

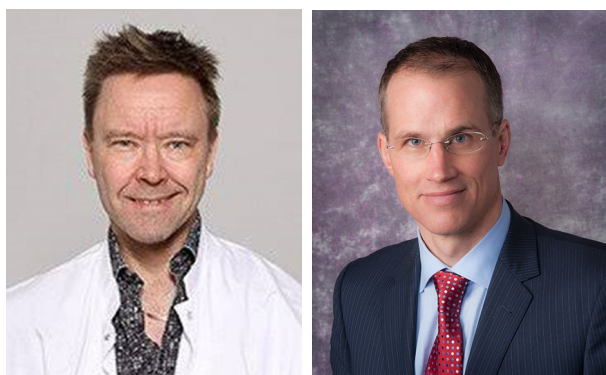


## Revising a double-bundle anterior cruciate ligament: one- or two-stage procedure?

Timo Järvelä<sup>1</sup> · Volker Musahl<sup>2</sup>

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Timo Järvelä

Volker Musahl

There are many concerns in revising a double-bundle anterior cruciate ligament (ACL). The main clinical problem or fear may be the fear of potential coalition of tunnels and maybe even fear of fracture, which could make the revision ACL surgery very difficult. In these cases, two-stage procedure with bone grafting at the first operation and revision ACL reconstruction at the second operation may be needed [2]. However, one-stage revision ACL reconstruction with good results is possibly to perform, too [11, 14]. Also, a double-bundle technique can be used at the revision ACL surgery for the malplaced and failed primary single-bundle ACL reconstruction [3, 10, 16]. In general, revision surgery is always technically demanding and challenging procedure that requires flexibility and a repertoire of surgical

techniques, and this concerns especially revision surgery after primary double-bundle ACL reconstruction.

On the 27 prospective randomised trials comparing the clinical results of double-bundle versus single-bundle techniques, 8 trials (30%) did not find any significant differences in the clinical results between these two techniques. However, 19 trials (70%) reported significantly better results with double-bundle technique than with single-bundle technique, and no study reported any superiority of single bundle technique [7]. In general, double-bundle ACL reconstruction leads to better restoration of knee laxity and subjective outcomes than single bundle ACL reconstruction, as shown in a recent meta-analysis of 40 prospective randomised trials comparing the results of these two techniques [12]. The longest follow-up of these prospective randomised trials was in the study of Järvelä et al. [4]. This study compared double-bundle and single-bundle ACL reconstruction with hamstring autografts and aperture fixation with 10-year follow-up. They reported that the revision rate of the double-bundle ACL reconstruction was significantly lower with double-bundle technique compared to single-bundle technique. Only 1 patient out of 30 patients (3.3%) underwent revision ACL surgery in the double-bundle group during the 10-year follow-up, while 10 patients out of 60 patients (16.7%) were revised in the single-bundle group during the same time period. Four other prospective randomised trials have reported fewer graft failures with the double-bundle technique compared with single-bundle techniques, too [4].

According to the Swedish National Knee Ligament Register, a total of 22,460 patients underwent an ACL reconstruction with hamstring tendon autograft during the period 2007–2014. Of these, 614 were double-bundle ACL reconstruction and 21,846 single-bundle. Double-bundle ACL reconstruction had a revision frequency of 2.0% ( $n = 12$ ) and single-bundle 3.2% ( $n = 689$ ). Single-bundle reconstruction had an increased risk of revision surgery compared with double-bundle [13].

✉ Timo Järvelä  
timo.jarvela@sci.fi

<sup>1</sup> Sports Medicine and Arthroscopic Center, Hospital Mehiläinen, Tampere, Finland

<sup>2</sup> Blue Cross of Western Pennsylvania Professor and Chief Sports Medicine, International Sports Medicine, UPMC Freddie Fu Sports Medicine Center, Co-Head Team Physician Football, University of Pittsburgh, Pittsburgh, PA, USA

According to the National Knee Ligament Registers in Denmark, Norway and Sweden from July 1, 2005 to December 31, 2014 a total of 60,775 patients with primary ACL reconstruction were retrospectively analysed. Of these, 994 patients were reconstructed with double-bundle hamstring tendon grafts, 51,991 with single-bundle hamstring tendon grafts, and 7,790 with single-bundle bone patellar tendon bone grafts. A total of 3.7% were revised in the double-bundle group (37 of 994 patients) versus 3.8% in the single-bundle hamstring tendon group (1952 of 51,991), and 2.8% of the patients were revised in the bone patellar tendon bone group (219 of the 7790 bone patellar tendon bone patients). Based on the data from three national registers, the risk of revision was not influenced by the reconstruction technique in terms of using single- or double-bundle hamstring tendons, although national differences in survival existed. Using bone patellar tendon bone grafts lowered the risk of revision compared with double-bundle hamstring tendon grafts [1].

