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Alterations in Knee and Ankle Joint Orientation Following Medial Opening Wedge High Tibial Osteotomy: A Radiographic Analysis

*1Dr. Ritesh K Singh, 2Dr. Sandeep V Gavhale, 3Dr. Vijay Chandele, 4Dr. Pranil Yadav, 5Dr. Vijay S Kumawat and 6Dr. Vaibhav Jagtap

*1, 4, 5, 6Junior Resident, Department of Orthopaedics, JJ Hospital & Grant Government Medical College (JJH & GGMC), Maharashtra University of Medical Sciences (MUHS), Mumbai, Maharashtra, India.

2Associate Professor, Department of Orthopaedics, JJH & GGMC, MUHS, Mumbai, Maharashtra, India.

3Assistant Professor, Department of Orthopaedics, JJH & GGMC, MUHS, Mumbai, Maharashtra, India.

Abstract

Background: Medial opening wedge high tibial osteotomy (MOWHTO) is a reliable treatment for medial compartment osteoarthritis with varus deformity. While the primary aim is to correct coronal malalignment at the knee, realignment also alter ankle orientation. This study evaluated radiographic changes in knee and ankle joint orientation following MOWHTO.

Methods: Thirty patients (18 males, 12 females; mean age 48.6 years) underwent MOWHTO. Full-length standing hip–knee–ankle radiographs were obtained preoperatively and at six months postoperatively. Radiographic parameters included hip–knee–ankle (HKA) angle, mechanical medial proximal tibial angle (mMPTA), joint line convergence angle (JLCA), tibial plafond inclination (TPI), and talar tilt angle (TTA). Paired t-tests were used for analysis.

Results: The mean HKA angle improved from varus 7.8° ± 2.5° to valgus 2.1° ± 1.8° ($p < 0.001$). The mMPTA increased from 83.2° ± 2.1° to 90.5° ± 1.7° ($p < 0.001$), and the JLCA decreased from 4.2° ± 1.5° to 2.1° ± 1.2° ($p < 0.05$). At the ankle, TPI shifted from varus 2.8° ± 1.4° to valgus 0.9° ± 1.2° ($p < 0.01$), and TTA decreased from 1.6° ± 0.8° to 0.7° ± 0.6° ($p < 0.05$). No patient developed symptomatic ankle pain during follow-up.

Conclusion: MOWHTO effectively corrects knee varus deformity and induces significant changes in ankle orientation, as demonstrated by alterations in TPI and TTA.

Keywords: High tibial osteotomy, knee alignment, ankle orientation, varus deformity, radiographic evaluation.

Introduction

Medial compartment osteoarthritis of the knee remains a highly prevalent cause of pain and disability, particularly in middle-aged patients with varus malalignment. This deformity leads to abnormal load distribution across the knee joint, resulting in accelerated degeneration of the medial compartment while sparing the lateral side. High tibial osteotomy (HTO) was developed as a joint-preserving surgical strategy to realign the lower limb, thereby shifting the mechanical axis laterally and redistributing load from the diseased medial compartment to the relatively preserved lateral compartment. Among the techniques of HTO, the medial opening wedge high tibial osteotomy (MOWHTO) has gained considerable popularity due to its technical simplicity, precision in correction, and avoidance of complications related to fibular osteotomy required in lateral closing wedge osteotomy [1, 2].

Although MOWHTO primarily targets coronal alignment of the knee, it is increasingly evident that changes induced by the procedure extend beyond the knee joint. The correction of tibial alignment alters the orientation of the mechanical axis of the entire lower limb, which inevitably influences adjacent joints, most notably the ankle. Recent radiographic and biomechanical investigations have highlighted the possibility of altered ankle joint line orientation, changes in tibial plafond inclination, and modifications in talar tilt following MOWHTO [3–5]. These alterations may remain clinically silent in patients with otherwise healthy ankle joints but could potentially exacerbate symptoms in individuals with pre-existing ankle pathology.

