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**Dr. Jayanta mondal**  
Associate Professor, Medical  
College, Kolkata, West Bengal,  
India

**Dr. Nabarun saha**  
Assistant Professor, Medical  
College, Kolkata, West Bengal,  
India

**Dr. Rahul mondal**  
RMO CUM Clinical Tutor,  
Medical College, Kolkata, West  
Bengal, India

**Dr. Sabyasachi santra**  
Associate Professor, R.G. Kar  
Medical College, Kolkata, West  
Bengal, India

**Dr. Aniruddha sengupta**  
Professor, Medical College,  
Kolkata, West Bengal, India

## Outcome of simultaneous high tibial osteotomy and anterior cruciate ligament reconstruction in anterior cruciate ligament deficient varus knee

**Dr. Jayanta Mondal, Dr. Nabarun Saha, Dr. Rahul Mondal, Dr. Sabyasachi Santra and Dr. Aniruddha Sengupta**

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### Abstract

For patients with concomitant genu varum deformity and anterior cruciate ligament deficiency, there is constant adduction moment at knee joint during weight bearing leading to increased load over medial compartment. In this prospective cohort study we treated these patients by anatomical single bundle ACL reconstruction and medial open wedge high tibial osteotomy and evaluated their clinical and radiological outcomes. The mean follow up period was 25 months. The mean International Knee Documentation Committee score improved from pre-operative 45 to post-operative 77. Range of motion was near normal in all cases. Lachman test and Pivot-shift test showed significant improvement post-operatively. The femorotibial mechanical axis was significantly corrected from 7.0° varus to 1.2° valgus and tibial posterior slope was not significantly changed. Thus to conclude although the procedure requires long learning curve, it decreases load on medial compartment, preserving articular cartilage and reduces adduction moment thereby lessening tension on the graft, both of which are important for future of these knees.

**Keywords:** Medial open wedge high tibial osteotomy, ACL deficient knee, varus knee, posterior slope

### Introduction

In long standing anterior cruciate ligament (ACL) deficiency there are altered gait biomechanics and repeated episodes of subluxation leading to chondral and meniscal damage within 6-10 years of injury. Worst case is in subset of patients with meniscal injury. Thus chronic ACL deficiency leads to early osteoarthritis. Medial compartment of knee is more affected than lateral compartment enhancing varus knee [1]. Varus alignment in turn creates a constant, static adduction moment at the knee resulting in increased loads in the medial compartment and tension on ACL, lateral and postero-lateral soft tissue structures during stance phase of gait [2, 3]. Thus there is progressive varus deformity leading to double varus when there is slackening of lateral soft tissues structures and triple varus when in addition there is increased external tibial rotation and hyperextension with an abnormal varus recurvatum position [4]. Hence, this vicious cycle of ACL deficiency and varus knee continues. Symptoms usually are instability related to ACL deficiency, pain originating from medial compartment arthrosis and varus or hyperextension gait. There are several treatment options. But our study population is young active individuals where joint preservation is of primary concern. Hence our plan of treatment is ACL reconstruction with a realignment procedure and high tibial osteotomy is a well-established realignment procedure. These are of two types: Lateral closing wedge osteotomy and Medial open wedge osteotomy. In this study we carried out simultaneous procedure of anterior cruciate ligament reconstruction and medial open wedge high tibial osteotomy and evaluated the results on basis of clinical and radiological criteria.

### Materials and Methods

The study is prospective cohort study without any control done in time period between June 2016 and December 2018.

