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Evaluation Of The Functional Outcome Of Arthroscopic Reconstruction Of Grade III Isolated Posterior Cruciate Ligament Tear By Quadruple Hamstring Tendon Autograft

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Abstract
Background: *The Posterior Cruciate ligament (PCL) is an important dynamic stabilizer of the knee and the number of PCL injuries are increasing now a days due to motorcycle accidents. Surgical reconstruction of PCL is the treatment of choice in patients with symptomatic grade III isolated PCL tear.*
Objective: *The aim of this study is to evaluate the functional outcome of arthroscopic reconstruction of grade III isolated posterior cruciate ligament tear by quadruple hamstring tendon autograft.*
Methodology: *This prospective observational study was conducted in the department of Orthopaedic Surgery, BSMMU, Dhaka from July, 2019 to September, 2021. Within this period total 16 patients after considering the inclusion and exclusion criteria, underwent arthroscopic reconstruction of isolated grade III PCL tear with quadruple hamstring tendon autograft. Tegner activity level, Lysholm score, IKDC score & Posterior drawer test were used to assess the functional outcome and ligamentous stability of the knee.*
Results: *The mean preoperative Lysholm score for 16 knees was 60±6.18 (Range, 50 to 74) and the mean postoperative Lysholm score was 88.56±4.31 (range, 79 to 97). Fifteen of 16 patients (93.7%) showed good or excellent results in the final assessment. The mean preoperative Tegner score for 16 knees was 2.94±0.93 (range, 2 to 5), whereas the mean postoperative Tegner score was 5.75±1.61 (range, 3 to 9). There were statistically significant improvements in Lysholm score (P <0 .001), Tegner score (P <0 .001), final IKDC rating (P<0.001) and thigh atrophy and muscle strength (P <0 .001), when compared with preoperative data.*
Conclusion: *After follow-up for 09 months, the analytical results showed patients achieved satisfactory knee function after PCL reconstruction by using a quadruple hamstring autograft. This study suggests that a quadruple hamstring autograft is sufficiently large & strong and can achieve good ligamentous function after reconstruction.*

Keywords: *Isolated Grade III PCL tear, Quadruple hamstring tendon autograft, Arthroscopic reconstruction, Motor cycle accident.*

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I. Introduction

The posterior cruciate ligament (PCL) is an intra-articular, extrasynovial structure which acts as the primary stabilizer to posterior tibial translation. In addition, it is a secondary stabilizer to external rotation, predominantly between 90° and 120° of knee flexion [1]. In general, the incidence of PCL injury is lower than that of anterior cruciate ligament (ACL) injury, because PCL injury occurs only when the knee is bent at the time the trauma [2]. Isolated PCL injuries are less common (3%) than those with concomitant posterolateral corner (PLC) or other ligamentous injuries (97%). Complete tears occur in approximately 40% of cases; partial tears in approximately 55% and avulsion tears in 7% [3]. Annual incidence of Isolated PCL tear is 2 per 100000 persons and these group of patients are at higher risk of developing osteoarthritis [4]. The sport-specific incidence of PCL injuries ranges from 1% to 4%. Deficiency of the PCL results in abnormal tibiofemoral knee kinematics during functional activities as well as degenerative changes primarily in the medial and patellofemoral compartments. Patients with an isolated grade III PCL injury may report vague knee pain, stiffness, swelling or discomfort with activities requiring higher levels of knee flexion, such as squatting, kneeling or walking on stairs & running [5]. Posterior force on the proximal tibia is the main mechanism of injury to PCL. In motor vehicle accidents this is commonly known as the dashboard injury. A PCL injury from sports activity can occur when an athlete falls to the ground with the knee flexed and the foot plantarflexed,