The literature has reported variable outcomes with respect to ankle orientation following MOWHTO. Some studies demonstrated significant shifts in tibial plafond inclination and talar tilt, while others suggested minimal clinical relevance [6, 7]. Furthermore, long-term consequences of these alterations, particularly regarding the progression of ankle osteoarthritis, remain a subject of debate. Therefore, it is critical to systematically evaluate both knee and ankle

*Corresponding Author: Dr. Ritesh K Singh

alignment in patients undergoing MOWHTO in order to fully understand the biomechanical implications of the surgery.

This prospective study aimed to evaluate the alterations in knee and ankle joint orientation following MOWHTO in a cohort of thirty patients with medial compartment osteoarthritis and varus deformity. Radiographic parameters were measured preoperatively and postoperatively to quantify changes in both knee and ankle alignment. By analyzing these changes, this study seeks to add clarity to the biomechanical effects of MOWHTO on adjacent joints and provide practical guidance for surgeons during preoperative planning.

Methods

This prospective observational study was conducted at a tertiary referral center specializing in joint preservation surgery. The study was approved by the institutional ethics committee, and informed consent was obtained from all participants.

Patient Selection

Thirty patients diagnosed with symptomatic medial compartment osteoarthritis associated with varus deformity were enrolled. The study cohort consisted of 18 males and 12 females with a mean age of 48.6 years (range, 40–60 years). Inclusion criteria were symptomatic medial compartment osteoarthritis refractory to conservative treatment, varus deformity greater than 5°, and ability to comply with radiographic follow-up. Patients with prior knee or ankle surgery, inflammatory arthropathy, advanced ankle osteoarthritis, or severe flexion contracture were excluded.

Surgical Technique

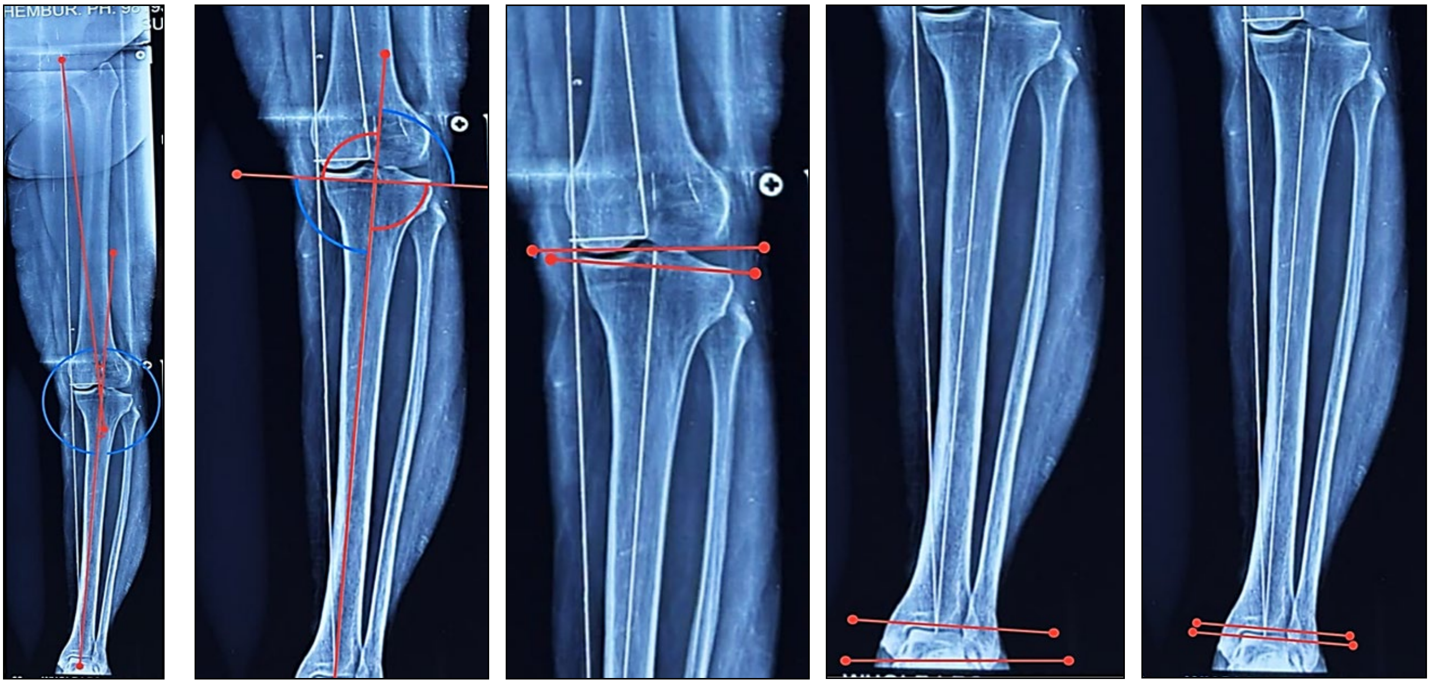
All patients underwent medial opening wedge high tibial osteotomy using a standardized technique. Under spinal anesthesia and tourniquet control, a longitudinal incision was made along the proximal medial tibia. The superficial medial collateral ligament was partially released, and an oblique osteotomy was performed approximately 3.5–4 cm distal to the medial joint line, directed toward the tip of the fibular head. The lateral cortex was preserved as a hinge. Gradual distraction of the osteotomy was performed under fluoroscopic guidance to achieve planned correction of the mechanical axis. A preoperative planning method based on the Miniaci technique was used to determine the correction angle. The osteotomy site was stabilized with a locking plate system.

