

**IN BRIEF**

# Simultaneous High Tibial Osteotomy and Anterior Cruciate Ligament Reconstruction in knees with Bony Frontal and/or Sagittal Deformities: Review of the Current Literature

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**Abstract**

Simultaneous anterior cruciate ligament (ACL) reconstruction (ACLR) and valgus high tibial osteotomy (HTO) alleviates pain in 70% of individuals with ACL deficiency and varus femorotibial osteoarthritis, allows for sustainable stabilization of the knee at the 10-year follow-up and a return to sport (RTS) in 33%-80% of cases, but femorotibial osteoarthritis progression occurs in 39% of cases. The complication rate ranges from 0% to 23.5% (6.5% revision valgus HTO, 17.5% ACL graft failure, 7.7% venous thrombosis). Simultaneous ACLR and HTO leads to satisfactory results in patients with ACL deficiency and varus femorotibial osteoarthritis associated with a high posterior tibial slope (PTS) and appears to have a protective effect on further ruptures in the reconstructed ACL. The younger the patient and the more sporting demands he/she poses, the more we should be inclined to perform a combined intervention (ACLR and valgus HTO).

**Level of evidence:** III

**Keywords:** Combined chronic ACL deficiency and varus osteoarthritis, Results, Simultaneous valgus high tibial osteotomy and ACL reconstruction

**Introduction**

The combination of anterior cruciate ligament (ACL) deficiency and varus osteoarthritis (OA) is a challenging clinical problem for orthopedic surgeons. However, the simultaneous performance of valgus high tibial osteotomy (HTO) and ACL reconstruction (ACLR) may solve the problem in a single surgical intervention.<sup>1-8</sup>

It is important to separate between frontal and sagittal bony deformities. The proposed target for frontal alignment is 2 to 4° of valgus in varus knees and 4 to 6° of posterior tibial slope (PTS). There are different osteotomy types: medial or lateral valgus, anterior closing wedge, and combined two dimensional corrections.<sup>9-20</sup>

In this article a narrative literature review on the results of simultaneous valgus HTO and ACLR in ACL deficiency and varus OA was performed. On May 18, 2024, we

performed a literature search in PubMed of the last three years (2022-2024), using the keywords ACL and HTO. Thirty-one articles were found, 18 of which were ultimately analyzed because they were considered the most directly related to the subject and of greatest scientific interest. Two important articles on the subject published in 2018 and 2020 were also added, to finally analyze 20 references.

**Main body****Recent publications**

Several case series and systematic reviews have been published on simultaneous valgus HTO and ACLR in ACL deficiency and varus OA, the main findings of which are summarized in [Tables 1 and 2]. The decision to carry out simultaneous valgus HTO and ACLR must be made based on the individual's age and athletic pursuits. In terms of the HTO

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fixation type, it is not only healing that may be of interest, but also loss of reduction.<sup>1</sup>

There is evidence to suggest that the PTS should be diminished when it is greater than 13° and associated with chronic ACL deficiency demonstrated by increased anterior tibial translation of at least 10 mm compared to the contralateral knee [Figures 1 and 2)].<sup>2</sup> [Table 3] summarizes the advantages and disadvantages of the 3 types of slope-reducing HTO according to the level of the anterior tibial tubercle.<sup>3</sup>

It has been reported that increased PTS is a risk factor for ACLR and posterior root repair failure. Most studies carry out anterior closed wedge osteotomies for slope corrections only. The role for valgus correction osteotomy combined with ACLR remains still controversial. Only few studies report on combined valgus and PTS correction osteotomies. This may be done with lateral closed or medial open wedge technique. 3-D planning and the utilization of patient specific instruments may be helpful for complex 2-D corrections.<sup>9-20</sup>

