

**Original article****Comparing and predicting the outcome of anterior cruciate ligament reconstruction performed within one year and one year after injury**Salahuddin AL<sup>1</sup>, Muzaffar T. Shihabudin<sup>2</sup>, PS Au Yong<sup>3</sup>, Azril Syazwan Mohd Ali<sup>4</sup>

**Background:** The anterior cruciate ligament reconstruction (ACLR) should not be delay too long to get a good outcome but how long delay could be considered acceptable is not known. The objective of this study was to assess the outcome of surgery performed within and after a year of injury. We also predicted the operative outcome if the surgery is further delayed and several associated factors were also evaluated if they could influence the outcome. **Methodology:** Thirty-six patients were recruited in the early group where surgery is performed within a year of injury and thirty were in the delayed group where surgery was after a year of injury. Age, sex, body mass index, Tegner activity level and duration from the time of injury to surgery were evaluated. Surgical outcomes were measured at one year follow up after surgery were Lysholm score and limb symmetry index (LSI). **Results:** Mean time from injury to surgery for early and delayed groups were eight months and 18 months. Timing from injury to surgery affects the outcome parameters. Both groups showed good outcomes but the early group showed better LSI and Lysholm scores ( $p < 0.5$ ). LSI was better in predicting the outcome of surgery compared to Lysholm score (67% vs 43%). **Conclusions:** Early ACLR showed better outcome but the late ACLR still demonstrate acceptable result in the absent of high grade cartilage lesion. LSI is better at predicting the outcome of surgery.

**Keywords:** anterior cruciate ligament; reconstruction; outcome; delayed; predict.

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**Introduction:**

Anterior cruciate ligament reconstruction (ACLR) is a common knee ligament surgery. It is a preferred treatment for those who has knee instability following the anterior cruciate ligament (ACL) injury especially among the athletes or physically demanding occupations. The surgery restores stability and minimize the progressive degeneration that may occurs following chronic knee instability.<sup>1</sup> ACLR surgery should not be delayed too long as this could lead to meniscal injury and degenerative

changes. Literatures support that late ACLR was associated with an increased incidence of meniscal damage and chondral injury.<sup>2-4</sup>

There has been an increasing trend towards earlier ACLR to minimize the intra-articular injury risk. The literature, however, is mixed about the time where the occurrence of these intra-articular lesions become more prevalent, thus affecting the outcome of ACLR.<sup>5-8</sup> It is not known how long a delay in surgery would be detrimental to the operative outcome. Whether the meniscal lesion alone would

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contribute to poor ACLR results is also not known. Although performing early surgery is preferred, delayed surgery sometimes occurs due to many factors especially in developing country.

Highlighting the outcome of surgery when the operation was delayed and predicting the deterioration of outcome with times would be beneficial as this information may give a clue to the limit of delaying surgery when the optimum time is not feasible. Therefore, the main aim of our study was to evaluate the outcome of ACLR surgery when it is performed within and after a year. Secondly, we assessed and predicted the operative outcome in this cohort with each month of delaying the surgery and the possible association factors that may affect the outcome.

### **Methodology:**

#### *Ethical review and study design*

This was a cross-sectional study. This study was approved by the National Medical Research Register (NMRR) [NMRR-16-440-29162(IIR)] and the Human Research Ethics Committee USM (USM/JEPeM/ 160100064)

#### *Selection Criteria*

This was a cross sectional study. Consecutive patients who came for ACL surgery during the study periods were identified and demographic data were recorded. Those who met the selection criteria were identified and followed up. Patients aged 18-45 years old with one-sided isolated ACL injury were included in the study. Those with deep-seated infection, fracture or another ligament injury were excluded. The cartilage was assessed during ACLR surgery. We also excluded those with chondral injury Outerbridge grade III and IV due to the increased possibility of secondary cartilage procedures if not simultaneously performed in this group of patients. We also exclude those with ankle injury as it may affect the knee.<sup>9</sup> All patients with concomitance meniscal injury that were managed accordingly were included in the study. Patients were divided into groups where ACLR was performed within one year of injury and the second group where ACLR was performed after one year.

The same surgeon reconstructed the ACL ligament using the single-bundle technique with hamstring autograft. A similar rehabilitation program was introduced to the patients.

