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Original Research Article

Functional Outcome of High Tibial Osteotomy in Anterior Cruciate Ligament Reconstruction in Knees with Coronal and Sagittal Plane Deformity

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Conflict of interest: Nil

Abstract

Background: Anterior cruciate ligament (ACL) deficiency associated with varus malalignment alters knee biomechanics and may increase stress on the reconstructed graft. High tibial osteotomy (HTO) combined with ACL reconstruction offers simultaneous correction of osseous malalignment and ligamentous instability, with the potential to improve knee stability and functional recovery.

Objectives: To evaluate the clinical, functional, and radiological outcomes following simultaneous medial open-wedge HTO and ACL reconstruction in patients with ACL deficiency and varus deformity, with particular emphasis on knee stability, range of motion, posterior tibial slope, and functional outcome scores.

Materials and Methods: This prospective longitudinal study included 30 patients aged 18–60 years treated at Rohilkhand Medical College and Hospital, Bareilly, Uttar Pradesh, India over 1.5 years. All patients underwent simultaneous medial open-wedge HTO and arthroscopic ACL reconstruction using a hamstring graft. Clinical and radiological assessments included knee flexion and extension, Lachman test, posterior tibial slope, Lysholm score, IKDC score, and VAS pain score. Follow-up evaluations were performed at 6 weeks, 6 months, and one year. Statistical analysis was carried out using SPSS version 26. A p value of <0.05 was considered statistically significant.

Results: Mean knee flexion improved from 105.7±10.6° preoperatively to 134.8±4.6° at one year, while the extension deficit decreased from 7.5±1.0° to 0.6±0.6° ($p<0.001$). All patients achieved Grade 0 Lachman findings by one year. Posterior tibial slope increased from 7.5±1.1° to 12.2±1.0°. Mean Lysholm score improved from 50.9±9.9 to 86.5±7.6, and IKDC score increased from 43.5±9.8 to 79.4±4.2, with statistically significant improvement across follow-up intervals.

Conclusion: Simultaneous medial open-wedge HTO with ACL reconstruction effectively improves knee stability, range of motion, functional scores, and sagittal-plane radiological parameters in appropriately selected patients with ACL-deficient varus knees.

Keywords: Anterior cruciate ligament; High tibial osteotomy; Varus deformity; Posterior tibial slope; Lysholm score; IKDC score; Knee instability.

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Introduction

The anterior cruciate ligament (ACL) is central to control of anterior tibial translation and rotational stability, and reconstruction is intended to restore knee stability and permit return to activity. When ACL deficiency coexists with varus malalignment, the altered weight-bearing axis may contribute to persistent instability and greater stress on the reconstructed ligament. Medial opening-wedge high tibial osteotomy (HTO) is used in selected young, active patients to correct varus alignment, including complex revision situations. [1] Contemporary surveillance has reported favourable outcomes when

ACL reconstruction is combined with HTO in appropriately selected knees. [2] Sagittal-plane morphology is equally important. An increased posterior tibial slope promotes anterior tibial translation and has been associated with greater risk of ACL reconstruction failure; slope-reducing osteotomy can decrease graft forces and improve stability in selected patients. [3] Long-term follow-up of combined ACL reconstruction and lateral closing-wedge HTO has demonstrated sustained clinical improvement and satisfactory survivorship, although osteoarthritis may continue to progress. [4]

Despite advances in reconstruction, complications remain clinically relevant and may include technical errors, arthrofibrosis, infection and neurovascular injury. [5] Indian experience with arthroscopic ACL reconstruction has demonstrated substantial postoperative improvement in validated functional measures such as IKDC and Lysholm scores. [6] Evidence from a rural Indian tertiary-care setting has similarly shown favourable nine-month functional recovery using the Lysholm score, supporting effective postoperative rehabilitation in Indian practice. [7]

For knees with combined ligament insufficiency and malalignment, simultaneous arthroscopic ACL reconstruction with medial open-wedge HTO addresses instability and alignment during one operative episode, although tunnel planning, osteotomy correction and fixation remain technically important. [8] HTO also has durable joint-preserving potential; in a 20-year series for medial compartment osteoarthritis, overall survivorship was 44% and reached 62% among favourable candidates, with high satisfaction among surviving knees. [9] ACL surgery has progressively evolved toward anatomically oriented, arthroscopic and patient-specific reconstruction aimed at restoring normal knee kinematics and function. [10]

However, evidence remains limited regarding functional and radiological recovery when ACL deficiency coexists with coronal and sagittal plane deformity, particularly in Indian tertiary-care populations. This provides the rationale for evaluating simultaneous open-wedge HTO with ACL reconstruction using clinical stability, alignment and validated functional outcomes.