**Table 1. Case series: Simultaneous anterior cruciate ligament reconstruction (ACLR) + high tibial osteotomy (HTO)**

AUTHORS [REFERENCE]	YEAR	LoE	METHODS	RESULTS	CONCLUSION
Moradi et al [2]	2020	4	This study presented the technique and clinical results of a series of simultaneous LCW distal femoral osteotomy and ACLR. Nineteen individuals with confirmed ACL rupture and femoral varus deformity (mechanical lateral distal femoral angle $\geq 93^\circ$ ) associated with medial OA ( $\pm$ lateral thrust) were analyzed. The individuals experienced simultaneous LCW distal femoral osteotomy and ACLR. At 1 year follow up, the final ROM and stability of the knees and the last alignment of extremities were assessed. Surgical results were evaluated on 2000 IKDS subjective scores and KOOS subscales.	The mean preoperative varus knee was 10.6° mostly from the femoral side. The mean union time was 3.2 months. At 1 year follow up, all individuals were free of knee instability. Subjective evaluation based on questionnaires demonstrated a substantial improvement in all aspects of knee function after surgery, however there was no considerable change in the knees ROM.	Simultaneous LCW femoral osteotomy and ACLR was a valuable procedure in femoral varus knees with medial OA and anterior knee instability. After 1 year follow up all aspects of knee function were improved without serious adverse events.
Mabrouk et al [4]	2023	4	These authors assessed the impact of combined ACW-HTO and at least a second revision ACLR procedure on knee stability, function, and sports performance in 64 patients. These patients experienced a second (or more) revision ACLR procedure and ACW-HTO, and had a PTS >12°. The mean age was 29.6 years, and the mean preoperative PTS was 13.79°.	There were 3 cases of a re-rupture with a severe pivot shift on the clinical examination. None of these individuals experienced revision per the patient's preference. Increased knee recurvatum was found in one-third of the individuals, but all were asymptomatic.	In the setting of chronic ACL-deficient knees, PTS reduction (ACW-HTO) with revision ACLR restored knee stability and improved function with an acceptable rate of adverse events. Also, half of the individuals were able to return to impact sports.
Agostinone et al [5]	2023	4	This study reported clinical and radiographic results of 27 patients who underwent ACLR and LCW-HTO at a mean of 14 years of follow-up.	Statistically significant improvement was encountered for all the clinical scores between the preoperative status and the mid-run follow-up. Significant progression of OA was found for all the knee compartments. The survivorship was 95.7% at 5 years, 82.6% at 10 years, and 72.8% at 15 years.	Combined ACLR and LCW-HTO showed satisfactory clinical outcomes and survivorship at a mean of 14 years follow-up.
Cance et al [6]	2024	4	This study compared preoperative and postoperative coronal plane alignment after TDO, and analyzed its effect on patellar height.	A total of 68 patients were included in this study. Pre- and postoperative radiographs were performed 1 month before and 3 months after surgery, respectively. There was a significant increase in the mean MPTA of 0.95° varus, a decreased PTS of 8.86° and an increased CDI of 0.08 in individuals experiencing TDO. Insall-Salvati ratio measurements showed no difference.	TDO was performed without large changes to coronal alignment or patellar height.

Table 1. Continued

Guy et al [7]	2024	4	These authors assessed the impact of tibial tubercle-sparing ACW-HTO on patellar height in revision ACLR in 47 individuals.	Fifteen individuals (31.9%) exhibited a postoperative change in their patellar height category when measured by the Insall-Salvati index (6 moved up a category, 9 moved down one), and 18 individuals (38.3%) changed category according to the CDI (10 moved up a category, 8 moved down one). No substantial difference was encountered between pre- and postoperative patellar height among these individuals.	Changes in patellar height ratio were common after tibial tubercle-sparing ACW-HTO in individuals experiencing revision ACLR.
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LoE, level of evidence; LCW, lateral closing-wedge; OA, osteoarthritis; ROM, range of motion; IKDC, International Knee Documentation Committee; KOOS, Knee Injury and Osteoarthritis Outcome Score ; ACW-HTO, anterior closing-wedge HTO; PTS, posterior tibial slope; LCW-HTO, lateral closing-wedge HTO; TDO, tibial deflexion osteotomy; MPTA, medial proximal tibial angle; CDI, Caton-Deschamps index

Table 2. Systematic reviews and meta-analyses: Simultaneous anterior cruciate ligament reconstruction (ACLR) + high tibial osteotomy (HTO)

