Effect of Timing of Surgery in Partially Injured ACLs

Bin Li, MD; Lunhao Bai, MD; Yonghui Fu, MD; Guangbin Wang, MD; Ming He, MD; Jiashi Wang, MD

Abstract: The purpose of this study was to explore the optimal timing for surgical intervention of partially injured anterior cruciate ligaments (ACL). Thirty-eight patients were divided into early (n=17) or delayed (n=21) surgery groups based on the interval between injury and surgery. Minimum follow-up was 2 years. The outcome measures used were the International Knee Documentation Committee score, Lysholm knee score, Tegner activity rating, range of motion, and arthrometer measurements. The findings of this study indicate that early surgical reconstruction of partially ruptured ACLs did not result in arthrofibrosis but may prevent secondary loosening of the intact bundles and further meniscal and chondral injury.

The anterior cruciate ligament (ACL) consists of 2 functionally separate and distinct bundles: anteromedial and posterolateral.\textsuperscript{1,2} The anteromedial bundle is tight when the knee is in flexion, whereas the posterolateral bundle is tight when the knee is in extension, which contributes to knee stability collaboratively.\textsuperscript{3} The traditional idea is that conservation treatment to isolated partial ACL injuries can be successful and the prognosis is better\textsuperscript{3-5}; however, some studies have reported that partial ACL tears can develop into full ligament ruptures because of vascular interruption and result in necrosis of the intact fibers.\textsuperscript{6-9} Furthermore, anatomic 2-bundle ACL reconstruction has been applied clinically due to its ability to restore knee rotation stability compared with 1-bundle reconstruction.\textsuperscript{10,11} Thus, many authors now believe that most patients with partial ACL tears, particularly those who demand a high level of sporting activity, will require reconstructive surgery.\textsuperscript{12-14}

However, the ideal timing of surgical intervention for ACL tears remains controversial among arthroscopic surgeons. Some studies in the current literature have reported the effect timing of surgical intervention has on complete ACL ruptures,\textsuperscript{15-17} but few have researched the optimal timing for reconstructing partially injured ACLs.

The current study retrospectively analyzed 38 patients with isolated partially ruptured ACLs to elucidate this tissue. The hypothesis of this study was that early surgery (<3 weeks between injury and surgery) of partially ruptured ACLs, when compared with delayed surgery (≥3 weeks between injury and surgery), prevents secondary loosening of the intact bundles and further meniscal and chondral injury but does not result in arthrofibrosis.

Materials and Methods

Thirty-eight patients with unilateral partial ACL tears were treated between 2005 and 2009. All patients sustained knee trauma with mild or moderate swelling and pain and reported an inability to resume their previous activity level because of instability in the affected knee joint. Partial ACL tears were diagnosed based on a combination of factors, including an asymmetric Lachman sign or anterior drawer sign (as compared with the result in the uninjured knee),\textsuperscript{18} a negative or trace-positive pivot shift,\textsuperscript{19} an asymmetric kneelax arthrometer measurement,\textsuperscript{20} and a magnetic resonance imaging scan showing ACL disruption with the presence of high-signal intensity within the ACL, which

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may have a wavy course or focal thinning but maintains its continuity and orientation. Diagnosis of the partial tear was made during arthroscopic exploration.

The lesion involved the anteromedial band of the ACL in 30 patients and the posterolateral band in 8 patients. Twenty-six patients were men and 12 were women. Eleven left knees and 17 right knees were operated on. Mean patient age was 26.1 years (range, 17–49 years). The interval between injury and surgery ranged from 1 week to 12 months, with 17 patients operated on <3 weeks after injury. Thus, the patients were divided into early (n=17) and delayed (n=21) surgery groups.

**Surgical Technique**

One senior surgeon (L.B.) performed all procedures. After adequate anesthetization, preliminary diagnostic arthroscopy was performed via standard anterolateral and anteromedial portals. Partial rupture of the ACL was confirmed visually, and the quantity and quality of the remaining fibers were subsequently assessed through palpation and the anterior drawer test at 20° flexion for posterolateral remnant following anteromedial band injury and 70° flexion for anteromedial remnant following posterolateral band injury.