Radiographic Assessment

Standardized full-length standing anteroposterior radiographs of the hip, knee, and ankle were obtained preoperatively and at six months postoperatively. Radiographs were acquired with the patella facing forward to minimize rotational bias. The following parameters were measured:

- Hip–Knee–Ankle (HKA) angle: the angle between the mechanical axis of the femur and tibia, with negative values representing varus and positive values representing valgus.
- Mechanical Medial Proximal Tibial Angle (mMPTA): the medial angle between the tibial mechanical axis and the proximal tibial joint line.
- Joint Line Convergence Angle (JLCA): the angle between the femoral condylar line and the tibial plateau line, reflecting intra-articular deformity.
- Tibial Plafond Inclination (TPI): the angle between the horizontal axis and the line tangent to the tibial plafond, with varus denoted as positive.
- Talar Tilt Angle (TTA): the angle between the tibial plafond line and talar dome line.

Measurements were performed by two independent musculoskeletal radiologists blinded to patient identity, and interobserver reliability was calculated.



HKA Angle mMPTA Angle JLCA Angle TPI Angle TTA Angle

Fig 1

Statistical Analysis

Data were analyzed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation. Paired t-tests were used to compare preoperative and postoperative values. A p-value <0.05 was considered statistically significant. Interclass correlation coefficients (ICCs) were used to assess reliability, with values above 0.9 considered excellent.

Results

All thirty patients completed the six-month radiographic follow-up. No patient was lost to follow-up. Union at the osteotomy site was achieved in all cases within an average of 14.2 weeks. There were no incidences of hinge fractures requiring revision, implant failure, or loss of correction.

Knee Alignment: Significant improvements were noted in knee joint orientation. The mean HKA angle improved from 7.8° ± 2.5° varus preoperatively to 2.1° ± 1.8° valgus postoperatively ($p < 0.001$). The mMPTA increased from 83.2° ± 2.1° to 90.5° ± 1.7° ($p < 0.001$), reflecting effective correction at the tibial level. The JLCA decreased from 4.2° ± 1.5° to 2.1° ± 1.2° ($p < 0.05$), suggesting a reduction in intra-articular varus alignment following realignment.

Ankle Alignment: Notable changes were observed in ankle orientation. The TPI shifted from a mean of 2.8° ± 1.4° varus to 0.9° ± 1.2° valgus ($p < 0.01$). The TTA decreased from 1.6° ± 0.8° to 0.7° ± 0.6° ($p < 0.05$), reflecting a more horizontal alignment of the talar dome relative to the tibial plafond.