AUTHORS [REFERENCE]	YEAR	LoE	METHODS	RESULTS	CONCLUSION
Malahias et al [1]	2018	2	Systematic review	The vast majority of the individuals were treated with hamstrings autograft (85.6% of the individuals), whereas a small minority had a patellar bone-to-bone autograft (12.8% of the individuals) and 3 individuals received a patellar allograft. High tibial open wedge osteotomy was performed in 116 individuals (57.4%) and closed wedge in 86 individuals (42.6%). The mean preoperative angle of the individuals was 6.6° varus, while the mean final postoperative angle was encountered to be 1.3° valgus.	This study demonstrated improved postoperative IKDC with the use of one-stage HTO and ACLR, whereas the reoperation rate was very low. In spite of the lack of high quality studies, it seemed that one-stage HTO and ACLR was a safe and effective procedure for treatment of individuals suffering from symptomatic varus OA in combination with anterior knee instability.
Bosco et al [8]	2023	4	Systematic review and meta-analysis	ACLR combined with ACW-HTO restored knee stability and function with satisfactory clinical and radiological results in individuals with an ACL injury associated with a high PTS.	ACLR combined with ACW-HTO seemed to have a protective effect from further ruptures on the reconstructed ACL.
Itthipanichpong [9]	2023	4	Systematic review and meta-analysis	Patients demonstrated postoperative improvements in Lysholm, pivot-shift test, and side-to-side difference in anterior tibial translation. After ACW-HTO, all studies reported mean postoperative PTS of <10°. Of 43 patients with available RTS data, the same-level RTS rate ranged from 65% to 100%. The overall complication rate was 0.9% to 1.3%, and there were no reported ACL re-tears.	ACW-HTO with single- or two-stage ACLR in individuals with ACL insufficiency and increased PTS was associated with substantial improvements in PROs and high return to RTS rates.

IKDC, International Knee Documentation Committee; LoE, level of evidence; OA, osteoarthritis; ACW-HTO, anterior closing-wedge HTO; PTS, posterior tibial slope; PROs, patient related outcomes; RTS, return to sport

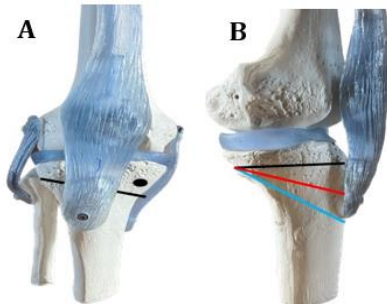


Figure 1 (A-B). (A) Knee model depicting tibial tunnel placement (black circle) and high tibial osteotomy - HTO placement (black oblique line) in the proximal tibia; (B) levels of the slope-reducing osteotomy: supra-tubercular (black line), trans-tubercular (red line), and infra-tubercular (blue line)



Figure 2 (A-B): Postoperative radiographs of a patient with anterior cruciate ligament (ACL) chronic deficiency and varus osteoarthritis. He underwent simultaneous hamstring autograft ACL reconstruction (ACLR) and medial open-wedge high tibial osteotomy (MOW-HTO): (A) anteroposterior radiograph; (B) lateral view

**Table 3. Pros and cons of various types of slope-correction osteotomy [anterior closing-wedge high tibial osteotomy (ACW-HTO)]**

OSTEOTOMY	PROS	CONS
Supra-tubercular	<p>*ATT osteotomy is not required.</p> <p>* Better bone healing in pure cancellous bone.</p> <p>* Allows for the use of a BTPB graft for the ACLR.</p>	<p>* Only a short oblique ACL tibial tunnel is possible.</p> <p>* Can cause patella alta.</p> <p>* It causes a higher riding patella.</p> <p>* Can injure the patellar tendon.</p> <p>* The small proximal segment could compromise osteotomy fixation.</p>
Trans-tubercular	<p>*ATT can be used as a bio-plate.</p>	<p>* Normally requires an osteotomy of the ATT.</p> <p>* Postoperative mobilization is slower.</p>
Infra-tubercular	<p>* No ATT osteotomy is required.</p> <p>* Leaves enough space for the tibial perforation of the ACL.</p> <p>* Does not compromise patellofemoral mechanics.</p>	<p>* Metaphyseal-diaphyseal bone has less healing potential than epiphyseal-metaphyseal bone.</p>

ATT, anterior tibial translation; BTPB, bone-patellar tendon-bone; ACLR, anterior cruciate ligament reconstruction; ACL, anterior cruciate ligament

## Conclusion

Despite the lack of high-quality studies, simultaneous HTO and ACLR appears to be an effective procedure for treating patients with symptomatic varus OA combined with ACL deficiency. However, future research is required to confirm the effectiveness of the simultaneous procedure and evaluate the long-term progression of medial compartment OA following the procedure.

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## Authors Contribution:

All authors contributed similarly to this article. All of them conceived and designed the analysis, collected the data, contributed data or analysis tools, performed the analysis, and wrote the paper.

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