Outcomes of Anterior Cruciate Ligament Reconstruction in Rajavithi Hospital

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Background: *Anterior cruciate ligament reconstruction (ACL) is one of the most common orthopedic procedures performed worldwide. Many studies have reported results of single- and double-bundle ACL reconstruction with regard to long-term follow-up; however, few have examined the outcomes of the early postoperative period.*

Objective: *This study was undertaken to evaluate early postoperative clinical outcomes after ACL reconstruction.*

Material and Method: *A retrospective study was carried out between April 2004 and February 2016. A total of 183 isolated ACL-injury patients underwent primary ACL reconstruction using patellar tendon bone and hamstring tendon. Demographic data and complications, including length of hospital stay (LOS) and operative time, were recorded.*

Results: *The mean age of the 183 patients was 28.52±7.43 years. Most of the subjects were male, single, and employed, with no underlying diseases. The mean ± SD of BMI was 24.34±3.36 kg/m^2. The main cause of surgery was injury resulting from accidents sustained while playing sports. The average operative time was 144.49±47.35 minutes, and LOS ranged from 3 to 23 days (mean ± SD = 7.34±2.43 days). The majority of the patients underwent single-bundle ACL (92.2%) and bio absorb screw was most commonly used for tendon fixation. Medial meniscus tear (MM) was the most common injury, accounting for 59.1% of cases, whereas no lateral meniscus (LM) tear was observed in 64.0% of subjects. ACL reconstruction due to sports injury was more prevalent in younger patients than in older ones (p-value = 0.019), and a significant correlation between time after injury and meniscus tear was identified (p-value = 0.017).*

Conclusion: *ACL surgery was most commonly associated with sports injury and was most prevalent in younger patients. Operative times, LOS and complications in early postoperative outcomes were not significantly different in single- and double-bundle cases. More research is needed to assess early postoperative rehabilitation and long-term follow-up.*

Keywords: *Anterior Cruciate Ligament, Early postoperative, ACL outcomes, Medial and lateral meniscus*

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Anterior cruciate ligament reconstruction (ACL) is the most frequently-performed reconstructive knee surgery. Currently, the most commonly-attempted technique, and the one which is regarded as the gold standard for ACL reconstruction, is arthroscopic single-bundle reconstruction, and this has provided high success rates[1-3]. Single-bundle ACL reconstructions have been performed for decades[1] and have obtained success rates of over 80.0%, mostly in restoring anterior stability; however, there have been some cases in which residual instability and patient dissatisfaction after ACL surgery have been identified[4-6]. Studies from the literature suggest that, compared with single-bundle ACL reconstruction, the double-bundle technique is more effective in restoring anterior-knee and rotational stability in the ACL-deficient knee close to the normal intact knee[7-10]. The majority of authors have tended to focus on double-bundle ACL reconstruction rather than on the single-bundle technique, and many cases in the literature have reported favorable clinical outcomes; however, some previous clinical and biomechanical studies have revealed that double-bundle ACL reconstruction has no significant advantage over its single-bundle counterpart[11-13]. Although double-bundle ACL reconstruction is capable of reproducing the 2 functional bundles of the ACL for anatomical insertion sites, no consensus has been reached with regard to the benefits of this technique over the single-bundle one[14]. Furthermore, there is insufficient data to allow comparative assessment of rotational stability after these two modalities, and no comparative study has been carried out of the intra-operative stability and clinical outcomes obtained using these two techniques[15].

Restoring knee stability has the advantage of

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allowing patients to return more speedily to playing sports. Although the ACL surgical technique is widely accepted, there are some specific aspects of it that remain generally debated. The most controversial question concerns graft choice, especially in autograft reconstruction, where donor site morbidity and long-term outcomes are major concerns[16]. There are two commonly-used autografts: bone-patellar tendon-bone (BPTB) and quadrupled hamstring (HS)[17]. Several studies have been performed to compare these graft types, most of which have focused on short-term outcomes with follow-up of less than two years[18]. Magnussen et al[19] published the first systematic review on the topic of autograft choice with a minimum of 5 years of follow-up for intermediate-term outcomes of ACL reconstruction. Due to the growing emphasis being placed on evidence-based medicine in the past 20 years, an increasing number of studies with intermediate- and long-term follow-up have recently been documented[16]. More current reports in the literature with longer follow-up provide surgeons with valuable evidence in the decision-making process and may be useful in discussions with patients regarding long-term clinical outcomes.