causing the proximal tibia to strike the ground first. Hyperflexion of the knee produces commonly isolated injuries in the athletes and it frequently results in proximal avulsion of the PCL from the femur with adjacent periosteum. Other mechanism of injury includes hyperextension of the knee and forceful valgus or varus stress combined with leg rotation [6]. Thorough history & specific physical examinations, such as the posterior sag sign, quadriceps active test and posterior drawer test have been found to have high accuracy, sensitivity and specificity in the diagnosis of PCL tears, with better results for grade II and III injuries than for grade I injuries [5]. Plain radiographs are advocated when one is examining the presence of avulsion fracture fragments, segond fractures, fibular head avulsions and lateral joint space widening. MRI have proven to be very accurate for diagnosing acute PCL tears, with reported sensitivity values of 100% and specificity values of 97% to 100% [7]. Treatment of a PCL injury is perhaps the most controversial current topic in knee surgery, primarily because the natural history of this injury is unknown. Most reports in the literature have relatively short follow-up and include a mix of acute and chronic injuries, as well as isolated and complex ligament injuries. Treatment of a posterior cruciate ligament injury must be based on an understanding of the natural history of this injury, as well as on an accurate understanding of the long-term results of various treatment alternatives [8]. Conservative treatment is enough for most of the Grade I and Grade II PCL Injuries, because PCL has an intrinsic capability for healing [9]. A substantial number of patients have been reported to experience declining knee function and early osteoarthritis following the nonoperative treatment of isolated Grade III PCL injuries [10]. The desire to restore knee function has driven growing interest in surgical reconstruction of the injured PCL. With improved arthroscopic instruments and techniques, a greater number of Grade III isolated Posterior Cruciate Ligament Reconstruction (PCLR) are being performed [11]. PCLR has been shown to produce more satisfactory and consistent stability when compared to the non-operative group in a systematic review [12]. Arthroscopic PCL reconstruction technique has been advocated to avert the potential morbidity of an open posterior incision, avoid the inconvenience of prone or lateral positioning and decrease the surgical time compared with that of an open procedure. Arthroscopic PCL reconstruction includes various techniques such as single bundle or double bundle, transtibial or tibial inlay technique [5]. Numerous tissues have been advocated to reconstruct the knee with PCL deficiency. Different type of autograft has been studied in PCL reconstruction, with hamstring autograft being one of the most common graft used. Hamstring autograft is easy to harvest and has less donor site morbidity compared to Bone-Patellar-Tendon-Bone (BPTB) autograft, quadriceps tendon autograft or peroneus longus tendon autograft. The hamstring tendon is a very useful tool in the reproduction of the PCL's biomechanical properties with the advantages of ready availability without the need of a tissue bank, no aggression to the extensor mechanism, low morbidity in the donor area and the graft's easy passage through the bone tunnels, in addition to complete filling of tunnels, favoring integration and stability [13]. Therefore, the aim of this interventional study is to evaluate the functional outcome of arthroscopic reconstruction of isolated grade III PCL tear by quadruple hamstring tendon autograft.

II. Materials & Methods

Types of Study: Prospective observational study.
Study Period: July, 2019 to September, 2021.
Place of Study: This study was carried out in the department of Orthopaedic Surgery at BSMMU, Shahbag, Dhaka and Labaid Specialized Hospital, Dhaka.
Study population: Patients attended at the department of Orthopaedic Surgery at BSMMU, Shahbag, Dhaka and Labaid Specialized Hospital, Dhaka with the complaints of PCL injury.
Sample: Isolated grade III PCL injured patient who need operative treatment.
Sampling technique: Purposive non-randomized sampling.
Sample size:
Sample size determination depends on time and resources. Estimated population was calculated by using the following statistical formula [14].

$$n = \frac{(Z\alpha + Z\beta)^2 \times (\sigma_1^{\,2} + \sigma_2^{\,2})}{(\mu_1 - \mu_2)^2}$$

If we include 10% plus, then sample size will be 16
So, finally sample size was 16.

Inclusion criteria:
1. Presence of an isolated Grade-III PCL tear.
2. Age between 20 to 45 years.
3. Both male & female.

Exclusion criteria:

1. Age < 20 years and >45 years.
2. Fracture at knee region (tibial plateau, patella, femoral condyles).
3. Associated ligamentous injury.
4. Associated meniscal and cartilage lesion.
5. Patients with osteoarthritis.

