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Original Article

Arthroscopic anatomic double bundle anterior cruciate ligament reconstruction: Our experience with follow-up of 4 years

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ABSTRACT

Background: Double bundle (DB) anterior cruciate ligament (ACL) reconstruction has been proposed to recreate the natural anatomy of ACL. Reconstruction of the anatomy of both the bundles of ACL has been thought to be able to restore the rotational stability of the knee joint. Nevertheless, it remains unclear whether DB reconstruction has better functional outcome than single bundle (SB) ACL reconstruction.

Purpose: To evaluate the clinical outcomes, patient satisfaction and manual laxity tests of knee in patients treated with DB ACL reconstruction in Indian population.

Methods: We prospectively followed 25 patients with an isolated ACL injury operated for DB ACL reconstruction after applying the inclusion and exclusion criteria. Patients were evaluated pre-operatively and in the post-operative period at regular intervals with the minimum follow up of 4 years. Clinical stability was assessed by anterior drawer test, Lachman test and pivot shift test. Functional outcome was assessed by IKDC, Lysholm and Modified Cincinnati scores.

Results: At the end of 4 years, functional outcome in terms of all subjective scores was satisfactory. Graded stability results of the Lachman, Anterior drawer and pivot shift tests were almost near to that in normal knee. No complication occurred post-operatively.

Conclusion: Anatomical DB ACL reconstruction seems to offer satisfactory results in terms of subjective scores and stability tests to patients with ACL tear. It has been found to be associated with no obvious complications and no failures. However a larger patient pool is desired for conclusive results.

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1. Introduction

Anterior cruciate ligament (ACL) tear is one of the frequent disabling injuries seen commonly in athletes, physically active men and women, while sports injury activities and road traffic accidents are being the leading causes of this injury. Single bundle ACL reconstruction has been a standard option to treat symptomatic ACL-deficient knees; however, it does not completely reproduce the anatomy and function of native ACL.¹

It is crucial to re-establish the double bundle (DB) anatomy of the ACL in order to obtain better restoration of normal biomechanics of knee and to improve the rotational stability.¹ Biomechanical studies have also found that DB reconstruction significantly reduced rotational instability when compared to single bundle (SB) ACL reconstruction.²⁻⁴ Several prospective clinical trials have reported significantly better outcomes in anatomic DB procedures than the SB procedures in terms of pivot shift test and anterior laxity.⁵⁻⁸ Several workers have suggested that DB ACL reconstruction should help preserve menisci and limit progression towards arthritis.⁹⁻¹⁴ Moreover, clinical studies have also reported significantly better IKDC score, subjective Lysholm score, Tegner score and visual analogue scale in DB ACL reconstruction than in SB ACL reconstruction.^{3,5}

However, several authors have reported the comparison of functional outcomes of both these procedures without any definitive conclusion.^{1,6,7} Moreover, several meta-analysis studies have been published reporting no significant differences in outcome between both the techniques.^{15,16} To our knowledge, there are few reports concerning DB ACL reconstruction in Indian population.¹⁷

The purpose of this study was to evaluate the clinical outcomes, patient satisfaction and manual laxity tests of knee and of course any complications in patients treated with DB ACL reconstruction in Indian population.

2. Methods

The entire treatment protocol was approved by the Institute Ethics Committee and was conducted according to the principles established in Helsinki. Consent for the publication of clinical details was obtained, together with radiographs and photographs were taken from all patients.

We operated 38 patients of ACL tear with DB ACL reconstruction from July 2009 to December 2010, which were performed by the senior surgeon (HLN). Patients with age less than 40 years with unilateral isolated ACL injuries and with no arthritis, deformity or previous surgeries were included in this study. In 8 patients, meniscectomy was done, and in another 5 patients meniscal repair was performed. So, these 13 patients were excluded from the study. Rest 25 patients were then followed up for a minimum follow-up period of 4 years.

2.1. Surgical technique

Examination under anaesthesia was done, and tourniquet was used in all cases. A standard arthroscopic examination was

done via anteromedial and anterolateral portals. Anatomic insertion sites of the anteromedial and posterolateral (PL) bundles on the tibia and femur were marked. The tibial footprints were left intact.

The semitendinosus and gracilis tendon were harvested through a 2-3 cm anteromedial incision. Once the graft was cleaned and devoid of excess tissues, measurement of the tendon was done. A whipstitch was placed in the free end of the graft.