Material and Methods

Study Design: This prospective longitudinal study was conducted over 1.5 years to assess clinical, functional, and radiological outcomes following simultaneous high tibial osteotomy (HTO) and anterior cruciate ligament (ACL) reconstruction.

Study Setting: The study was conducted in the Department of Orthopaedics at Rohilkhand Medical College and Hospital, Bareilly, Uttar Pradesh, India. Patients attending the Orthopaedic OPD or admitted to the IPD with knee pain or instability and considered suitable for combined HTO and ACL reconstruction were screened.

Study Population: Patients aged 18–60 years with clinically and radiologically confirmed ACL deficiency/chronic ACL tear associated with varus deformity were enrolled after written informed consent.

Sample Size: A convenience sample of 30 patients fulfilling the eligibility criteria was included.

Inclusion Criteria: Patients of early medial tibiofemoral osteoarthritis with varus deformity, symptomatic ACL deficiency with medial compartment osteoarthritis, long standing ACL deficiency with double or triple varus, varus malalignment with symptomatic medial-compartment osteoarthritis and clinically and radiologically diagnosed chronic ACL tear in the age group of 18–60 years were included.

Exclusion Criteria: Patients aged <18 or >60 years, those with advanced knee osteoarthritis (Kellgren–Lawrence grade 4), multiligamentous injury/deficiency, rheumatoid arthritis, or varus deformity >20° were excluded.

Data Collection and Investigations: Demographic and clinical data were recorded using a predesigned proforma. Evaluation included detailed history, local and neurovascular examination, AP and lateral knee radiographs, CT, orthoscannogram, and MRI. Preoperative assessment comprised range of motion, anterior drawer test, Lachman test, and posterior tibial slope, Lysholm score, IKDC score, and VAS pain score. All patients underwent simultaneous arthroscopic ACL reconstruction using a hamstring graft with medial open-wedge HTO and plate fixation by a trained surgeon. Follow up was at 6 weeks, 6 months and 1 year.

Ethical consideration: The study was approved by the Institutional Ethics Committee and informed consent was obtained from all participants.

Statistical analysis: The data were analyzed by SPSS 26. Continuous variables are expressed as mean ± SD and categorical variables as frequency and percentage. Paired comparisons were performed with appropriate paired tests including paired t-test/Wilcoxon signed-rank test as applicable. Categorical variables were applied with chi-square test. A p-value of <0.05 was taken as statistically significant.

Results

Table 1: Post-operative changes of knee flexion

Time point	Mean (SD) (Degree)	Mean improvement from baseline (pre-operative period); 95% CI; p-value
Pre-operative	105.7 (SD 10.6)	-
6 weeks post-operatively	117.5 (SD 9.5)	11.8 (9.5, 14.2); <0.001*
6 months post-operatively	128.5 (SD 7.4)	22.8 (20.3, 25.4); <0.001*
One year post-operatively	134.8 (SD 4.6)	29.2 (25.7, 32.6); <0.001*

Table 1 shows a progressive improvement of knee flexion after surgery. Average flexion improved from 105.7 degrees preoperatively to 117.5 degrees at 6 weeks, 128.5 degrees at 6 months and 134.8 degrees at one year. All follow-up time points showed statistically significant improvement from baseline (p<0.001) indicating continued postoperative recovery of knee mobility.

