

Anterior Cruciate Ligament Repair with Internal Brace Ligament Augmentation

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ABSTRACT

Background: Anterior cruciate ligament (ACL) reconstruction using tendon or ligament autograft is the gold standard surgical treatment for acute ruptures; however, this is still associated with subsequent problems and variable outcomes. Renewed interest in healing of injured ACL tissue has led to new surgical repair techniques.

Case Description: We report the case of one of the first patients to undergo this novel procedure of ACL repair with internal bracing. An internal brace is a bridging concept using braided suture tape and knotless bone anchors to reinforce ligament strength. We followed the case of one of the first patients to undergo this technique over two years post-operatively.

Outcomes: In this case, we present a good functional outcome along with radiographic and arthroscopic evidence of a healed ACL with normal appearance. The successful application of this technique has been demonstrated.

Discussion: ACL repair techniques are re-emerging as a promising treatment option for acute proximal ruptures. Repair of the ACL can be performed successfully and has the advantage of retaining the natural proprioceptive fibres of the ligament. The internal brace acts as a secondary stabiliser after repair, which may allow accelerated rehabilitation and return to sports, whilst resisting injury recurrence when this is possible.

Conclusions: Repair with internal bracing of the ACL provides an unobtrusive support which allows accelerated recovery. In this case, we demonstrate with radiographic and arthroscopic evidence, a robustly healed ACL after repair with internal bracing. Functional outcomes are excellent over two years following surgery and long term; retained proprioception may prevent re-injury and development of post-traumatic osteoarthritis.

INTRODUCTION

The anterior cruciate ligament (ACL) is one of the main stabilising structures of the knee joint in several movement planes, but primarily acts as the main restraint to anterior translation of the tibia with respect to the femur.¹ It is thought that the ACL also carries a number of proprioceptive fibres, playing a key role in the sensing of joint position.² Indeed, studies show that ACL-deficient knees have more proprioception deficits compared to uninjured and control groups.³

The ACL is the most commonly injured knee ligament and the injury often occurs in young, active, and otherwise healthy individuals.^{4,5} It is most often damaged from a non-contact, sudden torsion, or hyperextension of the knee in sports such as football, basketball, or skiing, with females having a higher risk of being affected than males.⁶

Acutely, these injuries often result in joint effusion, pain, altered movement, and instability. This leads to muscle weakness, reduced functional performance, and inability to perform sporting or occupational activities with knock-on

socio-economic effects.⁷ Longer term, ACL injuries are linked to the development of early onset post-traumatic osteoarthritis.^{7,9} In view of this, surgical intervention has strived to restore normal knee biomechanics to improve function and prevent long-term sequelae.

Historically, the healing capacity of the ACL is thought to have been poor,¹⁰ with failure rates thought to be higher than 40% after early attempts at surgical repair.^{11,12} In a randomised controlled trial in 1987, Sandberg showed that there was no difference in outcomes after early primary repair versus conservative treatment.¹³ Although no explanation of why these repairs were failing was ever shown, unsatisfactory outcomes led to abandonment of the primary repair technique in favour of ACL reconstruction.¹⁴

ACL reconstruction has remained the gold standard procedure for ACL injuries until the present day. Autologous hamstring or patella tendon graft is used to replace the ACL, removing all the remnants of the injured ligament in the process.¹⁵ However, ACL reconstruction has been associated with a number of problems. Firstly, a degree of morbidity is associated with autografts, with hamstring muscle weakness following har-

vesting,¹⁶ and anterior knee pain common with patellar tendon grafts.^{17,18} Secondly, reconstruction with graft material does not restore the proprioceptive properties that the native ligament possesses, which possibly explains why some athletes never regain the same level of sporting performance as pre-injury, even after reconstruction.^{3,15,19} Thirdly, and possibly subsequently, long-term follow-up data shows high rates of post-traumatic osteoarthritis within 20 years, despite treatment with ACL reconstruction.^{7,9,20,21}

Realisation of these limitations of reconstruction has led to renewed interest into other techniques which could improve outcomes after ACL surgery. Modern arthroscopic surgical instrumentation has made repair of ACL tissue easier and advancements in functional tissue engineering and regenerative medicine have resulted in a renewed interest in ACL repair.¹⁰ This is an attractive option to restore normal patient anatomy, retaining proprioceptive fibres, and not causing donor site morbidity that can be associated with reconstructions.