Methodology

Patients attended at the department of Orthopaedic Surgery at BSMMU and Labaid Specialized Hospital, Dhaka with the complaints of PCL injury was selected on the basis of the inclusion and exclusion criteria from July, 2019 to September, 2021. The patients were diagnosed clinically and radiologically. After taking informed consent & detailed history, physical examination of each patient was performed. A structured case record form was used to interview and collect data. All necessary investigations for surgery were performed before operation. Then arthroscopic reconstruction of isolated grade III PCL tear was done by quadruple hamstring tendon autograft. Functional outcome of isolated grade III PCL reconstruction was measured postoperatively by posterior drawer test, Lysholm score, Tegner activity level score & International Knee Documentation Committee (IKDC) score.

Statistical Analysis

All the data was compiled and sorted properly and the quantitative data was analyzed statistically by using Statistical Package for Social Science (SPSS-25). The results were expressed as percentage and mean ± SD and $p<0.05$ was considered as the level of significance. Comparison of continuous variables between the two groups were made with student t-tests. Comparison of proportions between two groups were made with Chi-Square tests.

III. Results

Table-I: demographic characteristics of the patients (N=16)

Age Group	**Frequency**	**Percentage (%)**
20-25	2	12.5
26-30	5	31.3
31-35	5	31.3
36-40	4	25
Total	16	100
Mean Age	31.56± 4.94	
Gender		
Male	12	75
Female	4	25
Total	16	100
Occupation		
Service Holder	5	31.3
Athlete	4	25
Businessman	3	18.8
Student	3	18.8
Housewife	1	6.3
Total	16	100
BMI		
Normal (18.5- 22.9)	6	37.4
Overweight (23- 24.9)	5	31.3
Obese (≥25)	5	31.3
Total	16	100
Mean BMI	23.60±2.85	

Mean age of all study population was 31.56±4.94 years (22-40 year), where in maximum patients belonged to 26-35 years of age (62.6%).Most of the study population were male (75%) with a male: female ratio 3:1. Maximum study population were Service Holder (31.3%). Among rest, 25% were athlete, 18.8% were doing business, 18.8% were student and 6.3% were housewife. Mean BMI of all study population was

23.60±2.85 kg/m^2 (range: 18.64-28.61 kg/m^2), wherein majority of the study population (62.6%) were overweight or obese (BMI ≥23) (Table-I).

Table II: Injured side of the knee among study population (n=16)

Limb Involved	Frequency	Percentage (%)
Right	11	68.8
Left	5	31.3
Total	**16**	**100**

Most of the study population had suffered from injury over right knee joint (68.8%).

Table III: Causes of injury among study population (n=16)

Cause of Injury	Frequency	Percentage (%)
Motorcycle Accident	10	62.5
Domestic accident	3	18.8
Sports	3	18.8
Total	**16**	**100**

Most of the study population had injured from motor cycle accident (62.5%), while 18.8% had injured from daily accident and rest 18.8% had injured from sports event.

Table IV: Delay from injury to surgery of the study population (n=16)

Duration of suffering	Frequency	Percentage (%)
< 3 months	12	75
3-6 months	4	25
> 6months	0	0
Total	**16**	**100**

Mean duration of sufferings was 2.71± 0.82 months (range: 3-6 months), whereas majority of the study patients (75%) were suffered for <3 months.

Table V: Comparison of preoperative and postoperative Lysholm knee score (n=16)

Lysholm knee score	Preoperative n=16, N(%)	Postoperative (09 months) n=16, N(%)	p value*
Mean± SD (median, range)	60±6.18 (59.5, 50-74)	88.56±4.31 (88.50, 79-97)	<0.001
Interpretation			
Poor (<65)	13(81.3)	0(0)	
Fair (65-83)	3(18.7)	1(6.3)	
Good (84-90)	0(0)	11(68.8)	
Excellent (>90)	0(0)	4(25)	

***** Paired Students 't' test was performed

Preoperative Lysholm knee score (Appendix VII) was poor in majority of cases (81.3%), while 09 months postoperative functional outcome of the subjects were good or excellent in most of the cases (93.7%). Besides, significant improvement was found in this study when comparing the preoperative and 09 months postoperative Lysholm knee score (p <0.001).

Table VI: Comparison of preoperative and postoperative activity level of study population according to IKDC grading (n=16)

Activity level (IKDC grade)	Preoperative n=16, N(%)	Postoperative (09 months) n=16, N(%)	p value*
Strenuous (G-I)	0(0)	9(56.3)	
Moderate (G-II)	0(0)	6(37.5)	
Light (G-III)	8(50)	1(6.3)	
Sedentary (G-IV)	8(50)	0(0)	<0.001

* Chi-square test was performed between data of preoperative and postoperative after 09 months.