ACL surgery is one of the most common orthopedic procedures performed worldwide. Previous studies have tended to examine clinical outcomes after ACL reconstruction with regard to long-term follow-up periods while few reports have focused on the early postoperative period, which is also important. The associated complication rates are not yet clearly defined while complication rates for arthroscopic knee surgery range from 0.8% to 8.2%[20,21]. With the evolution of ACL techniques, and the increased frequency of arthroscopic surgery, it is possible to assess associated complications in order to improve the outcomes of arthroscopic procedures and provide prognostic information[22]. ACL reconstruction has been performed in Rajavithi Hospital for more than ten years, but clinical outcomes after operation have not been carefully investigated. The purpose of the present study was to assess postoperative outcomes after ACL reconstruction together with complications, lengths of hospital stay and operation times.

Material and Method

Patients and data collection

This was a retrospective study conducted in the orthopedics department of Rajavithi Hospital. Between April 2004 and February 2016, 183 patients underwent arthroscopic ACL reconstruction. ACL rupture was diagnosed based on medical history, physical examination and MRI. All subjects were actively engaged in daily activities and played sports before injury. Patients were informed of the benefits of ACL reconstruction and consent was obtained before surgery. The inclusion criteria were as follows: (1) date of surgery during study periods; (2) primary ACL reconstruction using patellar tendon bone and hamstring tendon with none of the following: combined posterior cruciate ligament injury; lateral collateral ligament injury; posterolateral rotatory instability; fracture around knee; previous knee ligament surgery; arthritic changes; subtotal or total meniscectomy; or malalignment. The exclusion criteria were as follows: (1) Multiple ligament surgeries and (2) Pedi pillow cut over 30%. Patients were sequentially selected to undergo either single- or double-bundle reconstruction based on surgeon's preference. A case record form was used to collect data, and demographic information was recorded, including age, gender, tendon type, affected side, BMI, cause of injury, and time from injury to operation. Complications included infection, length of hospital stay, and operation time. This study protocol was reviewed and approved by the ethics committee of Rajavithi Hospital (No. 096/2560).

Surgical technique of single-bundle ACL reconstruction with bone patella tendon graft[2,5,12-14]

A single-bundle ACL reconstruction with bone patella tendon graft is shown in Fig. 1. A surgical approach with longitudinal incisions was made from the inferior patellar pole to a point just medial to the tibial tubercle. A 10- to 11-mm-wide middle-third patellar tendon strip was harvested including a 25-mm-long and 10-mm-wide bone plug from the tibial tubercle and distal third of patella. The bone plug was shaped into a cylinder, using a 2 mm drill to make 4 drill holes into the graft: 2 for the tibial tunnel and 2 for the femoral one. Subsequently, Ethibond sutures were passed through the tibial bone plug and Ethibond sutures were passed through the femoral bone plug. The femoral and tibial tunnels were prepared with the same technique as that used for reconstruction with hamstring grafts. The bone plug of the graft was then pulled into the femoral tunnel through the tibial one. The fixation device for both fermoral and tibial fixation consisted of bioabsorbable or metal screws. A 10-mm femoral socket tunnel was created through the AMP in a hyperflexed position by means of a 10-mm drill for the notch cortex. The tip of a K-wire was drilled using a 6-mm offset femoral guide through the medial portal into the center between the

anteromedial (AM) and posterolateral (PL) bundles. On the tibia, a 2.5-mm tunnel was drilled with a drill guide set to an angle of 50° into the center of the tibial AM and PL insertions before being over drilled with a 6- to 9-mm drill. The bone plug of the graft was then pulled into the femoral tunnel through the AMP with the plug's cortex facing the tibial plateau, thus mimicking AM and PL bundle positions. After this, the bone plug was driven utilizing a press-fit technique into the femoral tunnel using a spiked impactor with the knee flexed to 120°. The distal free end of the graft was then pulled through the tibial tunnel.