#### *Outcome measures*

The outcome measured in this study were the Lysholm score and limb symmetry index (LSI). The associated factors that were evaluated were age, sex, body mass index and Tegner activity level. Patients filled up the TEGNER and the LYSHOLM form just before surgery. After the procedure, patients received a similar rehabilitation program. One year postoperatively, the patients filled up again the TEGNER form and LYSHOLM form. The LYSHOLM score is classified as the maximum score at 100 points, where 95–100 is considered excellent, 84–94 good, 65–83 fair, and 64 and below poor. The Lysholm score has been proven valid and reliable in patients with an ACL injury.<sup>10</sup>

The patient performed a single-leg hop test (SLHT) one year post-surgery. The single-hop for distance was performed with the patient standing on the leg to be tested, hopping as far as possible, and landing on the same leg.<sup>11 12</sup> The procedure was repeated three times, and the average reading was taken. The same procedure was performed on the unaffected limb. The distance of the affected leg and unaffected leg was measured as limb symmetry index (LSI), the distance was calculated as centimetre, and the LSI was calculated as percentage.<sup>12</sup> The desired value is to have the LSI of not less than 85 per cent.

#### **DISTANCE OF SINGLE-LEG HOP TEST (AFFECTED LEG(CM))**

$$\text{LSI} = \frac{\text{DISTANCE OF SINGLE-LEG HOP TEST (AFFECTED LEG(CM))}}{\text{DISTANCE OF SINGLE-LEG HOP TEST (UNAFFECTED LEG (CM))}} \times 100 \%$$

Using the statistical analysis, the Lysholm score and LSI percentage were predicted when the surgery is delayed from the time of injury. All data were entered into International Business Machines (IBM)® Statistical Packages for Social Sciences (SPSS) version 22.

### **Results:**

Seventy-eight patients were initially included in the study. However, twelve patients were lost during follow-up, leaving sixty-six patients who met the selection criteria. They were followed up until one year post-surgery. Two patients were complicated with superficial infection at the graft harvest site. They were treated with antibiotics, and none of them underwent graft revision. The demographic data of all patients were shown in table 1.

**Table 1:** Demographic data in this study (n=66)

Variable	Early Reconstruction Group (n=36) (54.5%)	Delayed Reconstruction Group (n=30) (45.5%)
Age in year mean(SD)	25.0(6.35)	27.9(8.20)
Duration of injury to surgery (mean in months)	8.5	18.5
Sex		
Male	32	28
Female	4	2
Body mass index (n)		
18.5 - 25	33	26
26 - 30	3	4
Pre-injury HIGH Tegner level (n)	11	2
Pre-injury LOW Tegner level (n)	25	28
Meniscal procedures performed	32	28
No meniscal procedure performed	4	2

The Lysholm score and LSI were summarized in table 2. Both groups showed good Lysholm score and LSI but better in the group where ACLR was performed within one year (p<0.05).

**Table 2:** Compare mean difference of outcomes between reconstruction performed within 1-year and after 1-year group (n=66) by using independent t- test

Variable	Duration < 1 year, Mean(SD)	Duration > 1 year, Mean(SD)	Mean difference (95% CI)	t-stat (df)	p- value
LSBO	68.28(6.37)	66.70(6.91)	1.58(-1.69,4.85)	0.96 (64)	>0.05
LSAO	90(3.16)	87.50(2.54)	2.50(1.07,3.93)	3.49 (64)	0.001*
LSI	95.31(5.75)	86.17(5.54)	9.14(6.35,11.93)	6.54(64)	<0.001*

LSBO- LYSHOLM score before the operation, LSAO-Lysholm score after the operation, LSI- Limb Symmetry index, \*p-value is statistically significant

Simple regression analysis was applied to determine the linear relationship between the duration of injury and the Lysholm score. It implied that the outcome as measured by LYSHOLM would be 2.5 points lower every one month longer in the duration of injury. (b = -2.5; 95% CI: -3.93, -1.07; p-value = 0.001). A delay of one year in getting surgery would greatly reduce patient LYSHOLM outcome by 25 scores.

Further analysis using multiple linear regression (table 3) was applied to control covariates that were age, gender and body mass index (BMI).