Steadman et al.²² described the "healing response technique" for treatment of complete, proximal ACL tears in a

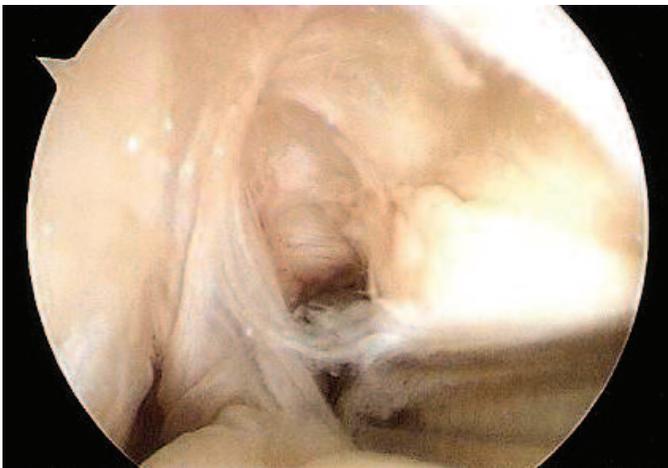


Figure 1. Arthroscopy picture demonstrating complete proximal tear of ACL.

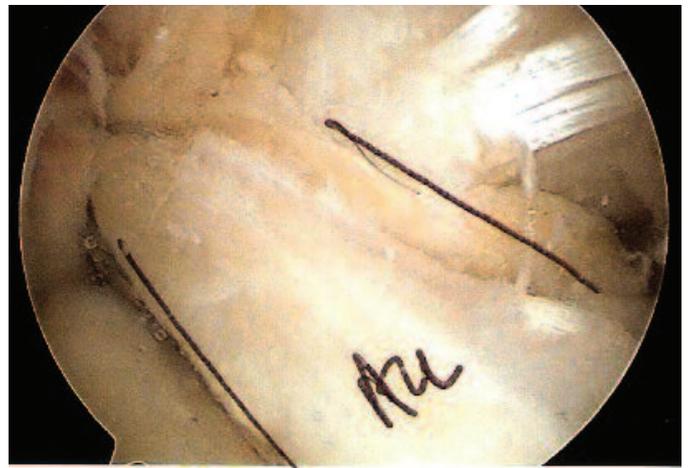


Figure 2. Arthroscopy picture demonstrating repaired ACL with internal bracing.



Figure 3. MRI sagittal image showing healed ACL two years after repair.



Figure 4. Arthroscopy picture demonstrating healed ACL two years after repair.

mature, active population who presented within six weeks of injury. This technique involves ligament repair with bone marrow stem cells used to promote ligament healing and then to limit range of motion during the healing period. Short-term results using this technique have been promising but rehabilitation is slowed by external bracing causing immobilisation in the early stages.

The senior author of this paper has developed a technique in which ACL repair can be carried out arthroscopically and is protected by an internal brace ligament augmentation (IBLA).²³ An internal brace is a bridging concept using braided suture tape and knotless bone anchors to reinforce ligament strength, acting as a secondary stabiliser after repair and on return to sports, which may allow accelerated rehabilitation without external protection and may resist injury recurrence. Initial pilot studies have shown good short-term outcomes,²³ and in this paper we report the case of one of the first patients to undergo this novel procedure of ACL repair with internal bracing.

CASE PRESENTATION

A 52-year-old woman—who is otherwise fit and well and is an active enthusiast of outdoor pursuits—presented to the orthopaedic clinic. She had been skiing three weeks previously when she lost her balance and fell, twisting her right knee. Her ski boot released from the ski but, as she fell, she heard an audible pop and felt pain in the knee. This was fol-

lowed by large swelling of the knee within hours of the injury. She did not ski for the rest of the trip and consulted her local emergency department upon return. A radiograph at this stage demonstrated no acute bony injury and she was reassured; however, she struggled to mobilise in the coming weeks. Pain persisted in the medial and posterior parts of the knee and she was unable to fully extend the joint.