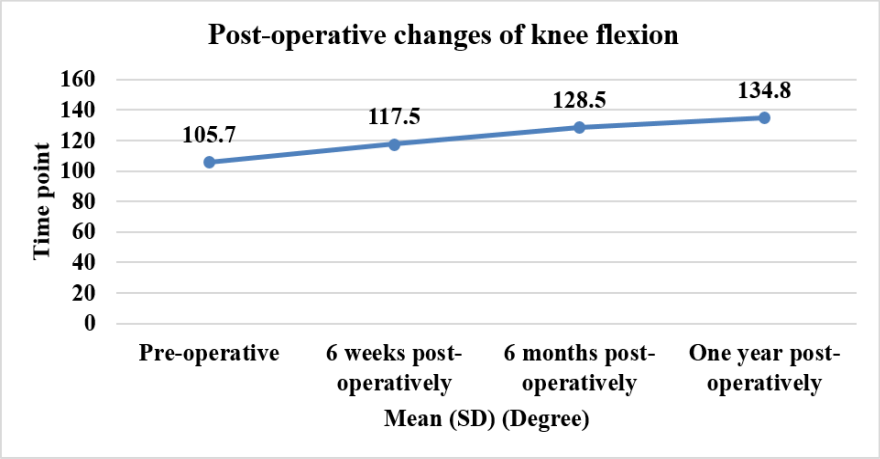

Figure 1: Post-operative changes of knee flexion

Table 2: Post-operative changes of knee extension

Time point	Mean (SD) (Degree)	Mean improvement from baseline (pre-operative period); 95% CI; p-value
Pre-operative	7.5 (SD 1.0)	-
6 weeks post-operatively	3.4 (SD 0.9)	4.1 (3.7, 4.5); <0.001*
6 months post-operatively	1.3 (SD 0.8)	6.2 (5.6, 6.6); <0.001*
One year post-operatively	0.6 (SD 0.6)	6.9 (6.5, 7.3); <0.001*

Table 2 shows a consistent improvement in the postoperative knee extension deficit. Mean extension improved from 7.5 degrees preoperatively to 3.4 degrees at 6 weeks, 1.3 degrees at 6 months, and 0.6 degrees at 1 year. Improvement from baseline was significant (p<0.001) at each follow-up interval demonstrating progressive restoration toward near-normal extension

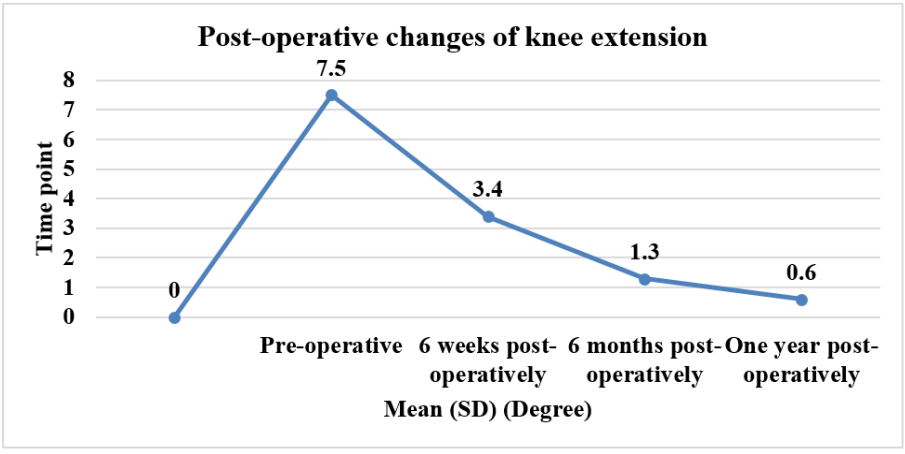

Figure 2: Post-operative changes of knee extension

Table 3: Post-operative changes of Lachman test

Grades	Pre-operative, n (%)	Post-operative, n (%)		
		6 weeks	6 months	1 year
Grade 0	0	4 (13.3)	29 (96.7)	30 (100)
Grade 1	0	15 (50.0)	2 (2.3)	0
Grade 2	16 (53.3)	11 (36.7)	0	0
Grade 3	14 (46.7)	0	0	0

Table 3 shows progressive improvement in the anterior knee stability postoperatively. Preoperatively 53.3% of patients had Grade 2 and 46.7% had Grade 3 Lachman findings. At 6 months postoperatively, the stability was Grade 0 in 96.7% of patients and at 1 year, the Lachman test findings were Grade 0 in 100% of patients.

