Prospective study of the anterior cruciate ligament reconstruction associated with high tibial opening wedge osteotomy in knee arthritis associated with instability

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ABSTRACT

Introduction: Chronic ACL insufficiency with associated varus malalignment due to knee osteoarthritis (OA) is challenging to treat surgically. A combined ACL reconstruction (ACLR) with medial open wedge high tibial osteotomy (HTO) without using any metallic implant for HTO is an effective technique.

Materials and method: All the patients attending the outpatient department ACL injury and with associated medial compartment OA (Kellegren's grade 2 and grade 3) were considered for inclusion in the study. Forty patients who met inclusion criteria were included in the study. Simultaneous ACLR (single bundle of quadrupled hamstring graft fixed with Endobutton on femoral side and biointerference screw on the tibial side) along with medial opening wedge osteotomy (with tricalcium phosphate wedge) was done. The patients were assessed with IKDC, KOOS scores and any change in anterior tibial translation was also checked.

Results: The combined procedure showed mean varus angle correction of 9° (10.5–1.5°), and the mechanical axis of the knee was restored from an average of 172–181.5°. There was a significant improvement in knee score (KOOS and IKDC) after the surgery ($p < 0.05$). The average time for the radiological union of the osteotomy was 3.56 months. The anterior tibial translation was improved. No intraoperative complications and slippage of the synthetic graft were noted in any case.

Conclusions: Combined ACLR with HTO (using TCP wedge, without any hardware) is a reliable method that prevents rapid progression of OA. It reliably corrects varus deformity and obviates the use of any hardware.

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1. Introduction

The chronic anterior cruciate ligament (ACL) deficient knee has high chances of progression to osteoarthritis (OA), mainly of the medial compartment and later progressing to be global osteoarthritis.^{1–9} Hence, it is not uncommon to find medial compartment OA in combination with chronic ACL ruptures. The reconstruction of ACL can help stall the progression of OA, but the medial compartment OA with varus deformity needs realignment osteotomy.

The results of combined ACL reconstruction (ACLR) with a medial open wedge high tibial osteotomy (HTO) have been described in the literature to provide satisfactory long-term

results.^{10–12} We describe our experience of doing simultaneous arthroscopic ACLR with medial open wedge HTO. An arthroscopic ACLR using a single bundle (quadrupled) of hamstring tendon graft with simultaneous medial open wedge HTO (using a tricalcium phosphate wedge), without any plate fixation, was used.

The present study hypothesized that the simultaneously performed arthroscopic ACLR with medial open wedge HTO (using TCP wedges, with no internal fixation) can provide a satisfactory outcome. It is also hypothesized that it could provide adequate pain relief and restoration of knee stability and alignment.

2. Materials and methods

All the patients in the age group of 30–55 years presenting to the outpatient department with a history suggestive of instability and knee pain were assessed clinically. A detailed examination of the knee was performed, and the knee was also examined for the presence of any medial joint line tenderness. Varus and valgus stress tests were performed and documented. The pre-operative

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Fig. 1. Pre-operative standing radiograph with grade II osteoarthritis and varus deformity on the left knee.

range of motion (ROM), IKDC score, and KOOS scores were documented.

The patients who had pain and instability underwent weight bearing antero-posterior radiograph and magnetic resonance imaging (MRI) of the knee to look for the cause of instability and knee pain (Fig. 1). The patients with radiologic and clinical evidence of OA (Kellgren Lawrence grade II/III) and MRI proven ACL tear were considered for inclusion in this study. The amount of varus deformity was calculated on the preoperative weight-bearing radiograph. The exclusion criteria included a history of previous ACL or any other ligament reconstruction, Grade IV OA, the presence of peri-articular implant, severe varus deformity ($>20^\circ$), and lateral joint line opening.

Forty-six patients met the inclusion criteria and underwent the surgery between 2009 and 2014. Of these, six patients were lost to follow-up. Forty patients were available for final follow-up. The patients were re-assessed for a union at osteotomy site, post-op ROM, KOOS score, and IKDC score.

2.1. Surgery

The pre-operative planning included calculation of the distance of the site of osteotomy from the medial joint line and its relationship from the tibial tuberosity. After taking informed consent from the patient, the surgery was performed. All the surgeries were performed under spinal anesthesia, under tourniquet, and by the senior author.

An examination under anesthesia (EUA) was done to test the ligamentous laxity, and an arthroscopy was performed through standard anteromedial and anterolateral portal. After documentation of the lesions in the knee, the lesions were addressed. Any unstable cartilage lesions were debrided to stable margins. Small cartilage ($<1\text{ cm}^2$) lesions, in the weight-bearing region, were further treated with microfracture after stabilization the edges, if needed. Larger lesions were treated with debridement alone. We did a conservative resection of meniscus trying to retain as much meniscal tissue as possible. The intercondylar notch and any

remaining femoral stump of ACL were cleared, and the footprint and resident's ridge were identified.