### Correspondence

**Dr. Nabarun saha**  
Assistant Professor, Medical  
College, Kolkata, West Bengal,  
India

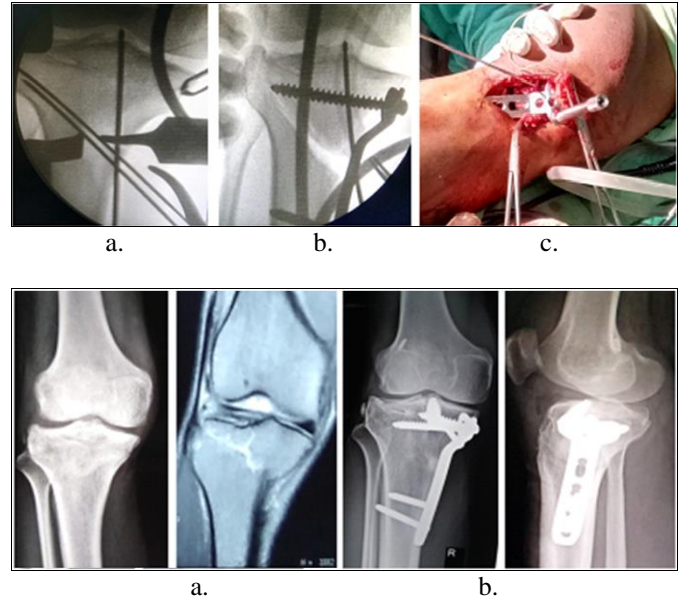
Patient selection criteria included young active individuals with ACL deficiency who progresses to varus knee, osteoarthritis (Ahlbäck grades 1-3) with varus knee which progresses to anteroposterior instability i.e. ACL tear and post traumatic varus knee due to tibial plateau fracture with antero-posterior instability i.e. ACL tear. Grade 4 tri-compartmental osteoarthritis knee with age more than 60 years, multiligament knee injury patients with varus malalignment and asymptomatic patients with less than 5 degrees of primary varus were excluded from our study.

Ortho Scanogram of both lower limbs in standing position and magnetic resonance imaging scans of the knees were performed preoperatively. Weight bearing axis, Fujisawa point<sup>5</sup> (lateral to lateral tibial spine) and Mechanical axis through Fujisawa point were drawn. The degree of varus deformity (i.e. tibio-femoral angles on mechanical axis), arthritic changes within different compartments of the knee joint, posterior tibial slope and angle of opening wedge ( $\alpha$  angle) were measured from standing X-rays. All the patients were evaluated pre- and post- operatively on the basis of following (1) clinical criteria viz: Degree of varus correction, International Knee Documentation Committee (IKDC) score, Range of motion, Lachmann test, Pivot-shift test and (2) radiological criteria viz: Angle of correction ( $\alpha$  angle), Posterior tibial slope and Progression of osteoarthritis.

### Surgical technique

the surgical technique proposed by Bonasia *et al* [6], is followed in this study. Patient is placed supine on radiolucent table, under regional or general anesthesia, and a tourniquet is applied at proximal thigh in such that it allows for knee hyperflexion. Diagnostic arthroscopy is performed through standard anteromedial and anterolateral portals. Chondral injuries are treated by microfracture of femoral or tibial articular surface and meniscal balancing was done for tears. The ACL stump, when present, is removed and medial wall of lateral femoral condyle is carefully debrided. In cases where osteophytes are seen in intercondylar notch they are removed with shaver and notchplasty is done to avoid ACL impingement. A 7-8 cm vertical incision midway between tibial tubercle and posteromedial tibial cortex is given starting 1 cm distal to the joint line. Hamstring (Semitendinosus with or without Gracilis) graft is harvested and prepared. Now with knee hyperflexed arthroscopic inside-out transportal femoral tunnel preparation is done according to standard extracortical suspension via endobutton technique. A shuttle suture is left in the femoral tunnel, exiting from the lateral thigh and anteromedial portal. Under guidance of tibial guide, tibial tunnel guidewire is passed through ACL footprint. Here slight anterior placement of tibial tunnel is preferred. Next with knee extended dissection is carried out and distal portion of superficial medial collateral ligament is partially detached. The patellar tendon is protected with retractor. Under fluoroscopy control two K wires are placed, parallel to each other in antero-posterior plane, from medial to lateral and distal to proximal, starting around 4 cm below the medial joint line, aiming at the tip of fibular head (around 1 cm below lateral joint line) as shown in Fig.1. The osteotomy is carried out just distal to the K wires and it should be parallel to posterior tibial slope. The mobility of osteotomy is checked by using gentle valgus force and pulling the handle of last osteotome distally. Graduated osteotomy wedges are inserted while taking care so that intraarticular or lateral cortex violation is avoided. When desired opening is achieved and long alignment rod passes through the Fujisawa point, medial