Clinical Outcomes: Although ankle alignment changed significantly, no patient reported new-onset ankle pain during the six-month follow-up period. Knee pain improved in all patients, and all were able to return to activities of daily living with reduced discomfort.

Table 1: Patient data collected (n=30)

Pt	Age (yrs)	Sex	Pre-op HKA (°)	Post-op HKA (°)	Pre-op mMPTA (°)	Post-op mMPTA (°)	Pre-op JLCA (°)	Post-op JLCA (°)	Pre-op TPI (°)	Post-op TPI (°)	Pre-op TTA (°)	Post-op TTA (°)
1	52	Male	8.2	1.9	82.5	90.1	4.5	2.0	3.0	1.0	1.8	0.7
2	45	Male	6.9	2.5	83.1	91.0	3.8	2.2	2.7	0.8	1.5	0.6
3	58	Female	7.6	1.8	84.0	90.3	4.0	2.1	2.5	1.0	1.4	0.6
4	50	Male	8.0	2.2	82.9	90.7	4.8	2.3	3.1	0.9	1.7	0.7
5	47	Female	7.2	2.0	83.5	91.2	4.1	2.0	2.6	1.0	1.5	0.8
6	59	Male	9.1	1.7	82.8	90.6	4.6	2.3	2.9	0.8	1.9	0.7
7	44	Male	7.4	2.3	83.4	90.9	4.0	2.2	2.8	0.9	1.6	0.6
8	53	Female	7.9	1.9	83.2	90.4	4.3	2.1	2.7	1.0	1.7	0.7
9	46	Male	8.3	2.1	82.7	90.8	4.5	2.2	3.0	0.9	1.8	0.6
10	55	Male	7.7	2.0	83.6	91.1	4.2	2.0	2.9	1.1	1.5	0.7
11	48	Male	8.0	2.3	83.1	90.6	4.0	2.2	2.7	0.8	1.6	0.7
12	57	Female	7.5	2.1	83.8	90.9	4.1	2.1	2.5	0.9	1.4	0.6
13	42	Male	8.2	1.8	82.9	90.5	4.7	2.2	3.2	0.8	1.8	0.7
14	49	Female	7.1	2.2	83.7	91.0	4.0	2.1	2.6	1.0	1.5	0.6
15	60	Male	8.5	2.0	83.0	90.7	4.3	2.3	2.9	1.0	1.6	0.7
16	43	Male	7.6	2.1	83.2	90.9	4.2	2.0	2.8	0.9	1.5	0.6
17	56	Female	8.1	1.9	82.8	90.6	4.4	2.1	3.0	0.8	1.7	0.6
18	41	Male	7.9	2.2	83.5	91.1	4.1	2.2	2.7	1.0	1.5	0.7
19	46	Male	8.4	2.0	83.1	90.8	4.2	2.1	2.9	1.0	1.6	0.7
20	54	Female	7.3	2.1	83.6	90.9	4.0	2.1	2.6	0.9	1.5	0.6
21	59	Male	9.0	1.7	82.7	90.5	4.6	2.3	3.1	0.8	1.9	0.7
22	44	Female	7.2	2.3	83.9	91.2	4.1	2.0	2.6	0.9	1.4	0.6
23	47	Male	8.3	2.0	83.0	90.7	4.3	2.1	2.8	0.9	1.7	0.7
24	55	Female	7.5	1.9	83.7	90.8	4.2	2.1	2.5	1.0	1.6	0.6
25	42	Male	8.1	2.2	83.4	91.0	4.0	2.2	2.9	0.9	1.6	0.7
26	60	Male	8.8	1.8	82.9	90.6	4.5	2.1	3.0	0.8	1.8	0.7
27	49	Female	7.2	2.0	83.5	90.9	4.2	2.0	2.6	0.9	1.5	0.6
28	53	Male	7.7	2.3	83.3	91.1	4.0	2.2	2.7	0.9	1.7	0.6
29	45	Male	8.2	2.1	83.1	90.8	4.4	2.1	2.8	0.9	1.6	0.7
30	57	Female	7.4	1.9	83.6	90.7	4.1	2.0	2.6	1.0	1.5	0.6