The second phase of surgery included identifying the tibial tubercle and making a skin incision on the anteromedial aspect of the proximal tibia. We did ACLR first, followed by medial open wedge HTO. The key to performing a simultaneous ACL reconstruction and HTO is the correct positioning of the tibial tunnel for ACL graft. An 8 cm oblique incision in the proximal anteromedial tibia, starting three finger breadths below the joint line, was given. The Sartorius fascia was identified and cut, and the Gracilis and Semitendinosus tendons were harvested using an open-ended tendon stripper.

The transportal technique was used for making femoral tunnel at the postero-lateral part of the femoral condyle to remain close to the isometric point of insertion of ACL. The tibial tunnel was made 1–1.5 cm proximal to the pes anserine tendon insertion. The guide is fixed at $40\text{--}45^\circ$ angle (acuter than the usual $50\text{--}55^\circ$). Hence, adequate bone is left distal to the starting point of the tibial tunnel (approximately 1 cm bone) for the starting point of the osteotomy. The rest of the ACLR is performed in the usual trans-portal manner. An Endobutton fixation was used to fix the graft in the femoral tunnel, and a biodegradable screw was used to fix the graft at the tibial tunnel.

After completing the ACLR, medial open wedge HTO was performed through the same exposure used for hamstring graft harvesting. The medial upper tibia adjoining the tibial tubercle was exposed and cleared off periosteum and soft tissue. A 4.5 mm drill bit was passed from the exposed medial tibial cortex directed obliquely distal to proximal toward the head of the fibula (under image intensifier guidance). The entry point is made distal to the tibial tunnel of ACLR and proximal to the tibial tubercle (leaving a safe gap of about 10 mm) (Fig. 2).

After confirming the orientation, an oscillating saw is passed just proximal and parallel to the drill bit. The saw is advanced till two-thirds of the diameter of the tibia, thus avoiding breaching the lateral tibial cortex. A completion of the osteotomy was achieved by osteoclasis by giving valgus stress. The opening on the medial

Fig. 2. Knee model depicting the placement of the tibial tunnel (black circle) and the placement of the osteotomy (oblique line) in the proximal tibia. A safe gap of approximately 1 cm is left between the entry of the tibial tunnel and osteotomy starting point.

side was maintained by a metallic spacer or a lamina spreader, after measuring the opening. The metallic trial spacer was substituted by the same sized tricalcium phosphate (TCP) wedge (Fig. 3) (OTISTM, SBM, France). Then, a final overall alignment of the knee, osteotomy, and the position of the wedge were checked under image intensifier (Fig. 4). This TCP wedge is maintained in position by the constant tendency of the osteotomized surfaces to go in varus, thus exerting a compressive effect at the osteotomy site. The osteotomy was found to be extremely stable in all the cases and hence did not require any additional internal fixation like metallic plates and screws.

2.2. Postoperative protocol

The patients were given a knee immobilizer immediately postoperatively. Stockings and DVT prophylaxis were given to all patients. The patient was advised to start static quadriceps exercises immediately after resolution of the spinal anesthesia. They were advised nonweight bearing mobilization, with the knee

Fig. 3. Osteotomy in proximal tibia held open by the lamina spreader and the TCP wedge (white) being inserted into the gap produced. The scar for previous open medial meniscectomy is visible on the medial side.

immobilizer in place for two weeks. The nonweight bearing status was extended to three weeks in case microfractures were performed as part of the procedure and then allowed graduated partial weight bearing. Closed chain ROM exercises were started at the end of two weeks. Full weight bearing was allowed at the end of six weeks. Sequential radiographs were taken immediate post-op, at three weeks follow-up and then at monthly interval till union at the osteotomy site had been achieved (Fig. 5). Patients were regularly followed at six months interval thereafter.

3. Results

This prospective study comprised of 46 patients who underwent simultaneous ACLR and HTO, in a single sitting and was followed for a minimum of 2 years. Six patients (13.04%) were lost to follow-up. Hence, only 40 patients (27 males and 13 females) were included and evaluated in this study. The mean age of our patients was 37.3 years (range 30–55 years). Two patients had undergone previous arthroscopic meniscectomy, and one patient had undergone open meniscectomy. An average time of presentation for surgery (from injury) was 7.2 months (range 1–12 months). The interval from the operation to last follow-up was an average of 14.4 months (range 11–17 months). The most common cause of the knee injury was sports (85%), followed by domestic

Fig. 4. Final C-arm image to check the level of the osteotomy and the positioning of the TCP wedge.

injuries (15%). The right knee was involved in 74% of the patients. Preoperatively, the mean range of motion was 5–135°. According to the Kellegren's grading system, 82.5% (33 patients) were grade 2 and 17.5% were grade 3. The average varus angle was 10.5° preoperatively, which was found to be 1.5° postoperatively. The mean mechanical axis of the knee, preoperatively, was 172° which was corrected to a mean of 181.5° postoperatively (Figs. 6 and 7).