<sup>2</sup>Multiple linear regression ( $R^2 = 0.43$ , the model reasonably fit well. Model assumptions are met. There is no interaction between the independent variable and no multicollinearity problem.

There was a significant linear relationship between

**Table 3:** The association of duration of injury in months and LYSHOLM score after reconstruction when other covariates were adjusted (n = 66)

variables	Adj. b <sup>1</sup>	95% CI	t-stat	p-value <sup>2</sup>
Duration of injury	-2.49	-4.11, -0.87	-3.07	0.003
Age	-0.06	-0.17, 0.05	-1.07	> 0.05
Sex	-0.11	-2.89, 2.68	-0.07	> 0.05
Body Mass Index	1.27	-1.28, 3.82	1.00	> 0.05
Pre-injury Tegner Level	-0.24	-1.84, 1.35	-0.31	> 0.05

<sup>1</sup>adjusted regression coefficients

duration of injury and Lysholm score (p=0.028) after age, sex, BMI and pre-injury Tegner level were adjusted. On average, every one-month longer duration had Lysholm score lower by 2.5 (95% CI: -4.1, -0.9) or in other words, every ten months longer of duration had Lysholm score lower by 25 on average.

Similarly, simple regression analysis was applied to determine the linear relationship between the duration of injury and LSI. This implied that every one month longer in the duration of injury, the outcome as measured by LSI would be 1.2 points lower (b = -1.16; 95% CI: -1.55, -0.76; p-value < 0.001). Thus, if there were a delay of one year in surgery, the patient's LSI would be reduced by 12 %.

Multiple linear regression was conducted to control for other covariates (Table 4). Both duration of injury and pre-injury Tegner level are the significant associated factor of LSI (p=0.002; <0.001, respectively) after age, sex and BMI were adjusted. It implied that on average, when the duration of injury was ten months longer, the LSI was lower by 10.3 (b = -1.03; 95% CI: -1.42, -0.64).

**Table 4:** The association factors of LSI among patients treated with reconstruction operation after injury when other covariates were adjusted. (n = 66)

variables	Adj. b <sup>1</sup>	95% CI	t-stat	p-value <sup>2</sup>
Duration of injury	-1.03	-1.42, -0.64	-5.32	<0.001
Pre-injury Tegner Level	4.69	1.86, 7.52	3.31	0.002
Age	-0.02	-0.21, 0.21	-0.02	> 0.05
Sex	-0.23	-5.50, 5.04	-0.09	> 0.05
Body Mass Index	0.02	-4.80, 4.85	0.1	> 0.05

<sup>1</sup>adjusted regression coefficients

<sup>2</sup>Multiple linear regression ( $R^2 = 0.67$ , the model reasonably fit well. Model assumptions are met. There is no interaction between the independent variable and no multicollinearity problem.

## Discussion:

The definition of delayed ACLR surgery varies among the authors from more than six weeks to more than 12 months.<sup>1 13-15</sup> For the purpose of current study, we define 'early ACLR' when the surgery is performed within one year of injury because we were comparing with those after one year of injury.

Our study showed that after one year of follow up postoperatively, the Lysholm score was good for both groups when we compared the early ACLR performed within one year (mean eight months) and after one year of injury (mean 18 months). Both groups in our study also demonstrate good LSI at one year follow up with only two patients in our cohort who had LSI slightly lower than 85 per cent. LSI of more than 85% after completing the rehabilitation is always preferred and is one of the criteria for return to sport.<sup>16</sup> Our findings showed that despite undergoing surgery late at an average of 18 months, the functional outcome was still satisfactory at one year follow up.

Our early ACLR group showed significantly better Lysholm scoring and LSI than the late ACLR. There were high percentage of the meniscal lesion in both groups (Table I) but higher in the late ACLR group. This was expected and likely to have contributed to the relatively superior result in our early ACLR group. Several studies have suggested that patients who undergo ACLR after one year have more intra-articular injury incidences.<sup>4 8 13 17 18</sup> This explained that those in our late ACLR group has a less superior result. The main concern about late ACLR is the development of meniscal and chondral injury secondary to knee instability.