The condition of all of the relevant anatomic structures was evaluated, and any associated meniscus or cartilage injuries were identified. Meniscal lesions were treated with partial meniscectomy, and the cartilage lesions were treated with debridement. Damaged synovium was debrided, and ligament remnants at the attachment point were preserved. The intact anteromedial or posterolateral bundles were maintained carefully intraoperatively.

The semitendinosus was harvested carefully with a tendon stripper and sutured with interlacing sutures for 3 cm using #1 absorbable sutures in both ends. A tibial tunnel 6 to 7 mm in diameter was established by the register pins along the original incision for tendon removal after placement of a guide frame with the inner portal located at the anatomic insertion sites of the anteromedial or posterolateral band of the ACL on the tibia.

The femoral tunnel was created through the anteromedial portals (not transtibially) using a freehand technique with a guide to the anatomic insertion sites of the anteromedial or posterolateral band of the ACL on the femur. The prepared tendon was implanted into the tunnel. EndoButton fixation (Smith & Nephew Endoscopy, Andover, Massachusetts) was used for the femoral end, and a bioabsorbable interference screw was used to fix the tibial end as the graft was fully stretched.

**Postoperative Management**

All patients received early physical therapy and rehabilitation training under the supervision of physical therapists immediately postoperatively. Straight-leg raises and passive knee flexion exercises were started 48 and 72 hours postoperatively, respectively. Patients started to walk with the aid of crutches on day 4, with the affected leg in an extended position without weight bearing and with the protection of orthotic devices. Passive knee flexion could reach 90° one week postoperatively.

Three to 4 weeks postoperatively, patients were able to walk with crutches, with the affected leg in an extended position and partial weight bearing. Orthotic devices could be discarded and the affected leg could bear more weight between 6 and 8 weeks postoperatively until they were able to bear the entire body weight between 9 and 12 weeks postoperatively. All patients recovered by 6 months postoperatively and were able to engage in normal activities of daily living.

**Outcome Assessment**

Patients were assessed preoperatively and 24 months postoperatively with the Lysholm scale, the IKDC score, the Tegner activity scale, ROM, and kneelax arthrometer measurements, all of which were performed by the same examiner (G.W.) who was not involved in the patients’ care. The evaluation data at the latest follow-up were gathered and statistically analyzed with SPSS version 13.0 software (SPSS Inc, Chicago, Illinois). The results were compared between the 2 groups using the unpaired Student’s t test for the continuous measurements, chi-square test for the nominal data, and Wilcoxon signed ranks test for ordered categorical variables. A P value <.05 was considered statistically significant.

**RESULTS**

The groups were comparable in terms of sex, age, cause of injury, ROM, Lysholm score, and Tegner score (Table 1). Fourteen patients in the early surgery group and 16 patients in the delayed surgery group had involvement of the anteromedial bundle, and 8 patients had involvement of the posterolateral bundle. With regard to associated injuries, in the early surgery group, 1 patient had medial meniscus lesions and 1 had a lateral meniscus tear, and in the delayed surgery group, 2 patients had medial meniscal lesions and chondropathy, 2 had lateral meniscal tears and chondropathy, 3 had both menisci and chondropathy, and 2 had medial meniscal lesions only. This demonstrated that the associated lesions in patients in the early surgery group were significantly fewer than in patients in the delayed surgery group (P=.036).

As shown in Table 2, knee stability assessed by the kneelax arthrometer (30° flexion and 132 N) showed that mean side-to-side difference was 0.7±1.1 and 2.6±1.3 mm in the early and delayed surgery groups, respectively (P<.01). The stability results indicated that patients in the early surgery group had significantly less anterior displacement than patients in the delayed surgery group 2 years postoperatively.

