One stage revision single-bundle anterior cruciate ligament reconstruction with impacted morselized bone graft following a failed double-bundle reconstruction

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ABSTRACT
Although double-bundle anterior cruciate ligament (ACL) reconstruction has theoretical benefits such as more accurate reproduction of ACL anatomy, it is technically more demanding surgery. This report describes the case of a one stage revision single-bundle ACL reconstruction after primary double-bundle ACL reconstruction. A professional dancer had an ACL previously reconstructed with a double-bundle technique, but the femoral tunnels were malpositioned resulting in residual laxity and rotational instability. The previous femoral tunnel positions were vertical and widened. The previous vertical tunnels were filled with impacted bone graft and a revision single-bundle ACL reconstruction was performed via the new femoral tunnel with a 2 O’clock position between the previous two tunnels. After 10 months of postoperative rehabilitation, the patient returned to professional dancing with sound bony union and without any residual instability.

Key words: Anterior cruciate ligament, impacted bone graft, double bundle reconstruction, single bundle reconstruction

MeSH terms: Anterior cruciate ligament, grafting, bone, reconstructive surgical procedures, revision, surgical

INTRODUCTION
Anterior cruciate ligament (ACL) reconstruction has significantly advanced over the last few decades; however, some literatures have shown that up to 20% of patients still have persistent instability on functional testing and degenerative arthritic changes after traditional single-bundle ACL reconstruction.¹² These outcomes have led to an attempt at anatomic double-bundle ACL reconstruction. There has been a significant increase in double-bundle ACL reconstruction. Although double-bundle ACL reconstruction has theoretical benefits, such as more accurate reproduction of ACL anatomy, it is a more technically demanding surgery. Therefore, double-bundle ACL reconstruction may cause additional problems such as graft failure, graft impingement, femoral condyle fracture, and tunnel expansion.³ As the incidence of double-bundle ACL reconstruction surgery has increased, the number of failures and need for revision reconstruction have also increased. Generally, when performing revision ACL reconstruction, there are numerous problems that are anticipated to revision ACL reconstruction such as a tunnel malposition, tunnel widening, preexisting hardware and injuries to concomitant structures in the knee.⁴ Therefore, the determination of the cause of failure and preoperative plan is the first step in obtaining a successful result after revision ACL reconstruction.

The techniques available to treat the failed ACL knee include: Graft and hardware removal, dealing with bone loss and tunnel expansion, the need for a staged procedure or concomitant surgery, anatomic placement of the bone tunnels, graft selection and fixation and rehabilitation. This report describes a case of a one stage single-bundle revision...
ACL reconstruction after a failed double-bundle ACL reconstruction with vertical and widened tunnels.

**Case Report**

A 23-year-old female, who is a professional dancer, sustained an acute ACL rupture during dancing in September 2009. She underwent double-bundle ACL reconstruction with a tibialis anterior allograft in December 2009 at another hospital. After 18 months of the primary surgery, she was fully able to return to dancing. She had a re-trauma on the same knee while performing a basic dance step 6 months after returning to performance. Magnetic resonance imaging (MRI) performed elsewhere revealed a bucket handle tear of the medial meniscus but the ACL graft was still attached but loose. The patient underwent arthroscopic medial meniscus repair with an inside-out technique; however, she was unable to return to dancing due to several episodes of instability after the arthroscopic meniscus repair. When the patients sought medical attention at our institute after 3 months, examinations revealed a grade 1+ Lachman test, grade 3+ pivot shift test, and 3 mm KT-2000 (MEDmetric, San Diego, CA, USA) side-to-side differences. X-ray and computed tomographic examinations showed tunnel widening in the femur and tibia (anteromedial [AM] femoral tunnel: 15.8 mm, posterolateral [PL] femoral tunnel: 7.5 mm, AM tibial tunnel: 13.1 mm, and PL tibial tunnel: 8.1 mm) [Figure 1]. Under arthroscopic evaluation, the patient had a vertically thinned AM graft with a proximally positioned PL graft. The ACL graft was lax with a probe and situated in a grossly vertically oriented position [Figure 2a]. After the removal of all remnant grafts, the footprint of the previous femoral tunnels was revealed. A new femoral tunnel was made in the 2 O’clock position between the previous two femoral tunnels via the previous AM tibial tunnel [Figure 2b]. An impacted morselized bone graft with a cancellous allograft to the previous femoral tunnels was performed, and a new 10 mm femoral tunnel was created. Since the previous AM tibial tunnel was too wider than the width of autograft with semitendinosus and gracilis tendon, a hybrid substitute with semitendinosus tendon autograft and an Achilles tendon allograft were used. A dual fixation was performed with Endo-button CL (Smith and Nephew, Andover, MA, USA) and rigid fix (Mitek, Norwood, MA, USA) to get the strong fixation on femoral condyle with severe bone defect [Figure 2c]. The tibial fixation was performed with a spike staple (Smith and Nephew, Andover, MA, USA) and reinforced with a postie after impacting the bone graft to the previously widened tibial tunnel [Figure 3].

She underwent the delayed postoperative rehabilitation to prevent the complication of the large bone defect on the femoral condyle. 3 weeks of postoperative immobilization with a locked brace in full extension and another 3 weeks of partial weight bearing with crutches, were allowed, and followed by a gradual increase in the knee range of motion up to 90°. Running was allowed at 4 months, and plyometric functional exercise was performed 8 months postoperatively.