The prepared grafts were hooked and looped to Endo-Button close loops (Smith & Nephew, Andover, USA), which were used in femoral side fixation. The tendons were pretensioned with 10-pound tension using a commercially available graft board until they are implanted. Bioabsorbable interference screws (Arthrex, Naples, Florida) were used for tibial side fixation. Staples were used for tibial side fixation in every case.

A special tibial aimer (Smith & Nephew, Andover, USA) was used to make two tunnels on tibia. Keeping knee flexed at 90°, the guide wire was passed at 55°-60° through the centre of AM bundle footprint on tibia. Using the same aimer and putting the long bullet of same diameter as that of the AM tunnel into the AM tunnel, guide pin was passed through the centre of the PL footprint on tibia. Then PL tunnel was made using drill of required diameter.

Guide wires for femoral drill holes were passed through the anteromedial portals. With the knee flexed at 100°-110°, an endofemoral aimer was inserted through anteromedial portal and a 2.4 mm guide wire was passed through it. A 4.5 mm cannulated endodrill was used to ream over the guide wire, until it exited the lateral femoral cortex (Fig. 1). Using a cannulated drill matching the desired graft diameter, femoral tunnel was drilled up to 20-30 mm of depth.

Using the PL femoral aimer for PL bundle, a PL tunnel was made in a similar manner through accessory anteromedial tunnel. It was ensured that at least 2-3 mm bony bridge was kept intact between AM and PL tunnels.

A beath pin with a long loop suture attached to the eyelet was passed through the anteromedial portal and into

Fig. 1 – Reaming for anteromedial femoral tunnel.

Fig. 2 – Hamstring graft in the two femoral tunnels.

the PL femoral tunnel and was pulled out at lateral aspect of thigh. The looped suture was visualised within the joint and retrieved with an arthroscopic suture grasper through the PL tibial tunnel. The PL graft was then passed through tibia into the femur, and the Endobutton was flipped to establish femoral fixation of the PL graft. The AM graft was then passed through the tibia into the femur in similar way (Fig. 2). Preconditioning of the grafts is performed by flexing and extending the knee through a range of motion from 0° to 120° approximately 20–30 times. The PL bundle was tensioned and fixed at near full extension, and the AM bundle graft was tensioned and fixed at 50°–60° of flexion. On tibial side, a bioabsorbable interference screw (Arthrex, Naples, FL) was used for fixation. Knee was tested for stability and full ROM. A mini suction drain was put intra-articularly.

2.2. Post-operative rehabilitation

From the first post-operative day, static quadriceps exercises were encouraged and patients were allowed full weight bearing with the knee brace locked in extension and with crutches as tolerated. Patients were discharged on 3rd–4th post-operative day unless requiring longer stay due to specific reasons. In the first 2 weeks, flexion up to 45° was allowed. In later 2 weeks flexion up to 90° was permitted. The same-sided crutch was discontinued at 2nd month, which was followed 2 weeks after by discontinuation of opposite sided crutch. Brace was discontinued 2 weeks thereafter. Non-contact sports such as swimming, biking and jogging in a straight line were allowed at 4–5 months post-operatively. Return to full activity level, running and sports were allowed at 6 months.

2.3. Evaluation methods

All patients were evaluated pre- and post-operatively to assess the functional outcomes. A 100% follow-up was ensured by maintaining a register and making regular phone calls to the patients. Post-operative evaluation was done by HLN and VM

at 3rd, 6th, 12th, 18th, 24th, 36th and 48th months following surgery. For the study purpose, the final follow up at 4th year was considered for evaluation. For the clinical evaluation, the Lachman test estimated manually and was graded as 0 (<3 mm), 1 (3–5 mm), 2 (6–10 mm), and 3 (>10 mm). The pivot shift phenomenon was graded as 0 (equal), 1 (glide), 2 (clunk), and 3 (gross). The Lachman test, pivot shift test, International Knee Documentation Committee (IKDC) score³⁶, Lysholm score^{16,37} and Modified Cincinnati Score³⁸ were evaluated before surgery and at 12, 24, 36 and 48 months post-operatively.

3. Results

There were a total of 23 males and 2 females [mean age (range) 28.3 ± 6.08 years]. The mean follow-up period following operation was 52 months (range, 48–56 months). Average time between the event leading to tear and ligament reconstruction was 9.8 months (range, 1–26 months). Difference of more than 1 cm between the thigh girths on the two sides was seen in 3 patients.