Postoperative assessments
of knee function are summarized in Table 2. Range of motion was 123.5°±10.9° and 126.4°±12.6° in the early and delayed surgery groups, respectively, which did not reveal significant differences between the 2 groups (P=.455). Mean Lysholm scores were 94.7±9.3 and 92.2±7.8 (P=.365), and mean Tegner scores were 6.6±1.9 and 6.3±1.8 (P=.923) in the early and delayed surgery groups, respectively. In terms of the IKDC evaluation system, 17 (94.4%) patients in the early surgery group and 20 (95.2%) patients in the delayed surgery group were graded as normal or nearly normal (P=.993). No significant difference was found between the 2 groups with respect to the 3 types of assessment results. In both groups, no immediate postoperative complications required reoperation or readmission.

**DISCUSSION**

The most important finding of the current study was that, compared with delayed surgery, early reconstruction of partial ACL tears with autograft semitendinosus augmentation may not cause arthrofibrosis but may prevent secondary loosening of the intact bundles and further meniscal and chondral injury. Shelbourne et al reviewed a cohort of 169 patients and found a higher incidence of arthrofibrosis (i.e., limited extension, scar tissue) as a result of early ACL reconstruction, especially in patients with surgical reconstruction within the first week of injury. Mayr et al reviewed 156 patients with postoperative arthrofibrosis following ACL reconstruction and found that knee irritation, effusion, and swelling were highly significant when correlated with the development of arthrofibrosis. Duquin et al conducted a survey of 993 patients showing that knee ROM and the presence of knee effusion were regarded as the most important factors in deciding when to perform ACL reconstruction.

The ROM results in the current study 2 years postoperatively showed no significant difference between the early and delayed surgery groups, which means that treating partial ACL ruptures early using autograft semitendinosus augmentation did not result in

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**Table 1**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Early Surgery (n=17)</th>
<th>Delayed Surgery (n=21)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of men/women</td>
<td>12/5</td>
<td>14/7</td>
<td>.796</td>
</tr>
<tr>
<td>Mean age at surgery, y</td>
<td>24.3±4.9</td>
<td>26.5±5.7</td>
<td>.497</td>
</tr>
<tr>
<td>Cause of injury, No.</td>
<td></td>
<td></td>
<td>.998</td>
</tr>
<tr>
<td>Traffic</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Sports</td>
<td>8</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>5</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Mean ROM, deg</td>
<td>93.9±21.5</td>
<td>110.3±28.7</td>
<td>.326</td>
</tr>
<tr>
<td>Mean Lysholm score</td>
<td>61.8±6.3</td>
<td>64.5±7.8</td>
<td>.283</td>
</tr>
<tr>
<td>Mean Tegner score</td>
<td>6.1±2.5</td>
<td>6.5±2.3</td>
<td>.642</td>
</tr>
<tr>
<td>Associated lesions</td>
<td>2 total: 1 lateral meniscus lesion and 1 medial meniscus lesion</td>
<td>9 total: 2 medial meniscus lesions and chondropathy; 2 lateral meniscus lesions and chondropathy; 3 both menisci lesions and chondropathy; 2 medial meniscus lesions</td>
<td>.036</td>
</tr>
</tbody>
</table>

Abbreviation: deg, degrees; ROM, range of motion.

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**Table 2**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Early Surgery</th>
<th>Delayed Surgery</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Kneelax arthrometer, mm</td>
<td>0.7±1.1</td>
<td>2.6±1.3</td>
<td>.000</td>
</tr>
<tr>
<td>Mean ROM, deg</td>
<td>123.5±10.9</td>
<td>126.4±12.6</td>
<td>.455</td>
</tr>
<tr>
<td>Mean Lysholm score</td>
<td>94.7±9.3</td>
<td>92.2±7.8</td>
<td>.365</td>
</tr>
<tr>
<td>Mean Tegner score</td>
<td>6.6±1.9</td>
<td>6.3±1.8</td>
<td>.923</td>
</tr>
<tr>
<td>Final IKDC rating results, No.</td>
<td></td>
<td></td>
<td>.993</td>
</tr>
<tr>
<td>Normal</td>
<td>12</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Nearly normal</td>
<td>5</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Abnormal</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Severely abnormal</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviation: deg, degrees; IKDC, International Knee Documentation Committee; ROM, range of motion.
arthrofibrosis. This is probably because the patients involved in the mentioned studies had complete ACL ruptures rather than partial ACL tears, and the latter is less severe than the former.