Surgical technique of single-bundle ACL reconstruction with hamstring graft [2,5,12-14]

In single-bundle reconstruction of the ACL, traditional AM bundle reconstruction with arthroscopy was performed with both semitendinosus tendon and gracilis tendon, with each segment folded in half to form a quadruple-thickness replacement graft. First, the tibial tunnel was drilled at a 50° angle in the horizontal plane and approximately 2 cm medial from the tibial tuberosity in the sagittal plane. The center of the tunnel was placed just posterior to the anterior horn of the lateral meniscus. The femoral tunnel was made in the femoral notch positioned at 10 o'clock (right knee) or 2 o'clock (left knee) through an anteromedial portal. After insertion of an offset guide through an anteromedial portal with the knee at nearly full flexion, a guide pin was inserted into the lateral femoral condyle to a depth of approximately 30 mm. Then, with the knee maximally flexed, guide pins were inserted completely through bone and emerged from skin with the assistance of a stab incision. The femoral end of the graft was pulled through the tibial tunnel and into the femoral one with the tendon length in the tunnel at 25 to 30 mm. The fixation device for femoral fixation comprised bioabsorbable screw, endobutton, or metal screw, and for tibial fixation, bioabsorbable or metal screws were used and secondary suture and post fixation were added in some cases if needed. Single-bundle endobutton bio screw suture to hamstring post AP view and endobutton screw lateral right knee are shown in Fig. 2.

Surgical technique of double-bundle ACL reconstruction with hamstrings tendon auto graft [2,5,12-14]

The harvested autografts from the semitendinosus tendon were prepared into a 3-stranded graft used for AM bundle reconstruction and from the gracilis tendon into a 3-stranded graft used for PL

Fig. 1 Single-bundle ACL reconstruction with bone patella tendon graft.

Fig. 2 Single-bundle endobutton femoral fixation and bioscrew and suture on tibial side in AP view (left) and single bundle endobutton femoral and bioscrew fixation on tibial side lateral view (right) screw lateral right knee (right).

bundle reconstruction. The 2-femoral tunnel and 2-tibial tunnel technique was used to reconstruct double-bundle ACL. After confirmation of the ACL attachment site, a tibial tunnel for the PL and AM bundle, a femoral tunnel for the PL and bundle were made one by one; anterior cruciate ligament remnants can be used to determine these sites. On the femoral side, the bony landmarks, such as the lateral intercondylar ridge and lateral bifurcate ridge, can be used, as can the posterior

cartilage border. The femoral tunnel for the AM bundle was located at the 10: 30 (right knee) or 1: 30 (left knee) position with respect to the intercondylar area. For fixation, suspensory fixation was used on the femoral side to avoid blocking of the insertion site, which can occur with aperture interference screw fixation. Interference screw fixation was utilized on the cortical tibial side. Double-bundle tendon and screw are displayed in Fig. 3, while double bundle endobutton screw suture post AP view is presented in Fig. 4.

Statistical analysis

Data were analyzed using SPSS version 17.0 (SPSS Inc., Chicago, Illinois, USA). Baseline characteristics were analyzed using descriptive statistics such as number, percentage, mean and standard deviation, minimum and maximum. Chi-square test was used to compare categorical variables and frequency difference while Independent t-test was used to compare continuous variables. A *p*-value of less than 0.05 was considered to be statistically significant.

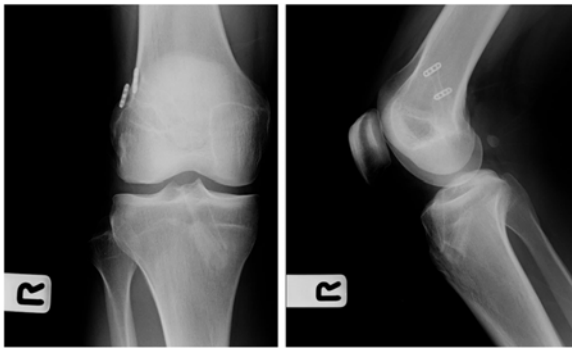

Fig. 3 Double-bundle endobutton and screw right knee crop.

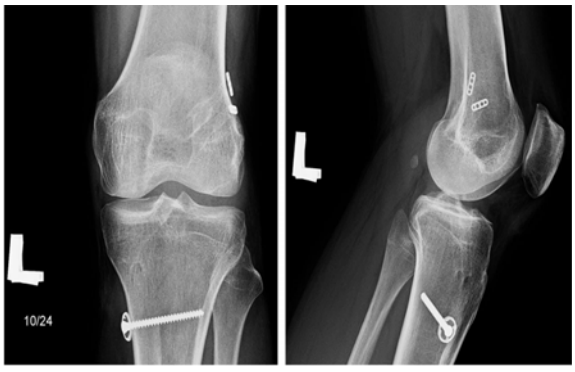

Fig. 4 Double-bundle endobutton screw suture post AP.