Swelling and stiffness at final review was found absent in 37 patients (92.5%) and mildly in 3 patients (7.5%).

In respect to the subjective KOOS scoring system 2012, there was an improvement in patient symptoms including stiffness in 93% patients, pain-free range of movements in 95% patients, normal activity of living in 94%. Patients could participate in preoperative sports in 87.5% and had a better quality of life in 91% whereas 92.5% returned to the same occupation preoperatively (Table 1).

The mean IKDC subjective score, including knee function, symptoms, and activity levels, was 87.5 (range 60–100) at final follow-up. The IKDC clinical score at final review showed significant improvement with no or minimal difficulty during physical activity signifying almost near normal outcome (Table 2). The anterior tibial translation was classified as grade 1 (0–5 mm), grade 2 (5–10 mm), or grade 3 (>10 mm). The tibial translation was also improved at the final review. The number of patients who had grade 3 laxity at presentation decreased from 60% to 10% and the number of patients with grade 1 increased to 52.5% from 10% (Table 3).

3.1. Complications

There were no intraoperative complications. We also did not encounter any infection, hematoma, thromboembolism, intra-articular fractures in the operated patients in this study. None of our cases had a recurrence of instability and slippage of TCP wedge. Only one patient (2.5%) had loss of 20 degrees of flexion. The average time for the radiological union of the osteotomy was 3.56 months (range 3–6 months), and two patients (5%) showed delayed union. No neurovascular complications were seen.

4. Discussion

Chronic ACL insufficiency of the knee may be a major contributing factor for an early onset and rapid progression of knee OA.^{7,8,13} The clinical manifestations of chronic ACL insufficiency may include pain, swelling, and instability.¹⁴ In cases of chronic ACL tears with associated OA, an isolated ACLR may lead to

Fig. 5. Postoperative AP weight bearing and lateral radiographs depicting the TCP wedge and the endobutton on the lateral femoral cortex.

Fig. 6. Preoperative long leg radiograph depicting varus deformity in the lower limbs.

Fig. 7. Postoperative long leg radiograph depicting the healed site of osteotomy (arrow) and the post operative correction achieved.

Table 1

KOOS score preoperatively and postoperatively 3 months follow-up and last follow-up.

S. No.	KOOS parameters	Pre OP KOOS score	3 months follow-up score	Last follow-up score
1	Pain	34	76	95
2	Symptoms including stiffness	29	60	93
3	ADL	31	55	94
4	Sports/recreation	24	53	87
5	QOL	27	67	91

Table 2

Table depicting ability of the knee to perform activities according to the IKDC score.

S. No.	Parameters	No difficulty at all	Minimally difficult	Moderately difficult	Extremely difficult	Unable to do
A	Go upstairs	31 (77.5%)	9 (22.5%)	0	0	0
B	Go down stairs	33 (82.5%)	7 (17.5%)	0	0	0
C	Kneeling on front of knee	29 (76.5%)	11 (27.5%)	0	0	0
D	Squat	26 (65%)	14 (35%)	0	0	0
E	Sit with knee bent	34 (85%)	6 (15%)	0	0	0
F	Rise from a chair	31 (77.5%)	9 (22.5%)	0	0	0
G	Run straight ahead	27 (67.5%)	12 (30%)	1 (2.5%)	0	0
H	Jump and land on involved knee	25 (62.5%)	10 (20%)	5 (12.5%)	0	0
I	Stop and start quickly	26 (65%)	9 (22.5%)	5 (12.5%)	0	0

further progression of OA.¹⁵ With this background information, it has been agreed that ACLR in an OA knee with varus malalignment should be combined with HTO. The timing of the two surgeries, though, has been a matter of debate. Some suggest simultaneous surgeries whereas others suggest a staggered, timed approach to reducing morbidity.^{11,16,17} In this study, a single stage medial open wedge HTO and ACLR was performed, and a satisfactory result was achieved.

Most of the studies, where a combined HTO and ACLR was done in the same sitting, have used different modes of internal fixation of HTO, ranging from plates to staples.¹⁸ No metallic implant was used to fix the osteotomy in this series. In the present study, TCP wedges alone for the fixation of the HTO were used and hence circumvented all the implant-related potential complications. Moreover, bio-degradable screws were used for fixation of hamstring graft at the tibial tunnel, which would not need any implant removal.