buttress plate is positioned posterior to tibial guide wire. All screws are positioned except proximal anterior cancellous screw. If more than 10 mm of opening is achieved ipsilateral iliac crest cortical bone graft is required to fill the gap. Following this, arthroscopic tibial tunnel is prepared and ACL graft is pulled into the joint and fixed proximally by flipping Endo Button on lateral femoral cortex. The graft is tensioned by moving the knee through full range of motion for about 20 cycles. Tibial fixation is achieved at 20° of flexion and downward displacement of tibia with an interference screw. Finally proximal anterior cancellous screw of HTO plate is placed.



**Fig 1:** Illustration of surgical technique. a) K wire placement for HTO, b) opening achieved over medial proximal tibia. *Note: Long alignment rod passes through Fujisawa point,* c) HTO plate placed posterior to ACL tibial tunnel guide wire. Posterior proximal screw is placed first leaving anterior cancellous screw, d) Pre-op radiograph and MRI images of malunited Type IV Schatzker presented with varus knee and chronic ACL tear, e) Post-op radiograph of medial open wedge HTO and ACL reconstruction

### Rehabilitation

Range of motion exercise is started as soon as possible. Knees are kept in range of motion brace for 6 weeks. Toe touch partial weight bearing given after 4 weeks. Gradually progressive weight bearing is encouraged and rest of rehabilitation protocol proceeds as in standard ACL reconstruction.

### Follow up

X-rays were performed on the 2nd postoperative day, stitch off at 14 days and subsequent follow-ups at 3 months, 6 months, 12 months, and 24 months postoperatively and annually thereafter.

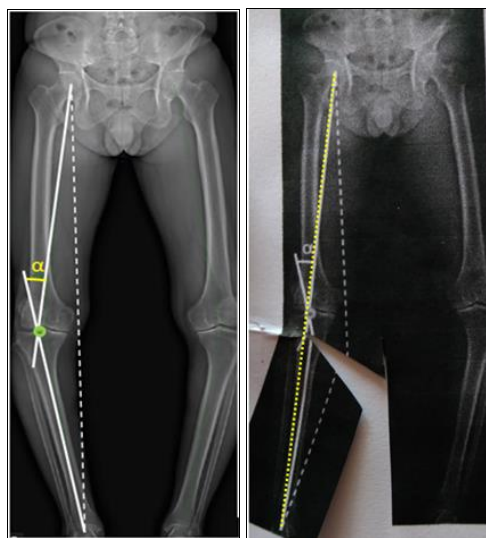
### Results and Discussion

Our study consists of 4 patients of age group 25- 45 years with ACL deficiency and varus knee. All of them were male. Their chief complaints were a combination of knee instability and medial joint line pain. Three of the patients were manual labourers and remaining one was leisure time sportsman. 2 patients had ACL deficiency who progresses to varus knee, 1 patient had osteoarthritis (Ahlbäck grade 3) with varus knee which progresses to antero-posterior instability and 1 patient was post traumatic tibial plateau fracture with ACL

tear leading to varus knee and instability.

On examination these patients revealed positive Lachman and Pivot Shift tests. Clinically knee varus was calculated by angle between imaginary line from mid inguinal point to centre of patella and centre of patella to midpoint of intermalleolar line at ankle joint<sup>7</sup>. The varus deformity in these patients varied from primary varus with no lateral joint laxity to double or triple varus according to Noyes' classification<sup>4</sup>.