Table 4: Post-operative changes of tibial slope

Time point	Mean (SD) (Degree)	Mean improvement from baseline (pre-operative period); 95% CI; p-value
Pre-operative	7.5 (SD 1.1)	-
6 weeks post-operatively	9.2 (SD 0.9)	2.7 (2.3, 3.3); <0.001*
6 months post-operatively	11.3 (SD 0.8)	3.8 (3.1, 4.5); <0.001*
One year post-operatively	12.2 (SD 1.0)	4.7 (4.2, 5.2); <0.001*

Table 4 reveals a progressive increase of posterior tibial slope after surgery. The mean tibial slope increased from 7.5° preoperatively to 9.2° at 6 weeks, 11.3° at 6 months, and 12.2° at one year. Changes from baseline were statistically significant at all follow-up intervals (p<0.001).

Table 5: Post-operative changes of Lysholm score

Time point	Mean (SD)	Mean improvement from baseline (pre-operative period); 95% CI; p-value
Pre-operative	50.9 (SD 9.9)	-
6 weeks post-operatively	67.9 (SD 9.4)	17 (15.8, 18.3); <0.001*
6 months post-operatively	79 (SD 8.1)	28.1 (26.2, 30.0); <0.001*
One year post-operatively	86.5 (SD 7.6)	35.7 (33.6, 37.8); <0.001*

The functional knee outcome after surgery is shown in table 5 with a significant and progressive improvement. The mean Lysholm score improved significantly from 50.9 preoperatively to 67.9 at 6 weeks, 79.0 at 6 months and 86.5 at 1 year. Statistically significant improvements from baseline at each point of follow-up (p<0.001).

Table 6: Post-operative changes of IKDC score

Time point	Mean (SD)	Mean improvement from baseline (pre-operative period); 95% CI; p-value
Pre-operative	43.5 (SD 9.8)	-
6 weeks post-operatively	58.1 (SD 8.1)	14.6 (13.6, 15.7); <0.001*
6 months post-operatively	69.8 (SD 6.5)	26.3 (24.6, 28.1); <0.001*
One year post-operatively	79.4 (SD 4.2)	35.9 (39.8, 47.2); <0.001*

Progressive improvement of the IKDC scores was observed after surgery. The mean IKDC score increased from 43.5 preoperatively to 58.1 at 6 weeks, 69.8 at 6 months, and 79.4 at 1 year. Statistically significant improvement was seen at all post-operative follow-up time points from baseline (p<0.001).

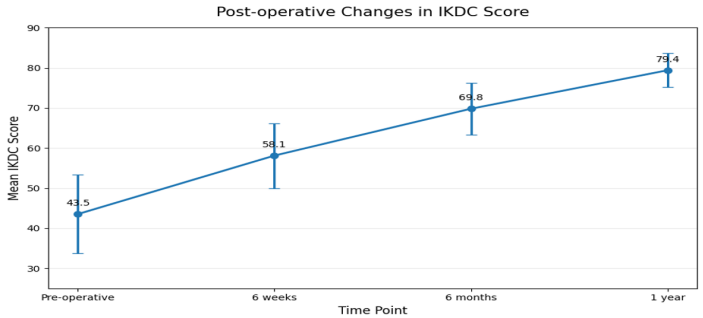

Figure 3: Post-operative changes of IKDC score

Discussion

Knee flexion improved progressively from 105.7±10.6° preoperatively to 117.5±9.5° at 6 weeks, 128.5±7.4° at 6 months and 134.8±4.6° at one year (11.8°, 22.8°, 29.2° respectively, all $p<0.001$). Such recovery is similar to that of Agostinone et al. (2023) [4] who observed significant improvement in clinical scores ($p<0.001$) and Dash et al. (2023) [6] who reported improvement in IKDC from 51.4+2.84 to 91.8+2.59 and Lysholm from 53.9+3.72 to 91.4+3.61 Moreover, good functional recovery was reported by Bosco et al. (2023) [3] and Toofan et al. (2022) [8] in the postoperative follow-up of combined procedures. The comparator summaries did not provide exact flexion measurements so we could not directly compare degrees.