On examination three weeks after the injury, she had persistent swelling which was aspirated confirming a haemarthrosis. She was lacking 10 degrees of extension but had full flexion. She had no collateral instability, but an anterior drawer test and a Lachman's test were positive in keeping with a complete rupture of the ACL. In view of her age and activity profile, she was considered a good candidate for arthroscopic ACL repair or reconstruction to aim to restore her function. The decision as to which technique would be employed would be taken intra-operatively and the patient was made aware of the risks and potential benefits of each procedure and duly consented.

TREATMENT

A knee arthroscopy was carried out one week later, now four weeks following her injury. On examination under general anaesthetic, her knee was unstable with a positive pivot shift test. Arthroscopically, she had a complete tear of the proximal ACL (Fig. 1). She also had grade III chondromalacia of the

medial femoral condyle. Appearances of the remaining structures were normal.

As the ACL rupture was in the proximal portion, the decision was made to proceed with the newly developed technique of ACL repair and internal bracing, which was pioneered by the senior author. This was the first time the technique had been used *in vivo*.

The ACL repair technique involved repair of the ligament where it had avulsed from its femoral attachment on the medial wall of the lateral femoral condyle. The surgical technique has been described in detail in our previous paper as follows²³: The ACL remnant was “whip stitched” using an arthroscopic suture passing instrument (Scorpion™ FastPass—Arthrex, Naples, Florida). The proximal end of the ACL was then re-approximated against the medial wall of the lateral femoral condyle, in an anatomical mid-bundle position (Fig. 2). The bone on the femoral condyle at the anatomical insertion point was freshened with a microfracture probe. The repair was then protected using the Internal-Brace™ Ligament Augmentation Repair device, a 2.5 mm braided ultrahigh-molecular-weight polyethylene tape bridging from tibia to femur. Tensioning of the InternalBrace™ was carried out with the knee in extension. To facilitate the repair—and for the InternalBrace™ fixation—3.5 mm tunnels were drilled in the tibia and femur. Fixation of the repair stitch and Internal Brace proximally was carried out with the ACL TightRope® (Arthrex, Naples, Florida) whilst distal fixation of the Internal Brace was carried out with the Swive-Lock® Suture Anchor (Arthrex, Naples,

Florida).

Post-operatively, the patient underwent the standard ACL rehabilitation programme for our institute, which consists of early accelerated recovery and full weight bearing with no limitation on movement.

OUTCOME

The patient's peri-operative period was problem-free and she was discharged with an exercise programme and weekly physiotherapy sessions. She was reviewed at two weeks, five weeks, 10 weeks, and four months post-operatively. At each stage, she made steady progress with no pain or instability. At four months, her knee was stable and she had a full range of movement with excellent muscle tone. She was back attending the gym five times per week

and extremely happy with her outcome. She was discharged from our care and went on to lead the same active lifestyle that she had pre-injury, including skiing at the same level without any irritability.

Unfortunately, two years later the patient returned after she had re-injured her right knee eight days prior. While attempting to wash her foot in a sink, she fell backwards, twisting her knee. Since then, the knee had been locked and she was aware of some localised medially-based discomfort.

On clinical examination, she did lack a few degrees of extension and there was marked tenderness at the medial joint line and over the medial collateral ligament (MCL). Stressing of the ACL was stable, but there was a clinical suspicion of an MCL injury.

She had an MRI scan of the knee which confirmed a grade II/III MCL sprain, but crucially demonstrated that

the ACL repair was intact (Fig. 3).

Shortly after the scan, she underwent arthroscopy for chondroplasty of an unstable cartilage defect on the medial femoral condyle. This provided the opportunity to arthroscopically inspect the healed ACL which was normal in appearance (Fig. 4) and was robustly stable on stressing (Vid. 1).

She made a full recovery after this procedure and has again returned to her full level of function without symptoms, now almost three years since the primary procedure. Her Lysholm score is 100 and Tegner activity scale level 6, unchanged from pre-injury levels. Her Knee Injury and Osteoarthritis Outcome Score (KOOS) is currently 98.2.