For radiological evaluation weight bearing axis was drawn from centre of femoral head to centre of ankle joint (dotted line in Fig.2a). Fujisawa point is a point taken 62.5% between medial and lateral compartment of proximal tibia, slightly lateral to lateral tibial spine (green dot in Fig.2a)<sup>5</sup>. Mechanical axis of femur and tibia are drawn from this point to centre of femoral head and centre of ankle respectively (bold line in Fig.2a). Angle between these two mechanical axes is angle of correction ( $\alpha$  angle in Fig.2a)<sup>12</sup>. In medial open wedge HTO the aim is to achieve an opening of  $\alpha$  angle on medial proximal tibia osteotomy site so that 3-5° of valgus in the mechanical axis is achieved and the weight bearing axis passes through the Fujisawa point<sup>8</sup> (Fig.2b).



**Fig 2:** a) Standing radiograph showing weight bearing axis, mechanical axis, Fujisawa point,  $\alpha$  angle of correction, b) Medial open wedge at proximal tibia aligns weight bearing axis through Fujisawa point



**Fig 3:** Lateral radiograph showing posterior tibial slope

Another important aspect is posterior tibial slope. It is defined as the angle between a line perpendicular to mid-diaphysis of tibia and posterior inclination of the tibial plateaus (Fig.3).

This slope is usually 9–11° on medial plateau, whereas laterally it is typically 6–8°<sup>[2,9,10]</sup>. Several studies have shown that increase in slope causes anterior tibial translation<sup>[2, 11, 12, 13]</sup> and increases strain on ACL<sup>[14, 15]</sup> while decreasing the slope will decrease strain on ACL and anterior tibial translation, thus reducing instability. As stated earlier there are two types of high tibial osteotomy. Lateral closing wedge osteotomy causes a decrease in posterior tibial slope, thus stabilises knee with anterior instability and put less strain on ACL whereas medial open wedge osteotomy causes reverse effect<sup>[16]</sup>. However, in lateral closing wedge osteotomy there are increased chances of iatrogenic common peroneal nerve injury, compartment syndrome and proximal tibiofibular joint instability. Medial open wedge osteotomy has following advantages :- a) one cut is easier to titrate than two parallel cut, b) preserves bone stock and tighten capsuloligamentous structures around knee, c) avoids neurovascular risk<sup>[1]</sup>. These advantages make medial open wedge high tibial osteotomy current preferred technique.

The medial open wedge high tibial osteotomy is made from medial to lateral and distal to proximal, starting around 4 cm below the medial joint line, aiming at the tip of fibular head (Around 1 cm below lateral joint line) taking care to avoid intraarticular and lateral cortex violation<sup>[6]</sup>. For ligament reconstruction we followed anatomical single bundle ACL reconstruction with extracortical suspension via endobutton on femoral side and interference screw on tibial side.

Mean follow up period was 25 months. Average time interval between injury and surgery was 11 months. Pre-operative and post-operative result details are narrated in Table 1.

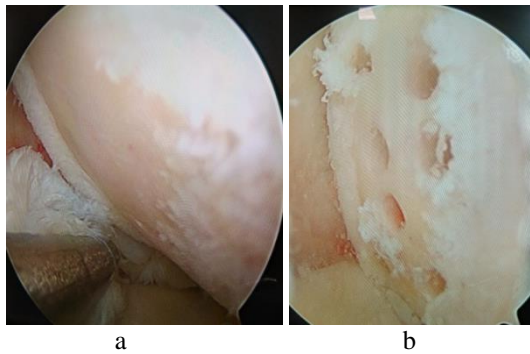
**Table 1:** Pre-operative and post-operative result based on clinical and radiological criteria