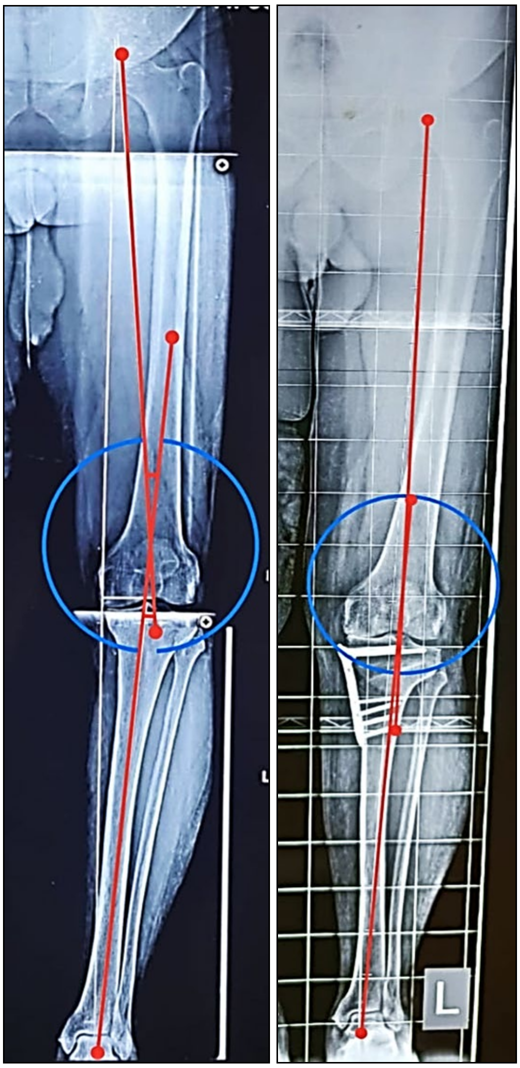


Fig 2: Above Radiographs showing Hip Knee Ankle Angle, preoperatively angle was 9.2° which changes to 2.2° postoperatively

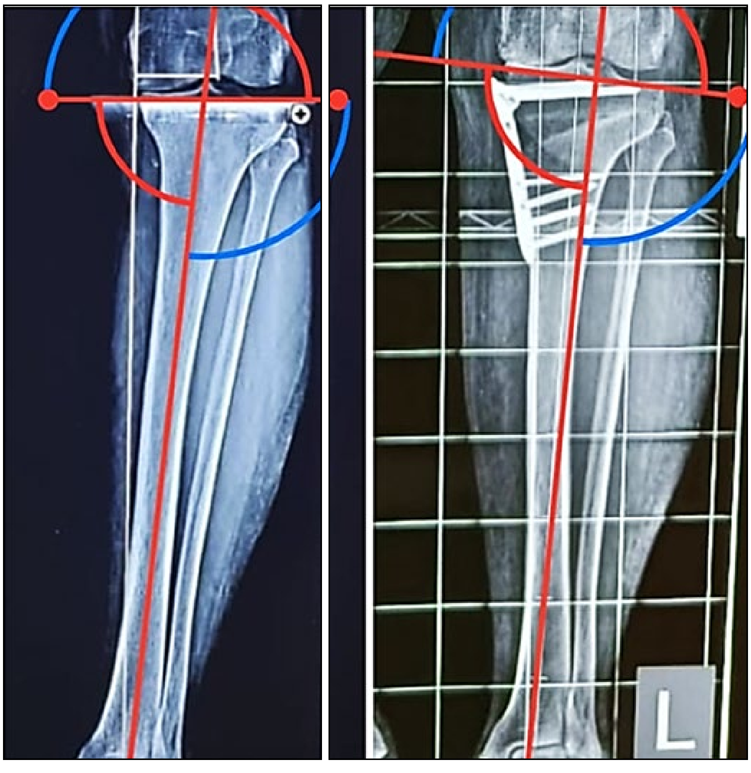


Fig 3: Above radiograph showing mMPTA, preoperatively angle was 83.7° which changes to 91.9°