In a recent retrospective review of the consecutive series of one experienced ACL surgeon during the period of 15 years, a total of 1319 patients underwent an ACL reconstructions, of which 716 were performed using double-bundle technique and aperture fixation with bioabsorbable screws. Out of these patients with double-bundle ACL reconstruction, only 4 patients underwent ACL revision surgery, because of graft failure caused by new knee injury [5]. The revision rate of the double-bundle ACL reconstruction in this retrospective consecutive series of one experienced ACL surgeon was 0.6%, which is very low.

The most common pattern of the double-bundle ACL graft re-rupture at the time of revision ACL surgery has been shown to be mid-substance anteromedial (AM) and posterolateral (PL) bundle rupture [15]. A revision surgery for the ruptured double-bundle ACL graft can be performed as one-stage operation using either the same tunnels than on the primary surgery or by drilling new PL tunnel [8]. One-stage revision ACL reconstruction using bone patellar tendon bone autograft after failed primary double-bundle ACL reconstruction provides almost compatible postoperative clinical outcomes and knee stability with primary ACL reconstruction using similar autograft [14]. If the femoral tunnels are malpositioned, the new femoral tunnel can be drilled between the previous two tunnels with filling the previous vertical tunnels with impacted bone graft at the same operation [11]. In this particular case, after 10 months of postoperative rehabilitation, the patient returned to professional dancing with sound bony unit and without any residual laxity.

In the experience with 4 consecutive revision cases after failed double-bundle ACL reconstruction from the total of 716 primary double-bundle ACL reconstruction during the time period of 15 years, no significant tunnel enlargement

was found. So, only bigger holes were drilled to old antero-medial (AM) tunnels of the ACL, and a revision ACL reconstruction with a single-bundle technique using bone patellar tendon bone or hamstring autograft and interference screw fixation was performed [5]. One-stage revision of the double-bundle ACL could be performed, because there was no significant tunnel enlargement or tunnel communication at the revision ACL surgery. This may be due to the fact that there was no tunnel communication at the primary operation, either. Otherwise the aperture fixation with bioabsorbable screws would be very difficult or even impossible to perform. In addition, the previous magnetic resonance imaging (MRI) studies have shown that there is less tunnel enlargement with double-bundle technique comparing to single-bundle technique at 2 years [6], and the ossification of the bioabsorbable screws and tunnels have already started at 5 years [9].

Revising a double-bundle ACL can be a demanding and challenging procedure, as a revision surgery in general usually is. The revision rate of double-bundle ACL reconstruction is quite low, from 0.6 to 3.7% [1, 4, 5, 13]. Maybe because of that, there are only few studies to describe the techniques and results of revision ACL surgery after failed primary double-bundle ACL reconstruction.

Pre-operative planning with 3D-CT imaging helps to evaluate if there is so much tunnel enlargement or tunnel communication that two-stage procedure with bone grafting at the first operation and revision ACL surgery at the second operation is needed [2]. However, one-stage revision is possible to perform, too [5, 8, 11, 14]. In these cases, the revision surgery was performed with single-bundle technique using bone patellar tendon bone autograft [5, 14], hamstring tendon autograft [5, 11], or Achilles tendon allograft [11]. If the tunnels were optimal on primary ACL reconstruction, the same AM tunnels were used by drilling the tunnels bigger than before [5]. In the case of malpositioned tunnels at the primary double-bundle ACL reconstruction, new tunnels were drilled to the anatomic position of the native ACL [8, 11]. Also, the revision ACL surgery could be performed with double-bundle technique using the both previous tunnels at the revision surgery [8].

In conclusion, the revision surgery of the failed primary double-bundle ACL reconstruction is a rare occurring according to the reported revision rates in the literature. It is a demanding procedure, which needs a careful pre-operative planning and repertoire of different surgical techniques. In the case of severe tunnel enlargement or tunnel communication two-stage procedure with bone grafting at the first operation and revision ACL reconstruction at the second operation may be needed. However, it is possible to perform as one-stage procedure with good clinical outcomes, too.

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