Results

One hundred and eighty-three patients were recruited, with a mean age (±SD) of 28.52±7.43 years old. The majority of the patients were male (88.5%), and their mean BMI (±SD) was 24.34±3.36 kg/m^2. Most were single and employed with no underlying diseases. Baseline characteristic of the patients are shown in Table 1.

A description of the ACL reconstruction is presented in Table 2. The main cause of ACL surgery was injury sustained playing sports (66.1%). Overall, length of hospital stay (LOS) ranged from 3 to 23 days (mean ± SD = 7.34±2.43 day), while mean LOS for patients with single- and double-bundle techniques were 7.37±2.47 days and 6.91±2.47 days, respectively. Average operative time was 144.49±47.35 minutes. Sides of ACL surgery were right (52.5%) and left (47.5%), and most of the patients had time of injury of less than 12 months (73.9%). The main graft type was hamstring graft (75.9%) and patella bone graft (24.1%). Single bundle ACL was most frequently performed (92.2%) while its double-bundle counterpart was used in only 7.8% of operations. Bioabsorb screw was the most frequently-used technique for tendon fixation on both

Table 1. Baseline characteristics of patients (n = 183)

Characteristics	n (%)
Sex (n = 182)	
Male	161 (88.5)
Female	21 (11.5)
Age (n = 180)	
≤30 years	121 (67.2)
>30 years	59 (32.8)
Mean ± SD	28.52±7.43
BMI (kg/m^2) (n = 90)	
<23 kg/m^2	31 (34.4)
≥23 kg/m^2	59 (65.6)
Mean ± SD	24.34±3.36
Status (n = 177)	
Single	138 (78.0)
Married	39 (22.0)
Occupation (n = 171)	
Government officer	18 (10.5)
Employee	92 (53.9)
Self employed	7 (4.1)
Student	43 (25.1)
Other	11 (6.4)
Underlying disease (n = 95)	
No	91 (95.8)
Yes	4 (4.2)

Table 2. Description of ACL reconstruction

ACL description	n (%)
Cause of surgery (n = 180)	
Non-sport injury	61 (33.9)
Sports injury	119 (66.1)
Length of hospital stay (days)	
Mean ± SD	7.34±2.43
Median (min-max)	7 (3-23)
Operative time (minutes)	
Mean ± SD	144.49±47.35
Median (min-max)	135 (65 to 380)
Onset of injuries (n = 165)	
≤12 months	122 (73.9)
>12 months	43 (26.1)
Median (IQR)	8 (4 to 16)
Graft types (n = 174)	
Hamstring graft	132 (75.9)
Patella bone graft	42 (24.1)
Techniques of tendon fixation using femur (n = 182)	
Bio absorb screw	113 (62.1)
Suture anchor	66 (36.3)
Metal screw	3 (1.6)
Techniques of tendon fixation using tibia (n = 183)	
Suture anchor	1 (0.5)
Bio absorb screw	168 (91.8)
Metal screw	7 (3.8)
Suture to post	35 (19.1)
Surgical techniques (n = 179)	
Single-bundle	165 (92.2)
Double-bundle	14 (7.8)
Femur double-bundle	3 (21.4)
Tibia double-bundle	1 (7.1)
Femur and tibia double-bundle	10 (71.4)
Medial meniscus (MM) (n = 176)	
No meniscus tear	72 (40.9)
Meniscus tear	104 (59.1)
No treatment	8 (7.7)
Repair	79 (76.0)
Partial resection	17 (16.3)
Lateral meniscus (LM) (n = 175)	
No meniscus tear	112 (64.0)
Meniscus tear	63 (36.0)
No treatment	9 (14.1)
Repair	39 (60.9)
Partial resection	16 (25.0)

Values are represented as n (%), mean ± SD, median (min-max), SD = standard deviation

femur and tibia. Medial meniscus tear (MM) was the most prevalent tear, occurring in 59.1% of cases, whereas no lateral meniscus (LM) tear was observed in 64.0%.