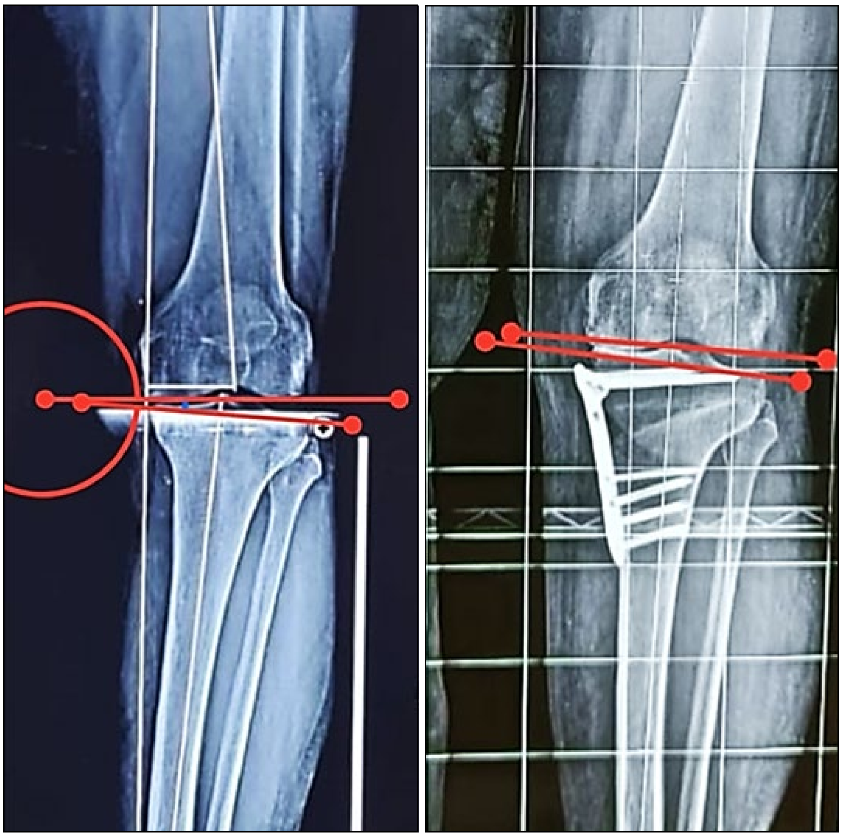


Fig 4: Above radiograph is showing JLCA, preoperatively angle was 4.8° which changes to 2.4°.

Fig 5: Above radiograph is showing TPI angle, preoperatively angle was 2.2° which changes to 1.1°.