Parameters	Pre-operative	Final follow up
Clinical		
1. Knee Varus	6.3 ± 2.3 (varus)	-1.2 ± 1.4 (valgus)
2. Ikdc Score	45 ± 12.0	77 ± 5.9
3. Range Of Motion	137.6 ± 6.2	136.5 ± 6.0
4. Lachman Test		
Grade 0	0	3
Grade I	0	1
Grade II	2	0
Grade III	2	0
5. Pivot Shift		
Grade 0	0	4
Grade I	2	0
Grade II	2	0
Grade III	0	0
Radiological		
1. $\alpha$ Angle	7.0 ± 2.3 (varus)	-1.8 ± 1.4 (valgus)
2. Posterior Tibial Slope	10.2 ± 2.3	10.0 ± 1.4
3. Progression of Oa	-	NIL

Intraoperative status of articular cartilage is categorised arthroscopically according to Modified Outerbridge classification<sup>[17]</sup> as shown in Table 2.

**Table 2:** Modified outerbridge classification

Grade	Description	Number
0	Normal articular cartilage	0
I	Softening of articular cartilage	2
II	Fibrillation or superficial fissures of cartilage	1
III	Deep fissuring of cartilage without exposed bone	0
IV	Exposed bone	1



**Fig 4:** a) Grade IV femoral chondral defect, b) Microfracture

Although medial open wedge HTO has increased propensity to increase posterior tibial slope a few modifications help prevent alteration of the slope and thus strain on ACL graft. First of all, posterior plate placement resists increase in posterior tibial slope and protects ACL graft from excessive tension [2]. Secondly it must be ensured that HTO hardware does not interfere with the tibial tunnel or fixation. Hence single stage simultaneous technique is preferred. It has advantages of a) single surgical procedure, b) no graft-tunnel mismatch, c) non-interference between tibial tunnel and osteotomy screws, d) fine-tuning of tibial slope possible and e) low cost [1]. In our study average posterior tibial slope remains unchanged.

We have made an extensive search of literature in support of our study. Noyes *et al.* [18] Treated 41 patients of chronic ACL deficiency and varus knee with lateral closing wedge high tibial osteotomy only. Of them 16 required second stage ACL reconstruction; 78 % felt subjectively improved and 88 % had revision HTO. Naudie *et al.* [19] Reported on 17 patients who received medial open wedge HTO for chronic ligamentous deficiencies. All patients had improved knee stability and were satisfied with the osteotomy surgery. Badhe *et al.* [20] Reported on 14 patients of double and triple varus deformity treated by ligamentous reconstruction and either of the osteotomies. He concluded triple varus patients who had medial open wedge HTO had better outcomes than those who underwent lateral closing wedge HTO. Ayman *et al.* [17] Reported 12 patients with ACL deficiency and genu varus treated by anatomical single bundle ACL reconstruction and open medial wedge high tibial osteotomy. He concluded that IKDC score has significantly improved from 37 (pre-operation) to 78 (post-operation) ( $p < 0.05$ ). Bonasia [6]. Suggested single stage combined medial open wedge HTO and ACL reconstruction has obvious advantage together with faster recovery compared to staged procedure and produces good results in active patients with symptomatic ACL deficiency, medial OA, and varus malalignment. Cheng *et al* [21]. Reported 24 patients with 5.2 years follow up and opined simultaneous open-wedge HTO and ACL reconstruction in patients with ACL injury with medial compartmental OA showed satisfactory functional outcomes and postoperative activity level scores.

### Conclusion

Simultaneous medial open wedge high tibial osteotomy and anterior cruciate ligament reconstruction is a viable option for ACL deficiency and varus knees in young active individuals where joint preservation is of primary concern. This operative technique improves the knee stability and coronal plane alignment without much alteration of posterior tibial slope. Although the procedure requires long learning curve, it

decreases load on medial compartment, preserving articular cartilage and reduces adduction moment thus decreasing tension on the graft both of which are important for future of these knees.

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