There was a significant difference between age and reason for surgery. ACL reconstruction due to sports injury was commonly found in younger patients with mean age of 27.59±6.36 years while the injuries of older patients with age of 30.71±8.93 years did not usually involve sports (p-value = 0.019) as shown in

Table 3.

No significant difference was evident between cause of surgery and techniques of ACL reconstruction as seen in Table 4. In addition, no significant difference between operative time, admission time and baseline characteristics was observed.

The associations between various factors and meniscus tear are presented in Table 5. In the ACL technique with medial meniscus (MM), there was a significant difference between injury time of MM and meniscus condition (p-value = 0.017). No association was identified between other factors such as age, sex, BMI or MM and LM tears.

Discussion

One of the most common knee ligament injuries is anterior cruciate ligament sprain or tear which is most frequently observed in athletes who participate in high-demand sports like soccer, football, and basketball in which players are more likely to injure their ACLs. The rate of knee injury is generally high in males, and this is consistent with the results of the present study which found that the majority of patients were masculine, and suggests that ACL reconstruction occurs most often in males[23].

The purpose of this study was to identify clinical outcomes in ACL-injury subjects who underwent surgery. The average operative time was up to two hours per case which is similar to other cases in the literature. No postoperative complications such as graft fixation, failure, or re-admission were observed. The present study's findings are consistent with those of a study by Song EK (2009)[24] which compared clinical outcomes in patients undergoing single- and double-bundle ACL and found no complications. The current findings revealed that only one case suffered surgical would infection. A revision screw was performed in only one case; this was necessitated by screw breakage and re-insertion was carried out. Three cases involved prolonged surgical time for 30 minutes due to postoperative fever and light source dysfunction.

Previous studies have compared clinical outcomes of single and double-bundle ACL reconstruction. Some have indicated that double-bundle ACL is more effective in restoring anterior rotational stability in ACL-deficient knees, and that it entails less residual pivot shift than that resulting from the single-incision single-bundle technique[24,25]. In the present study, no significant difference in early postoperative outcomes was found between single- and double-bundle ACL reconstruction. The current findings are consistent with those of a study by Song EK (2009)[24] which reported similarities in terms of clinical outcomes and postoperative stability, after a minimum of 2 years of follow-up, between single- and double-bundle ACL surgery. Similar to the present study, a meta-analysis found no significant difference in functional recovery achieved by single- and double-bundle reconstruction techniques[25]. In addition, Gobbi et al (2012)[26] concluded that double-bundle reconstruction of the ACL did not improve function or stability compared with single-bundle reconstruction with a minimum follow-up of 36 months.

In the present study, using a cutoff time from injury to arthroscopy of 12 months, the incidence of medial meniscus tear was significantly higher in subjects with longer injury time (75.6%) than those

Table 3. Comparison between age and cause of surgery (n = 177)

Cause of surgery	Mean ± SD (years)	p-value
Cause of surgery		0.019*
Non-sport injury	30.71±8.93	
Sports injury	27.59±6.36	

The p-value from independent t-test, * Significant at $p<0.05$

Table 4. Association between cause of surgery and techniques of ACL reconstruction (n = 124)

Cause of surgery	Single-Bundle	Double-Bundle	p-value
	n (%)	n (%)	
Cause of surgery			0.373
Non-sport injury	54 (90.0)	6 (10.0)	
Sports injury	108 (93.9)	7 (6.1)	

The p-value from Chi-square, * Significant at $p<0.05$

Table 5. Factors associated with meniscus tear

Information about surgery	No tear	Tear	*p*-value
	n (%)	n (%)	
Medial meniscus (MM)			
Age (n = 171)			0.087
≤30 years	54 (46.6)	62 (53.4)	
>30 years	18 (32.7)	37 (67.3)	
Sex (n = 174)			0.574
Male	64 (41.6)	90 (58.4)	
Female	7 (35.0)	13 (65.0)	
BMI (kg/m^2) (n = 171)			0.738
<23 kg/m^2	11 (36.7)	19 (63.3)	
≥23 kg/m^2	23 (40.4)	34 (59.6)	
Onset of injury (n = 157)			0.017*
≤12 months	53 (45.7)	63 (54.3)	
>12months	10 (24.4)	31 (75.6)	
Lateral meniscus (LM)			
Age (n = 170)			0.493
≤30 years	71 (61.2)	45 (38.8)	
>30 years	36 (66.7)	18 (33.3)	
Sex (n = 173)			0.474
Male	99 (65.1)	53 (34.9)	
Female	12 (57.1)	9 (42.9)	
BMI (kg/m^2) (n = 87)			0.426
<23 kg/m^2	21 (70.0)	9 (30.0)	
≥23 kg/m^2	35 (61.4)	22 (38.6)	
Onset of injury (n = 156)			0.515
≤12 months	72 (62.6)	43 (37.4)	
>12 months	28 (68.3)	13 (31.7)	