The knee extension deficit improved gradually from 7.5±1.0° preoperatively to 3.4±0.9° at 6 weeks, 1.3±0.8° at 6 months and 0.6±0.6° at one year with the respective improvements of 4.1°, 6.2° and 6.9° (all $p<0.001$). The repeated return to near full extension correlates with the overall clinical improvement reported by Agostinone et al (2023) [4] in their combined ACL reconstruction and HTO cohort with significant improvement in clinical scores ($p<0.001$). Good recovery of knee stability and function Bosco et al. (2023) [3], and reliable recovery after dual surgery Toofan et al. (2022) [8]. There was considerable functional improvement after ACL reconstruction, but extension values were not reported for comparison. Dash et al., (2023) [6]

Knee stability improved as assessed by the Lachman grade (preoperative 16 patients (53.3%) were Grade 2 and 14 patients (46.7%) Grade 3 laxity, 6 months 29 patients (96.7%) were Grade 0 and all 30 patients (100%) at 1 year). This is in agreement with the work of Bosco et al (2023) [3] which showed that there was significant improvement of anteroposterior stability after slope correcting HTO for ACL reconstruction ($p<0.05$). Stability needs simultaneous correction of malalignment and ligament insufficiency. However, Itou et al. (2023) [2] reported 1.4 % of ACL re-rupture rate in HTO cases indicating the complete stability is not a universal outcome across the cohort.

Posterior tibial slope increased significantly from 7.5±1.1° preoperatively to 9.2±0.9°, 11.3±0.8° and 12.2±1.0° at 6 weeks, 6 months and one year respectively with reported improvements of 2.7°, 3.8° and 4.7° respectively (all $p<0.001$). There was a statistically significant change in posterior tibial slope after ACL reconstruction with osteotomy ($p < .05$, Bosco et al., 2023)3. Other combined procedures showed improvement in malalignment (Angachekar et al. 2024 [1]; Toofan et al. 2022) [8]. Long term radiographic alignment after high tibial osteotomy and ACL reconstruction. Agostinone et al. (2023) [4] whereas, here the values increased gradually in total, Bosco et al. (2023) [3] specifically studied slope-reducing osteotomy.

Lysholm scores improved significantly from 50.9 ± 9.9 preoperatively to 67.9 ± 9.4 at 6 weeks, 79.0 ± 8.1 at 6 months and 86.5 ± 7.6 at one year. The improvements at 6 weeks, 6 months and one year were 17.0, 28.1 and 35.7 points respectively ($p < 0.001$). Dash et al (2023) [6] also reported improvement in functional scores (Lysholm scores) from 53.9±3.72 to 91.4±3.61 Also, significant improvement in Lysholm ($p< 0.05$) and positive functional recovery following ACL reconstruction has been reported by Bosco et al (2023) [3] and Soni et al (2024) [7]. Agostinone et al (2023) [4] reported clinically significant improvement ($p<0.001$) but longer follow-up showed deterioration in WOMAC and Tegner scores indicating some domains of function may decline over time.

The IKDC scores increased from 43.5±9.8 pre-operatively to 58.1±8.1 at 6 weeks, 69.8±6.5 at 6 months and 79.4±4.2 at one year. [6]. Dash et al. (2023)6 also noted a significant numerical increase from 51.4±2.84 to 91.8±2.59 after ACL reconstruction. All comparisons reported were $p<0.001$. Agostinone et al. (2023) [4] reported a significant overall improvement ($p<0.001$) and stable IKDC scores at long-term follow-up However studies differed in terms of outcome measures. Itou et al. (2023) [2]. The reported 1-year mean improvement of 35.9 points (95% CI 39.8-47.2), does not include the point estimate and has to be validated before publication.

Conclusion

In patients with ACL deficiency and varus deformity, simultaneous medial open wedge high tibial osteotomy and anterior cruciate ligament reconstruction resulted in significant improvement in knee function, stability and post-operative biomechanics. Knee flexion improved from 105.7° preoperatively to 134.8° at 1 year, and the extension deficit improved from 7.5° to 0.6° , with almost complete restoration of physiological range of motion. Objective stability also improved significantly with all patients having a Grade 0 Lachman at 1 year. Functional recovery was revealed by the increase of the mean Lysholm score from 50.9 to 86.5 and of the IKDC score from 43.5 to 79.4. All follow-up intervals showed a statistically significant improvement. Also, posterior tibial slope was significantly changed postoperatively. The results indicate that combined correction of ligamentous insufficiency and osseous malalignment can result in good short-term restoration of stability and function. This supports the use of combined correction in appropriately selected patients with ACL-deficient varus knees.

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