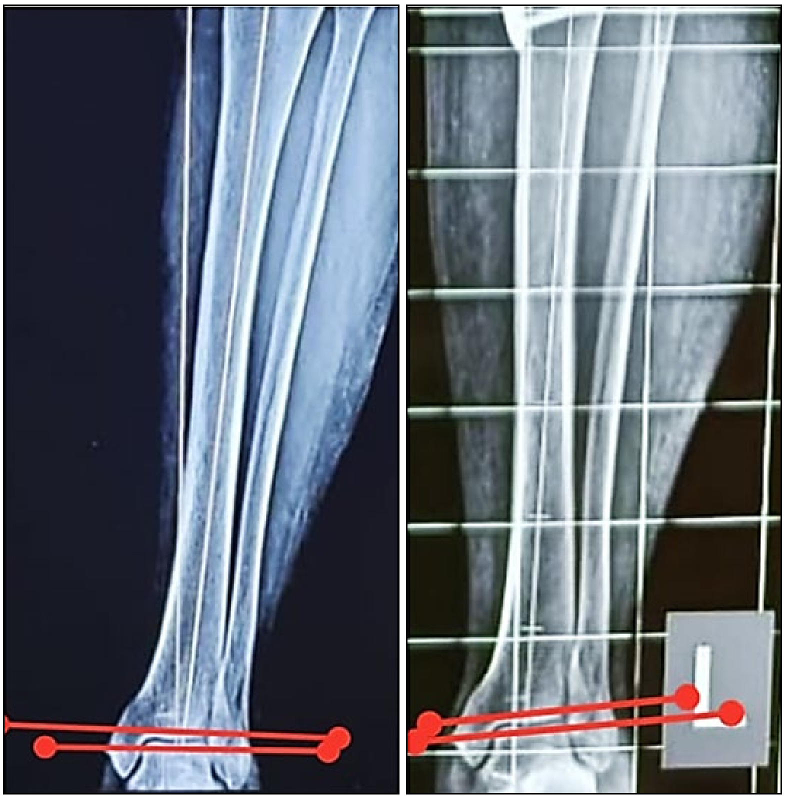


Fig 6: Above radiograph is showing TTA, which is 1.4° preoperatively and it changes to 0.7° postoperatively.