The *p*-value from Chi-square, * Significant at $p<0.05$. BMI = body mass index

with shorter injury time (72.7%). This study's findings suggest that, with regard to injury time associated with medial meniscus, the greater the duration of injury, the higher the rate of medial meniscus tear. Injury time was therefore a factor associated with medial meniscus tear, and this is similar to the conclusions of a study by Hagino (2015)[27] which revealed that lateral meniscal tear was normally associated with acute ACL injury, while medial meniscal tear tended to occur with chronic ACL injury. Previous studies have indicated an increased incidence of lateral meniscal injuries relative to medial meniscus in patients with ACL who present less than 1 year after sustaining their injury. Although no significant association between lateral meniscus tear and injury time was investigated, the present findings determined that the number of subjects who suffered meniscus tear was higher than those who had no tear. Additionally, early ACL reconstruction was found to be crucial for prevention of secondary injury.

The current study found a correlation between medial meniscus tear and longer injury time of more than one year. Previous studies have clearly demonstrated that the incidence of meniscus tear increases with delays in undergoing surgery, implying an association between meniscus tear and longer time from injury occurrence to surgery[28,29].

The meniscus plays an important role in the function of the knee, and appropriate preservation of the meniscus is highly desirable. The anatomy of the meniscus, the structure, the mechanics, and factors affecting meniscal healing and repair should be considered when evaluating the torn meniscus for a reparative procedure. Short-term results seem to favor the reconstruction technique[30].

The present study may prove useful for clinicians. First, this study was conducted at an early

stage after surgery to assess short-term outcomes during admission. Second, no significant differences in LOS, operative time or complications were found between the single- and double-bundle ACL techniques. Therefore, the selection of the modality to be used for operations should be left up to surgeon preference. The main goal of ACL reconstruction is to ensure that knee function is stable; the prevention of secondary injury is then required.

A limitation of this study was its small sample size especially with regard to patients with double-bundle ACL reconstruction. The findings may be different if a study is conducted with a larger sample size. With regard to the type of sport, we did not observe differences between sports types and clinical outcomes after ACL surgery. We did not investigate the outcomes of early postoperative rehabilitation or compare rehabilitation progression; furthermore, incomplete data may have resulted in some association not being identified.

Conclusion

In conclusion, the major cause of ACL surgery was sports injury and was most often found in younger patients. There were no significant differences between early postoperative outcomes of single- and double-bundle ACL reconstruction. Medial meniscus tear occurred most often in instances of longer injury time and delayed surgery. An implication of these findings is that surgeon preference is a major factor in management of ACL reconstruction. Further research should be carried out to assess early postoperative rehabilitation, and prolonged follow-up should be evaluated.

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What is already known on this topic?

The clinical outcomes of single- and double-bundle ACL reconstruction vary in the literature. Conventional single-bundle reconstruction techniques are used to reconstruct the anteromedial bundle of the ACL, and it has been found to be successful in restoring anterior stability; however, it may be less effective in controlling combined rotatory loads of internal torque. this ACL technique leaves a significant proportion of patients unable to return to their previous level of sports activity; furthermore, some surgeons turn to the double-bundle technique for improvement in ACL reconstruction. Some studies have revealed that the double-bundle modality improved anteroposterior stability, rotational laxity and resulted in less residual pivot shift than the single-bundle technique. On the other hand, there were no significant differences in terms of functional recovery between these two techniques. As such, surgeon preference should govern which technique is employed

What this study adds?

The postoperative outcomes of single and double-bundle ACL reconstruction normally occurred for longer follow-up. The present study focused on early postoperative outcomes and its findings suggest that no significantly different outcomes between these two techniques were identified. Meniscus tear is related to injury time, but not found in lateral meniscus.

Potential conflicts of interest

None.

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