At the time of surgery, all of the study patients were capable of light or sedentary activity. However, at final follow-up, 15 (93.7%) of 16 patients were capable of strenuous or moderate activity. Patient activity levels thus showed significant improvement 09 months after surgery (P <0.001).

Table VII: Comparison of preoperative and postoperative thigh atrophy and muscle strength difference between operative knee and healthy knee (n=16)

Thigh muscle parameter	Preoperative n=16, N (%)	Postoperative (09months) n=16, N (%)	p value*
Thigh muscle girth difference (in mm)			
<10 mm	4(25)	15(93.8)	
10-20 mm	6(37.5)	1(6.3)	
>20 mm	6(37.5)	0(0)	
Mean±SD (median, range)	15.72±5.47 (17,8-22.50)	5.78±2.44 (5.75, 2-10)	<0.001
Extensor strength ratio			
>90%	3(18.8)	15(93.8)	
80-90%	3(18.8)	1(6.3)	
<80%	10(62.5)	0(0)	
Mean±SD (median, range)	77.75±9.29 (76, 64-92)	94.38±2.47 (94, 90-99)	<0.001
Flexor strength ratio			
>90%	4(25)	16(100)	
80-90%	4(25)	0(0)	
<80%	8(50)	0(0)	
Mean±SD (median, range)	80.19±9.31(79.5,65-92)	95±2.73 (95.50, 91-99)	<0.001

* Wilcoxon signed rank sum test was performed

At final follow-up 93.8% patients revealed less than a 10-mm difference in thigh circumference. 93.8% patients achieved recovery of the extensor muscle strength in the reconstructed knee to more than 90% of normal knee strength. All of the study patients achieved recovery of flexor muscle strength in the reconstructed knee to more than 90% of normal knee strength which is statistically significant ($p < 0.005$).

IV. Discussion

Knee function deterioration may occur following nonoperative treatment in high-grade PCL injury. Therefore, PCL reconstruction is needed in high-grade PCL injury. The present study assessed the fruitfulness of isolated grade III posterior cruciate ligament reconstruction arthroscopically by quadruple hamstring tendon autograft. The analysis of age distribution in this study showed that the age range was 22-40 years and mean age was 31.56 years. Nearly similar result was shown by Wang et al [2]. In their study the mean age was 32.02 years. In another study Waly & Gawish et al. showed the mean age was 34 (range 27-45) years. In most of the cases young people are the victim of isolated PCL injury [15]. The majority of patients of our study were male 75% and female were 25%. Similar result was shown by Wu et al [16]. In their study 77.27% patients were male and 22.72% were female. Similar male predominant result was found by Norbakhsh et al [17]. The reason of male predominance may be due to their more involvement in random mobility for works with motorcycles, sports and manual activities. In our study maximum study population was service holder (31.3%) which is similar to the result of El Nahas et al. in which majority of the study population was worker (30%)[3]. Lee et al in their study showed that the mean BMI of the patients was 27.6±4.5 which is similar to our study where BMI of all patients mean was 23.60±2.85 kg/m^2 (range: 18.64-28.61 kg/m^2) [18]. But majority of our study population (62.6%) were overweight or obese (BMI ≥23). Out of 16 patients 68.8% had injury at right knee and 31.3% had injury at left knee. Similar result was shown by Boutefnouchet et al [19]. In their study they got predominant right knee injury (66.7%). The reason for predominant right knee injury may be due to motor bike accident. Causes of injury are important and vital factors for PCL injury. In our study we found motor bike accidents (62.5%) as the major cause of injury apart from other activities. According to Caldas et al motor vehicle accidents were the leading factor for isolated and combined PCL injuries which accounted for 49.3% the cohort [20]. On the other hand, similar result was shown by Wu et al and Lin et al [16, 21]. In their study Motorcycle accidents was 78% or traffic accidents 46.7% respectively. Boutefnouchet et al in their study found sports (73.33%) as the major cause [19]. In present study, 12 patients (75%) presented with symptoms within 3 months and 4 patients (25%) presented within 3-6 months. The mean duration of symptoms was 2.71± 0.82 months. Those patients who were operated within 3 months of the initial injury had significant functional outcomes. This result was nearly similar (mean 2.7 ± 0.9 months) to Waly & Gawish [15]. Hohmann et al have reported 31% of all patients with early surgery had a normal or near normal knee, whereas only 15% of patients with late reconstruction reported the knee to be normal or near normal & showed that early surgical reconstruction for injuries of knee ligaments had markedly better functional outcome than late surgical intervention [22]. For ligament laxity, 15 of our study population (95%) revealed less than 5 mm ligament laxity

