion contracture and is not associated with mid-flexion laxity.

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**Compliance with Ethical Standards**

Conflict of Interest There is no conflict of interest.

**Ethical approval** This study was approved by the institutional review board of Ghurki Trust Teaching Hospital, Lahore.

**Informed consent** All patients provided informed consent

## AUTHORS' CONTRIBUTION

NS: Write-up, data collection. SKK: Literature review, write-up. MUF: Data analysis. NA: Data collection, proof reading. AA: Proof reading, literature review. LK: Data interpretation.

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