4. Functional outcome

4.1. Lysholm score and Modified Cincinnati score

The mean pre-operative Lysholm score and mean pre-operative Modified Cincinnati score were 61.7 ± 14.74 and 51.9 ± 9.86, respectively. There was a progressive improvement in the scores, and at the end of 4 years, the mean Lysholm score and the mean Modified Cincinnati score were 95.4 ± 2.9 and 80.4 ± 3.87, respectively. A statistically significant improvement was found between the pre-operative and post-operative scores ($p < 0.05$) at the end of 4 years.

4.2. The 2000 IKDC Subjective Knee Evaluation Score

The mean pre-operative IKDC score was 47.25 ± 7.71. At the end of 4 years, the mean scores were 84.4 ± 3.28. There was a significant improvement in the post-operative status of the patients ($p < 0.05$).

4.3. Symptoms

Two (8%) patients reported pain during moderate or strenuous activities. Two (8%) patients had swelling following moderate or strenuous activity. No patient reported symptoms of giving away during moderate or strenuous activities.

4.4. Range of motion

Range of motion of knee joint was normal in 24 (96%) patients at the end of 4 years.

4.5. Patellofemoral crepitus

Patellofemoral crepitus with mild pain and with moderate pain was present in 1 patient.

4.6. Radiographic assessment

Twenty-four patients showed no radiographic deterioration at the end of 4 years. One patient showed grade I osteoarthritic changes according to Ahlback classification. All the changes were confined to the medial compartment.

4.7. Laxity Tests

On performing Lachman test pre-operatively, 16 patients had Grade 2, and 9 patients had Grade 3 laxity. There was improvement in the laxity of knees, and at the end of 4 years, 20 patients had Grade 0 and 5 patients had Grade 1 laxity. On performing Pivot shift tests, it was found that, pre-operatively 13 patients had Grade 1, 10 patients had Grade 2, and 2 patients had Grade 3 laxity. Post-operatively at the end of 4 years, 23 patients had Grade 0, and 2 patients had Grade 1 laxity.

5. Complications

Graft ruptures were not encountered in any of the subgroups. No post-operative infective arthritis or wound infection was noted requiring intervention.

6. Discussion

In past couple of decades, there has been great debate over the management of ACL tears in terms of technique of arthroscopic reconstruction. Good clinical outcomes have been achieved by SB ACL reconstruction because of better understanding of anatomy, improvement of surgical techniques and advances in fixation devices. But still rotational instability and development of osteoarthritis have been documented in 10–30% of the patients with SB ACL reconstruction.¹⁸ Due to this, increasing number of surgeons are now preferring DB ACL reconstructions. Deficiency of PL bundle in the SB reconstruction has been assumed to give rise to the rotational instability post-operatively.^{19–21} To take care of the rotational component, DB ACL reconstruction has been proposed and asserted to be more effective than SB reconstruction for restoring normal anatomy and knee kinematics^{22,23} However, DB reconstruction of four tunnels is technically more demanding than SB.

In United States, Denmark, and Sweden prospective ACL reconstruction cohorts are ongoing at present. In 2002, The Multicenter Orthopaedic Outcomes Network (MOON) has been established in the United States.²⁴ Similarly, the Norwegian National Knee Ligament Registry (NKLK) was established in 2004 in Norway.^{25–27} Data were compiled from 2 years of MOON and from three and half years of NKLK data on all primary ACL reconstructions. Demographic data in the Indian population regarding the ACL injuries are still not well established.

The median age at reconstruction in the MOON cohort was 23 years while that in the NKLK population was 27 years. In our study, median age of reconstruction is 28 years. There were 52% and 57% male patients in MOON cohort and the NKLK population, respectively. Our study group composed of 23 (92%) males and 2 (8%) females, which can be explained by less

involvement of the females in the contact sports and biking in the Indian subcontinent.

In the MOON cohort, 88% ACL tears were subsequent to the sports injuries. While in the NKLK, ACL injuries were associated with sports in 87% of patients. In our study, 50% patients sustained injury during sports, while road traffic accidents constituted 46% of the mechanisms of injury. Rest of the patients could recollect a history of fall from stairs or on level ground inciting their symptoms.

The average time from injury to reconstruction was 9.8 months (1–26 months). The median time from injury to reconstruction in the NKLK population was 7.9 months (4.2–17.8 months) ($p < 0.001$). In our study, delay in the ligament reconstruction could be attributed to the delay in seeking the surgeon's advice and inaccessibility to the highly specialised treatment, which can be given only at tertiary care centre.