when performed posterior drawer test. Instability of the operated knee is significantly improved (95%) from Grade III to Grade 0 in the present study (P value <0.001). Nearly similar result was found by Wu et al where 82% of the study population revealed less than 5 mm ligament laxity when measured and in the study of Norbakhsh et al 78.8% revealed less than 5mm ligamentum laxity at final follow-up [16,17]. To evaluate the subjective symptoms Lysholm score is essential. In our study the postoperative mean (±SD) Lysholm score (88.56±4.31) was significantly improved than preoperative scores (60±6.18). The preoperative Lysholm knee score was poor in majority cases (81.3%), while 09 months postoperative functional outcome of the subjects were good or excellent in most of the cases (93.7%). Besides, significant improvement was found in this study when comparing the preoperative and 09 months postoperative Lysholm knee score (p value <0.001). Mean (±SD) of Lysholm score improved from preoperative 46.4 ± 18.87 to postoperative 83.47 ± 10.54 (P < 0.001) in the study of Lin et al [21]; and from 58.2 ± 2.6 to 88.9 ± 4.1 (P <0.05) in the study of Waly & Gawish [15]. Similar result was also found by Lee et al., Boutefnouchet et al *and* Wu et al [16, 18, 19].

For the assessment of activity level in the present study we found mean Tegner score improved significantly from 2.94±0.93 preoperatively to 5.75±1.61(P value <0.001) at the final follow-up which is similar to the study of Lin et al where Tegner score improved from 2.47 ± 1.85 to 6.07 ± 1.58 (P <0.001) [21]. Similar result was also found by Rushdi et al; Wang et al; Zayni et al and Boutefnouchet et al [2, 19, 23, 24]. Regarding the IKDC activity level evaluation 93.7% of our study population were capable of strenuous or moderate activity and only one patient (6.3%) was restricted to light activity whereas Zayni et al in their study found 81% of the patients had resumed moderate or intensive level activities [24], with 71.5% of the study population practicing pivot and contact sports which is similar to the study of Wu et al [16]. Patient activity levels thus displayed significant improvement in our study after PCL reconstruction (P <0.001). Regarding ROM of the knee Norbakhsh et al found Eighty-five percent of the study population experienced full ROM. We also found nearly similar result 09 months postoperatively, where 87.5% of the study population obtained normal ROM [17]. In our study at final follow-up, 93.8% of the study population revealed less than 10-mm difference in thigh circumference between their reconstructed and normal limbs and all of the study population achieved recovery of flexor muscle strength in the reconstructed knee to more than 90% of normal knee strength. Norbakhsh et al in their study found less than 10-mm difference in thigh circumference between involved and healthy limbs in 79 % patients and at 3-year follow-up, 90 % of the patients recovered >90 % flexor muscle strength, in comparison with contralateral side. Similar result was also found in the study of Wu et al [16, 17].

V. Conclusion & Recommendation

After analyzing the results of the present study, it can be concluded that arthroscopic reconstruction of grade III isolated PCL tear by quadruple hamstring tendon autograft showed satisfactory functional outcome and all the functions of knee were improved in compared with their pre-operative status.

To make more conclusive results the following recommendations are proposed for further studies:

- Similar type of study can be done with larger sample size.
- A multicentric randomized clinical trial study can be done.
- Study must be longer period so that we find out the functional outcome of surgery more effectively.

Limitations

Although optimal care had been tried by the researcher in every step of the study, but there were some limitations:

- The sample was taken purposively. So, there may be chance of bias which can influence the results.
- The study and follow-up period were short in comparison to other studies.
- The study population might not represent the whole community.

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