The composition of the TCP wedge is very similar to the inorganic bone phase. The wedge comes in different sizes of pores. The surface of the wedge attracts osteoblasts that in turn manufacture extracellular matrix. The resorbable synthetic bone substitute of tricalcium phosphate (OTIS 50[®], SBM, France) alone is strong enough to maintain the osteotomy, until bone healing, without any loss of correction.¹⁹ The TCP wedge is held in position by the constant tendency of the osteotomy to collapse into varus and hence the graft is held in compression. Moreover, the quadriceps mechanism exerts an additional compressive effect at the osteotomy site.

This study revealed no loss of correction achieved after the HTO in any of the cases and excellent TCP wedge incorporation in all of the cases. There was no loss of fixation of the implant in the tibial tunnel, and all patients had significant improvement in the instability on follow-up reviews.

Table 3

Table depicting improvement in anterior tibial translation after combined ACL and HTO.

Anterior tibial translation	Preoperatively (no of patients)	At review (no of patients)
Grade 1	4 (10%)	21 (52.5%)
Grade 2	12 (30%)	15 (37.5%)
Grade 3	24 (60%)	4 (10%)

Medial open wedge HTO was preferred to lateral closed wedge osteotomy to correct the malalignment caused by secondary knee OA. A medial open wedge HTO has several distinct advantages, as in this procedure the bone stock is maintained, and the deformity is corrected close to its origin. Moreover, a fibular osteotomy is not required, and it is a technically easier procedure to do. If, in future, an arthroplasty is needed then the incision of this surgery can be used for TKA. Since no metallic implant is used for the fixation of osteotomy in this technique, the TKA surgery become simpler, almost akin to a primary TKA.^{3,8,11,20}

There are various possible disadvantages associated with the use of internal fixation in this combined surgery. There may be an interference of the internal fixation device with the tibial tunnel. Moreover, with the use of internal fixation device, there is a possibility of infection due to hardware. These patients are potential candidates for future joint replacement, and the presence of an internal fixation device necessitates the removal of the implant. Many surgeons are wary of performing a joint replacement in the presence of a previous implant due to the risk of low-grade infection hidden underneath the previous implant. Also, utilization of the same incision for the preparation of tibial tunnel and HTO potentially reduces blood loss and soft tissue scarring.

The functional outcomes after a combined ACLR and HTO in chronic ACL insufficiency with associated knee OA have been reported to be good, similar to our series. In the present series, the KOOS score for all the patients reported significant improvement (p -value < 0.05) and all the patients had relief of preoperative pain and instability, as assessed using IKDC scores postoperatively. There was an improvement in the anterior tibial translation in all the patients. Reduced anterior tibial translation can further have a bearing on the progression of patellofemoral arthritis. Although 10% patients had grade 3 laxity on clinical examination at the final follow-up, they did not have any subjective symptoms related to it. It is apparent from the average IKDC scores postoperatively. Mostly, ACL reconstruction provides good outcomes; however, some cases show residual laxity at clinical follow-ups. This may be of concern, especially if the patients report symptomatic instability (ref). But in asymptomatic patients, usually, no intervention is needed. The causes of residual laxity after ACL reconstruction could be related to surgery but also may be related to the degree of preoperative laxity and other associated lesions of the knee like OA.²¹

O'Neill described simultaneous HTO and ACLR and reported good results of this combined procedure.²² Williams et al. reported superior results of combined ACL and HTO as compared to HTO alone and reported lower morbidity of the combined procedure.²³ Bonin et al. at a follow-up of 12 years of combined ACL and HTO reported a return to intensive sports in 47% of the patients.¹ Although the studies in the literature seem to agree on the utility of the combined ACL and HTO, all have used some form of a fixation device for the osteotomy.

There are certain limitations of the present study. The cohort of our patients was not large. We were not able to have a second look arthroscopy (due to logistic and ethical reasons) which would have ideally allowed us to re-assess the previous cartilage changes. The study also had a follow-up of two years, and a longer follow-up may further substantiate the advantages of this combined procedure without fixation of the HTO. Also, the angle of tibial tunnel is made at a more acute angle (approximately 40–45°), and this may decrease the length of the tibial tunnel.

Combined ACL reconstruction and medial open wedge osteotomy with the use of TCP wedges and without the use of any implant has the potential to give satisfactory results. It has the potential to postpone the need for arthroplasty in a comparatively young patient. Also, avoiding the use of a metallic implant obviates the need for future implant removal and makes a future arthroplasty easier. The technique needs some modification from the standard procedure. The tibial tunnel is made at an acuter angle as compared to normal ACL reconstruction and the site of osteotomy on the proximal tibia is made such that a bone stock of 1 cm is present distal to the tibial tunnel.

Conflicts of interest

The authors have none to declare.

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