DISCUSSION

The last five years has seen significantly renewed interest in the application of repair techniques for ACL injuries. Early outcomes have been promising with success rates far exceeding those described historically.²⁴ Steadman demonstrated that the healing response procedure allowed patients to return to high levels of recreational activity and to restore knee function to normal levels, in a select group of mature patients with acute proximal ACL tears.²² However, others have found high revision rates when using the technique in younger patients.²⁵ This could be due to higher demands placed on the repair and pressure for faster rehabilitation and earlier return to sporting activity. The rehabilitation in the early phases was slowed by protective external bracing of the knee to protect the healing ligament.

In order to combat these issues thought to contribute to failure of primary ACL repair, a new technique has emerged using internal brace ligament augmentation to stabilise the healing ligament. The internal brace is a bridging concept using braided ultrahigh-molecular-weight polyethylene/polyester tape and knotless bone anchors. The goal of this is to protect the repaired ligament from noncompliant patient activity and subsequently from failure during early rehabilitation. Furthermore, the internal brace may act as a secondary stabiliser after return to sport, preventing secondary injury or construct elongation over time. The



Figure 5. MRI sagittal image showing bone loss associated with traditional ACL reconstruction tunnels.

technique has also been described regarding the medial knee structures²⁶ and shown to result in positive outcomes with a low rate of complications for tendon repair in the shoulder rotator cuff²⁷ and Achilles²⁸, and ligaments of the ankle^{29,30,31} and elbow.³²

The case we have presented highlights a successful application of this newly developed technique for ACL repair with internal bracing. Importantly, this patient presented early post-injury, with suggestions that if primary repair is to be attempted it should be within six weeks. The experience of the senior author suggests that residual ACL tissue may persist up until three months from the injury.²³ Additionally, this patient had a proximal ACL rupture close to the femoral insertion which is the most common pattern of injury and the one which is suitable for this technique. In cases where insufficient tissue is present for repair, or the rupture is too distal, a classical reconstruction technique provides a second option. Indeed, tunnels for repair suture placement and internal brace anchoring are drilled in such a way that they can be utilised for subsequent reconstruction if failure were to occur.²³ These tunnels are, however, significantly smaller in diameter than those used in reconstruction (Fig. 5). The result of this is less bone loss and possibly less stimulation of post-traumatic osteoarthritis.

Previous outcome studies have used subjective and objective knee outcome scores and assessment of function. This patient had a good functional outcome, returning to skiing, whilst at a recreational level; still a significant level of activity for her age. There has, however, until now, not been any definitive evidence that the ACL has healed with this technique. Favourable function and stability could be due to the presence of the internal brace. This would, however, be analogous to reconstruction, lacking the perceived benefits of repair. In this case, we demonstrate using MRI scanning and direct arthroscopic visualisation that the repaired ACL has completely healed and is robustly stable on stressing, two years down the line. This means that, in addition to stability, this patient has the added benefit of retained native ACL tissue exhibiting proprioceptive qualities, with benefits in coordination, balance, and overall function. This theoretical maintenance of normal knee kinematics may help prevent the

development of early onset osteoarthritis that has been proposed after cases of ACL reconstruction.^{7,8,9} This has the potential to offer more benefit to younger patients with this injury. This patient had grade 3 cartilage wear on her medial femoral condyle at initial presentation, but the repair may prevent acceleration in its progression.

CONCLUSION

ACL repair techniques are re-emerging as a promising treatment option for acute proximal ruptures. Repair with internal bracing of the ACL provides a stabiliser which allows accelerated recovery and quicker return to sport. In this case, we demonstrate with radiographic and arthroscopic evidence, a robustly healed ACL. Functional outcomes are excellent over two years following surgery and long term, retained proprioception may prevent re-injury and development of post-traumatic osteoarthritis. **STI**

AUTHORS' DISCLOSURES

Dr. MacKay is a consultant for, and receives royalties from, Arthrex, Inc. All other authors have no conflicts of interest to disclose.

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