Shelbourne and Patel\textsuperscript{25} reported that patients with ACL injuries with a minimal inflammatory response and almost normal knee ROM may be suitable candidates for an ACL reconstruction within the first 2 weeks after injury. The current study’s cutoff was set at 2 weeks because the patients with partial ACL tears showed mild or moderate swelling and pain in the affected knee, so the inflammatory response may subside within 3 weeks and the early surgery may not cause arthrofibrosis, which is similar to Shelbourne and Patel’s\textsuperscript{25} findings.

In a study of 32 patients with partial ACL ruptures with a follow-up period <2 years, Noyes et al\textsuperscript{8} observed that 38\% of partial ruptures evolved into complete tears; they also found that patients with partial ACL tears frequently had limitations for strenuous sports participation. In a study of 41 consecutive patients with partial ACL tears with a mean follow-up of 17 months, Fruensgaard and Johannessen\textsuperscript{7} observed that 51\% of tears evolved into complete ruptures. Although those patients had few symptoms, they significantly reduced their mean level of activity. In a study of 43 patients with partial ACL ruptures with a follow-up of >4.5 years, Fritschy et al\textsuperscript{8} reported that 42\% of tears developed complete ruptures.

The kneelax arthrometer results in the current study indicated that the intact ACL bundles tended to be loose because the injury-to-surgery interval of reconstructing injured bundles was prolonged, which is similar to the results reported in the 3 reported studies.\textsuperscript{5,8,25} Danylichuk et al\textsuperscript{9} reported that the reason partial ACL lesions evolve into complete tears may be the vascular interruption and necrosis of the intact fibers following their rupture. The authors of the current study thought that the intact bundles suffered continuous abnormal stress because maintaining knee stabilization after another bundle was damaged caused it to loosen gradually. The earlier the injured bundle is reconstructed, the less abnormal stress is placed on the intact bundle, thus the probability of laxity is decreased.

Several trials studied the relationship between the timing of constructing complete injured ACLs and the subsequent incidence of both chondral changes and meniscal tears. Kennedy et al\textsuperscript{11} reported that delayed surgery could significantly increase the risk of associated lesions. Granan et al\textsuperscript{16} reported that the odds of a cartilage lesion in the adult knee increased by approximately 1\% for each month that elapsed from injury to surgery, and that cartilage lesions were nearly twice as likely if there was a meniscal tear and vice versa. Papastergiou et al\textsuperscript{17} stated that the injured ACL should be reconstructed within the first 3 months after injury to minimize the risk of secondary meniscal tears. In the current study, the associated lesions’ outcomes were similar to the outcomes in the reported studies.\textsuperscript{15-17} This may be attributed to the abnormal tibiofemoral stability of ACL-deficient knees.

Limitations of the current study include the relatively insufficient follow-up period. Preoperative associated lesions were significantly fewer in the early surgery group than in the delayed surgery group, whereas assessments of knee function 2 years postoperatively, including Lysholm, Tegner, and IKDC scores, were not significantly different between the 2 groups. Longer follow-up is necessary to find the effects of these associated lesions on knee function occurring gradually. Another weakness of this study is the relatively small sample size. Patients with partially injured ACLs require a lower rate of operation. Therefore, a clinical study with a large sample size is difficult to achieve.

Despite these limitations, this study demonstrates an important and clinically relevant finding, adding support to the theory that early surgical re- construction of partially injured ACLs is beneficial for protecting the intact bundle and menisci and promotes patients resuming a normal life. The results of the current study indicate that as the time between partial injury of the ACL and surgery increases, the risk of secondary loosening of the intact bundles and associated lesions increased gradually; therefore, the ruptured band of the ACL should be reconstructed early, which may not result in arthrofibrosis.

REFERENCES


9. Danylichuk KD, Finlay JB, Kreek JP. Microstructural organization of human and bovine