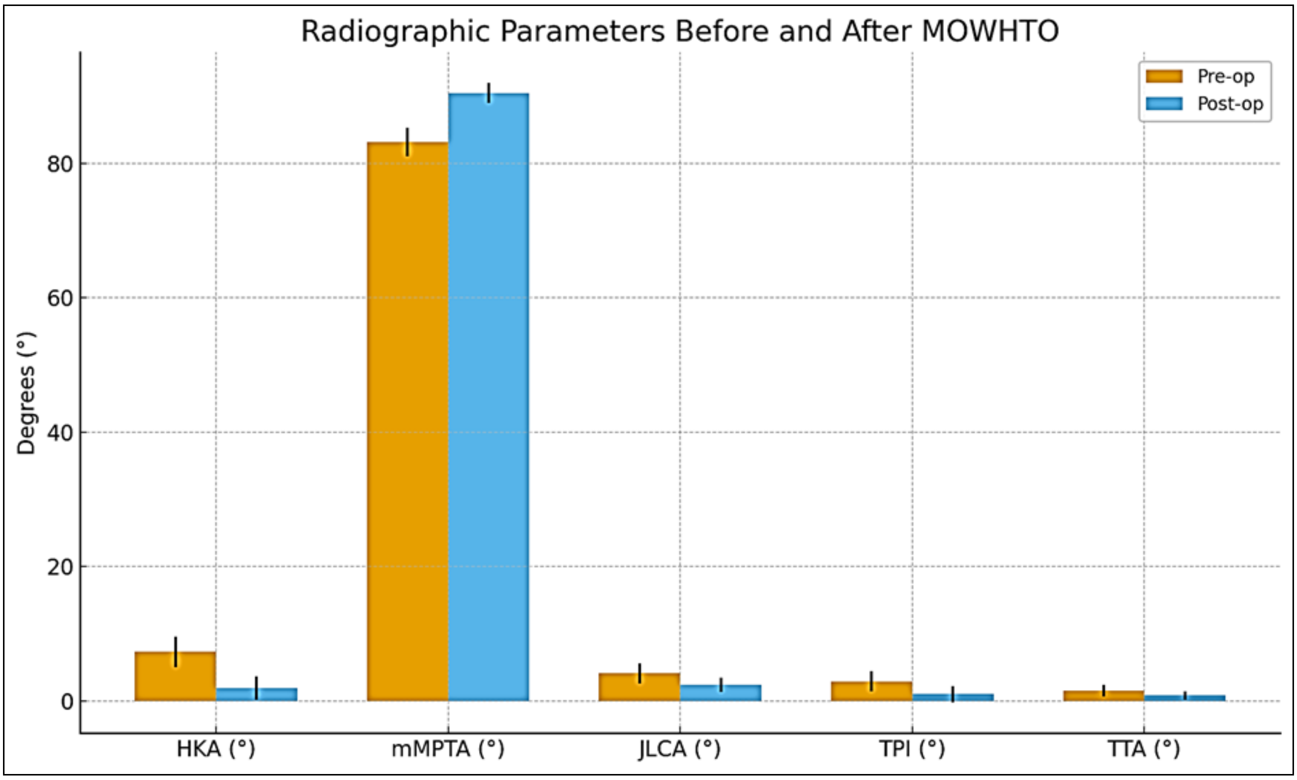


Fig 7

Discussion

This prospective study demonstrates that medial opening wedge high tibial osteotomy produces significant and measurable alterations in both knee and ankle joint orientation. Correction of varus deformity at the knee resulted in significant improvements in the HKA angle, mMPTA, and JLCA. Importantly, these corrections were accompanied by concomitant changes in tibial plafond inclination and talar tilt, indicating that the procedure influences ankle biomechanics.

The improvement in HKA angle from 7.8° varus to 2.1° valgus confirms that MOWHTO effectively corrects coronal malalignment. These findings are consistent with the results of Amendola and Panarella [2], who emphasized the reliability of MOWHTO in correcting varus deformity and delaying arthroplasty in younger, active patients. The observed increase in mMPTA underscores the success of osteotomy in restoring tibial plateau orientation, while the reduction in

JLCA highlights correction of both extra-articular and intra-articular components of deformity.

With regard to ankle orientation, our study revealed a significant decrease in TPI and TTA following osteotomy. These results are in line with the findings of Oh *et al*. [3], who demonstrated that coronal and sagittal alignment of the ankle is significantly altered following MOWHTO. Similarly, Choi *et al*. [6] reported that the magnitude of valgus correction at the knee was directly associated with changes in ankle joint orientation, particularly in patients with corrections exceeding 10°. Ariyawatkul *et al*. [4] further highlighted the potential risk of talar coronal malalignment in cases of overcorrection, underscoring the importance of careful preoperative planning.

Biomechanically, the observed changes in ankle alignment can be explained by the lateral shift of the weight-bearing axis induced by valgus correction at the knee. This alters the distribution of load across the ankle, resulting in modifications of tibial plafond inclination and talar tilt. Cadaveric studies by Suero *et al*. [5] confirmed that MOWHTO changes intra-articular contact pressures at both the knee and ankle, supporting the clinical relevance of these findings.

While the alterations in ankle orientation did not translate into clinical symptoms in our cohort within six months, the long-term implications remain uncertain. Kim *et al*. [7] reported that changes in ankle alignment following MOWHTO may worsen symptoms in patients with pre-existing ankle osteoarthritis. Therefore, it is critical for surgeons to consider ankle joint status during preoperative planning. In patients with concomitant ankle pathology, overcorrection at the knee may exacerbate ankle malalignment and accelerate degeneration.

This study has several strengths, including prospective design, standardized surgical technique, and objective radiographic evaluation with excellent interobserver reliability. However, certain limitations must be acknowledged. The sample size was relatively small, and follow-up was limited to six months, precluding assessment of long-term clinical outcomes. Additionally, functional outcome scores such as WOMAC or AOFAS were not included, which could have provided further insight into the clinical relevance of ankle alignment changes. Future studies with larger cohorts, longer follow-up, and combined radiographic and functional assessment are warranted. Advanced imaging modalities such as EOS three-dimensional analysis may provide further detail on multiplanar alignment changes.

Conclusion

Medial opening wedge high tibial osteotomy is effective in correcting varus deformity of the knee, as evidenced by significant improvements in HKA angle, mMPTA, and JLCA. However, the procedure also induces measurable changes in ankle joint orientation, including reductions in tibial plafond inclination and talar tilt. Although these changes did not result in short-term clinical symptoms in our cohort, they may have long-term implications, particularly in patients with pre-existing ankle pathology. Surgeons should incorporate an evaluation of adjacent joint biomechanics into preoperative planning for MOWHTO, and long-term studies are required to fully elucidate the clinical significance of these findings.

Declarations

Patient Consent: Written informed consent for treatment and publication of anonymized clinical details/images was obtained from all patients.

Ethical Approval: Conducted in accordance with institutional policies and the Declaration of Helsinki; institutional approval/exemption documented.

Conflicts of Interest: None declared.

Funding: None

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