At 24 months postoperatively, a clinical examination revealed a negative Lachman and Pivot shift test, a KT-2000 side to side difference of 0 mm and full restoration of the range of motion. There were improvements in the Lysholm knee score from 79 to 91, and the International Knee

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**Figure 1:** Computed tomography (a) Coronal view (b) Sagittal view showing tunnel widening before revision anterior cruciate ligament reconstruction

**Figure 2:** An arthroscopic view showing (a) previous double-bundle graft, stretched both anteromedial and posterolateral graft. (b) New femoral tunnel was aiming at the 2 O’clock position between the previous two tunnels. (c) A revision single-bundle graft after a morselized bone graft with previous two femoral tunnels
Documentation Committee subjective score improved from 73 to 96. A followup MRI after 10 months of revision showed sound bony healing with an intact revision graft [Figure 4]. She returned to her professional dancing activities without any discomfort.

**Discussion**

The most important aspect to this case report was an uncommon single-bundle revision surgery after primary double-bundle ACL reconstruction and a case dealing with the large previous bone defect in one stage surgery.

Double-bundle ACL reconstruction first proposed in the 1980’s. Zantop et al. reported an anatomic double-bundle ACL reconstruction technique with two femoral and two tibial tunnels; however, the definite position for a femoral tunnel is under debate. Whilst double-bundle technique may improve the bundle appearance of the ACL, it increases the operating time in both the number of tunnels to be drilled, the placement of the tunnels and the operative complexity of passing and securing the two grafts. Double-bundle ACL reconstruction with an inaccurate femoral tunnel position leads to many problems, such as persistent instability and serious femoral and tibial tunnel widening, as with our case. Having two tunnels within the femur may leave larger bony voids within the lateral femoral condyle to fill during revision surgery. Tunnel widening also makes revision surgery difficult, which prevents patients from fully returning to their previous sports activity. Therefore, orthopedic surgeons must consider their surgical technique during a double-bundle ACL reconstruction because this surgery is more technically demanding than the traditional single-bundle ACL technique. In the present case, the two femoral tunnels were located anterosuperior to the true anatomic ACL footprint, and the AM bundle was too vertical. A malpositioned femoral tunnel after double-bundle ACL reconstruction results in an ACL graft failure and a two-femoral tunnel bony defect results in severe bone stock deficiency for revision surgery. Therefore, orthopedic surgeons must consider revision surgery problems resulting from increasing the number of tunnels; additionally, a particularly delicate surgical technique is required prior to double-bundle ACL reconstruction.

Many different methods of revision ACL reconstruction were reported. Firstly, Several choice of grafts were

![Figure 3: Postoperative X-ray of knee joint anteroposterior view showing femoral tunnels of previous double-bundle anterior cruciate ligament (ACL) reconstruction and revision single-bundle ACL reconstruction. A new femoral tunnel was made at the 2 O'clock position between the previous two femoral tunnels. Anteromedial (AM): Tunnel for AM bundle of previous double-bundle ACL reconstruction. Posterolateral (PL): Tunnel for PL bundle of previous double-bundle ACL reconstruction. Single-bundle (SB): Tunnel for revisional single-bundle ACL reconstruction](image)

![Figure 4: Coronal and sagittal magnetic resonance imaging (MRI) at 10 months followup showing incorporated bone graft and completely filling the previous femoral tunnel defect and intact graft](image)
introduced, including BPTB, hamstring, or quadriceps autograft; and those allograft.8,9 Secondly, in technical terms, Shino et al.10 reported revision ACL reconstruction with a rectangular tunnel technique and Taketomi et al.11 presented three-dimensional fluoroscopic navigation guidance for femoral tunnel creation in revision ACL reconstruction. It was also reported than revision ACL graft fixation is not different that different form primary ACL graft fixation like aperture fixation (interference screw and cross pins) and extraarticular fixation (cortical fixation devices, femoral loops and tibial cortical fixation).3 Lastly, many published reports about outcome of revision ACL reconstruction reported that an analysis of the results of ACL revision was difficult and that the outcomes of ACL revision were various because of the multifactorial nature of ACL failure, the varied revision techniques and the concomitant procedures.12 Additionally, there are many methods for managing bony deficiencies and malpositioned tunnels during a revision ACL reconstruction and large defects often require a two-stage procedure. The initial procedure consists of graft removal, tunnel curettage and bone grafting and the second stage is the revision ACL reconstruction.13 In our case, the primary ACL reconstruction failed, so the patient was unable to return to her professional occupation for 4 years. Several operations led to an economic burden and social loss. Therefore, one stage ACL revision surgery is the best choice for the patient. We have performed one stage revision ACL reconstruction using an impacted morselized bone allograft14 and this technique provides good clinical outcomes. In other words, during one stage ACL revision surgery, it is critical to correct the previously failed tunnels with an impacted morselized bone graft and a dual fixation could be beneficial.

The limitations of this study are that this is a single case report and a case series is needed in the future.

To conclude, one stage revision single-bundle ACL reconstruction with impacted morselized bone graft is one of the techniques for managing a failure after primary double-bundle ACL reconstruction with considerable bone defect.

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Conflicts of interest
There are no conflicts of interest.

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