Most of the previous studies had very short period of follow-up. In our study, mean follow-up period was 52 months (range, 48–56 months). In our study at the end of 4 years Lysholm score, Modified Cincinnati score and 2000 IKDC Subjective Knee Evaluation score were 95.4 ± 2.9 , 80.4 ± 3.87 and 84.4 ± 3.28 , respectively. In the study by Rainer Siebold²⁸ et al., at the end of 19 months these scores were 90, 91 and 88 for the DB ACL reconstruction.²⁸ Nine studies with a total of 335 patients which included Lysholm score were available for comparison.^{6,18,28–34} Similarly subjective IKDC score was reported in seven studies with 256 patients. IKDC score in our study was found to be comparable to that in other studies.^{5,23,28–31,34} According to the table, all functional scores in our study fall in the range as that of the previous studies (Table 1).

Range of motion of knee joint was normal in 24 (96%) patients at the end of 4 years. In the study by Seibold et al. in 2008, 1 patient had knee extension deficit, and 2 patients had knee flexion deficit.²⁸ This suggests that there is usually good post-operative range of motion of the knee joint, but occasionally, there may be deficit in terminal range of motion both in flexion and extension.

None of our patients complained of laxity at the end of 4 years. Pivot shift test was evaluated in 12 studies with a total 488 patients.^{6,22,24,28–30} Test was negative in 428 out of 488 (87.70%) patients examined at the follow-up. In our study the pivot shift test was negative post-operatively in 100% of the patients. Kondo et al. in a prospective comparative study of 328 patients reported better results of DB as compared to SB in terms of pivot shift test.³⁵ Meta-analysis by Zhu et al. also established that DB reconstruction has lower risk of positive pivot shift testing than SB reconstruction.³⁶ However, Meredick et al. concluded that pivot shift results of the DB ACL reconstruction does not support its theoretical advantage over SB ACL reconstruction. In our study, rupture of the graft was not noticed in any case.¹⁶

From our experience with the DB ACL reconstruction technique, we can conclude that DB ACL reconstruction has good post-operative results in terms of restoring stability, functional outcome and incidence of graft rupture. None of the studies have reported DB ACL reconstruction inferior to SB ACL reconstruction. However it should be acknowledged that DB ACL reconstruction requires higher technical expertise and longer learning curve. We would like to recommend DB ACL

Table 1 – Summary of studies on DB ACL reconstruction.

Study	Lysholm score	Objective IKDC score	Subjective IKDC score	Negative pivot shift test	Graft failures	Year published	Patients	Follow-up	Graft material of DB	Weight bearing time after surgery
Lee ²⁹	87.4	9	79.6	13/19		2012	21	24	Autologus STG	As tolerated
Araki ²²	94.3			9/10		2011	10	24	Autologus STG	Not mentioned
Hussein ³⁰	93	122	92.1	122/131		2011	131	51	Autologus STG	As tolerated
Zaffagnini ²³			88	36/40		2011	40	103	Autologus STG	First 2 weeks
Suomalainen ³⁷		25	83	41/61	1	2011	67	24	Autologus STG	Immediately after surgery
Aglietti ⁵		28			1	2010	35	24	Autologus STG	Not mentioned
Ibrahim ³⁸		32		48/50		2009	50	29	Autologus STG	Immediately after surgery
Wang ³¹	86.5		81.86			2009	32	16	Autologus STG	Second day after surgery
Järvelä ³²	92	13		18/22	1	2008	25	24	Autologus STG	Immediately after surgery
Siebold ²⁸	90	26	88	34/35		2008	35	19	Autologus STG	First week
Streich ³⁴	91.8		89.5	23/24		2008	24	24	Autologus ST	1 month after surgery
Järvelä ³³	91	17		26/32	1	2008	35	27	Autologus STG	Immediately after surgery
Muneta ³⁹		20		29/34		2007	34	25	Autologus STG	3 days after surgery
Järvelä ⁶	89	11		29/35	0	2007	35	14	Autologus STG	Immediately after surgery
Our study	95.4 ± 2.9		84.4 ± 3.28		0		25	52	Autologus STG	Second day after surgery

reconstruction in patients engaged in high demand activities and sports.

Conflict of interest

The authors declare that they have no conflict of interest

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