Our statistical analysis found that duration of injury before surgery is a significant associated factor influencing the Lysholm score and LSI after age, sex and BMI were adjusted. In addition, the pre-injury Tegner level is also a significant factor of LSI but not the Lysholm score. Our analysis also showed that predicting the outcome base on LSI is more accurate than using the Lysholm score (67% vs 43%). Based on our statistical analysis in this cohort, when the patient seek treatment and the LSI is measured, then we can predict that after one year, there would be a reduction of 12 percent of the LSI. However we may need to consider the finding by Nagai et al whom noted that the hop test could result in higher LSI compared to leg press and isokinetic strength test after ACLR.<sup>19</sup>

The late ACLR group in our cohort still demonstrate a good outcome at early follow-up. It suggests that other factors should be considered besides timing from injury to surgery. One crucial factor is the activity level after the injury that may lead to further damage to the knee joint leading to a more unsatisfactory outcome. Some authors have emphasized the importance of recurrent instability episodes after the initial injury that would enhance intra-articular abnormalities.<sup>20 21</sup> The patient with frequent instability episodes would be more likely to have intra-articular lesions such as meniscal injury or chondral injury. The patient may have a short time duration from injury to surgery, but if the instability episodes are frequent during that period, then intra-articular injury would be more likely to occur, thus affecting the ACLR outcome.

On the other hand, the patient may have a chronic injury but remain cautious after that and avoid strenuous activity, resulting in a lower occurrence of instability episodes. Therefore, despite the delay in surgery, the outcome may still be favorable in this group. We believe this was the case in our cohort. It was observed in our series that patients did not involve in strenuous activity after the injury, and this may leads to lesser occurrence of intra-articular injury. However, we did not specifically assess the recurrent instability episodes in our cohort, and further study would be necessary to support this speculation.

In our opinion, Frobell et al in their level I study has made an exciting observation that in the group that underwent rehabilitation with the option of delayed ACL reconstruction only when needed. The authors noted that 23 patients from this group underwent ACL reconstruction at an average of 11.6 months, and the outcome was still comparable to the group that received early surgery.<sup>22</sup> The critical aspect in their study was that their patients were seen from the beginning of the injury, where the rehabilitation took place early. Whereas in our series, the patients presented late, which lead to delay surgery. We believe the similarity in Frobel el study and our cohort were both patients in these two studies did not involve in strenuous activity during the 'delay period' and, as a result, these patients experiencing less instability episode that eventually leads to favorable surgical outcome despite the delay in surgery.

Many literatures suggest that ACLR should be performed early for the obvious reason of fear of developing meniscal or cartilage injury. The American

Academy of Orthopaedic Surgeons (AAOS) has suggested that ACLR should be performed within five months of injury in order to minimize the risk of subsequent cartilage and meniscal injury.<sup>23</sup> Our study findings should be interpreted with caution as it is not to counter the recommendation of early surgery but rather to highlight that a good outcome is possible in a selected group of patients if the delay is not too long. The surgeon should not simply delay the surgery if there is an option to do it early.

#### *Strength and Limitation*

A single experienced surgeon conducted the surgery, and the patients underwent rehabilitation in the same central. We include all cases with meniscal lesions but had to exclude those with high-grade cartilage lesions as these patients were likely to undergo cartilage procedures. This exclusion could have 'masked' the actual outcome of surgery in our cohort. However, from a different perspective this exclusion has made our cohort represent a specific group that is those without high-grade cartilage lesions. We

believe highlighting the outcome in this specific group is worthwhile as rarely reported. Furthermore, not all patients are fortunate enough to undergo early surgery. The retrospective nature of this study is also a disadvantage, but the prospective study would be ethically inappropriate when the surgery is purposely delayed.

#### **Conclusion:**

Early follow up showed ACLR within a year of injury give a better outcome than the surgery later than a year. However, those underwent late ACLR at an average of eighteen months post-trauma could still result in satisfactory outcome in the absence of high-grade cartilage lesion. This outcome is not influenced by age, sex and body mass index. Both LSI and Lysholm scores deteriorate when the surgery is predicted to be delayed and in this regard, LSI is more accurate.

#### **Conflict of Interest and Source of Funding**

All the authors involved in this study has no conflict of interest and receive no funding.

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