All Arthroscopic Suture-Bridge Fixation of a Delaminated Chondral Fragment

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Internal fixation of a traumatic chondral or osteochondral defect presents a therapeutic challenge in terms of obtaining an anatomic congruous reduction and stable fixation with adequate compression to promote healing. We sought to retrospectively evaluate the clinical and functional outcome of a 12-year-old boy treated with a new all-arthroscopic suture bridge fixation method for a large thinly delaminated chondral defect in the medial trochlea. We describe, for the first time, treatment of a large chondral defect by an all arthroscopic suture bridge construct formed by biodegradable, knotless bone anchors and absorbable suture distal to femoral physis. At about 24 months, the patient had retained full painless range of knee motion and returned to competitive sports. The all-arthroscopic suture bridge technique appears to be a viable alternative for treatment of traumatic osteochondral fractures of the knee.

Introduction

Articular cartilage lines the surface of joints and transmits the forces generated with joint loading. When damaged, it has poor healing potential[1]. Conditions such as osteochondritis dissecans, trauma, and occasionally avascular necrosis, can create free or detached fragments of articular cartilage with varying amounts of attached subchondral bone. Detached fragments require operative intervention because of the intra-articular loose body. With removal of a detached fragment, the resultant articular incongruity can lead to rapid joint degradation. If possible, fixation of the loose or detached osteochondral fragment can lead to healing of the fragment and good long-term outcomes[2].

Multiple techniques have been described for fixation of loose osteochondral fragments with open, mini-open and arthroscopic assisted approaches[3]. The earliest descriptions were of headed metal screws, which necessitated a repeat surgical procedure for implant removal[4]. Headless, and more recently bio-absorbable headless compression implants, have been developed that eliminate the need for subsequent surgery to remove the implants[5,6]. Because these devices need to be countersunk below the level of the articular cartilage to avoid damage to the apposing articular surface, all of these techniques depend on their interaction with the subchondral bone to achieve fixation. Thus as the thickness of subchondral bone on the free piece decreases, the stability of the fixation afforded by these devices would be expected to decrease.

Recently, two case series of suture bridge fixation of loose osteochondral fragments have been described with good results[7,8]. In these cases, drill hole tunnels were created from four corners of the defect to an area away from the articular surface. Two absorbable sutures were then passed in a cross configuration, capturing the free fragment in the defect. The sutures were then tied over a bone bridge off of the articular surface. Because this technique does not require fixation based on the integrity of the subchondral bone on the free piece, it is a useful technique for thinly delaminated osteochondral fragments, or osteochondral pieces where the integrity of the subchondral bone has been compromised. It also affords uniform compression across the piece to promote healing and more secure fixation at the edges of the lesion where edge loading and catching during range of motion would be thought to lead to early failure. A notable downside to this approach is the requirement of a large open arthrotomy with all the attendant risks and rehabilitation delays.

Based on the clinical success of this fixation method, and the proposed biomechanical advantages, we have devised an all-arthroscopic technique to secure osteochondral fragments with a suture bridge construct. (Figure 1) We present a case in which successful fixation of a completely displaced, thinly-delaminated chondral fragment involving most of the medial trochlea was achieved in the knee of a 12-year-old skeletally-immature boy. This is the first description in the literature, to our knowledge, of an all arthroscopic suture bridge fixation of a completely displaced osteochondral fracture in the knee joint.

Case Report

A 12-year-old boy presented with persistent pain and swelling in his right knee following a twisting injury while skateboarding about two weeks earlier. He did note several months of prior intermittent knee pain and occasional mild limping after running in basketball and lacrosse but had no prior mechanical symptoms or swelling. Physical examination revealed a large effusion and tenderness over the medial joint line anteriorly. He had limited motion, lacking 10 degrees in extension and only flexing to 100 degrees. No ligamentous laxity was noted. Magnetic resonance imaging showed a large full thickness chondral defect of the medial trochlea

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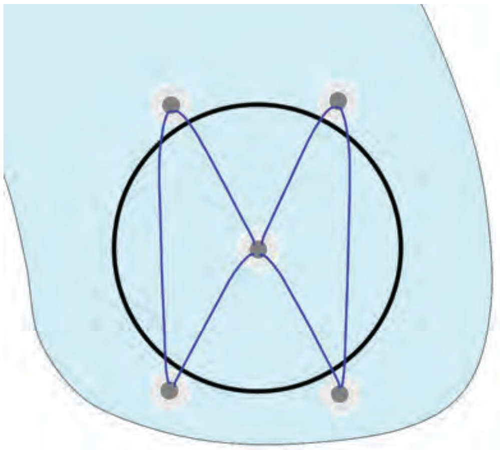

Figure 1. All arthroscopic suture bridge schematic. A knotless Pushlock suture anchor is placed in the middle of the lesion. The impact nature of the anchor provide initial compressive fixation. The central anchor is loaded with two absorbable monofilament sutures leaving four strands exiting this fixation point. One strand is taken to one corner, tensioned and fixed to a second Pushlock anchor. A second strand is similarly fixed. The free sutures from these first two peripheral anchors are then combined with one of the central sutures, tensioned, and fixed to the other two corners.

with a large free fragment lying in the lateral gutter of the knee. (Figure 2 A&B) After full discussion with the patient and his family and with their written informed consent, it was decided to fix the fragment with all-arthroscopic suture bridge technique.

All Arthroscopic Suture Bridge Osteochondral Fragment Fixation Technique

Standard anteromedial and anterolateral arthroscopy portals were created. An isolated large defect measuring approximately 3 x 3-1/2 cm was noted on the medial trochlea. The defect appeared to be a full thickness cartilage delamination. (Figure 2C) There was no loss of the subchondral bone and the contour of the bone appeared normal. The calcified cartilage layer appeared to have been removed with the free fragment. A large chondral free fragment was present in the lateral gutter. The fragment had only scattered areas where any bone could be appreciated on its non-articular surface. The donor site was prepared by removing the small amount of fibrinous material in the lesion and trimming

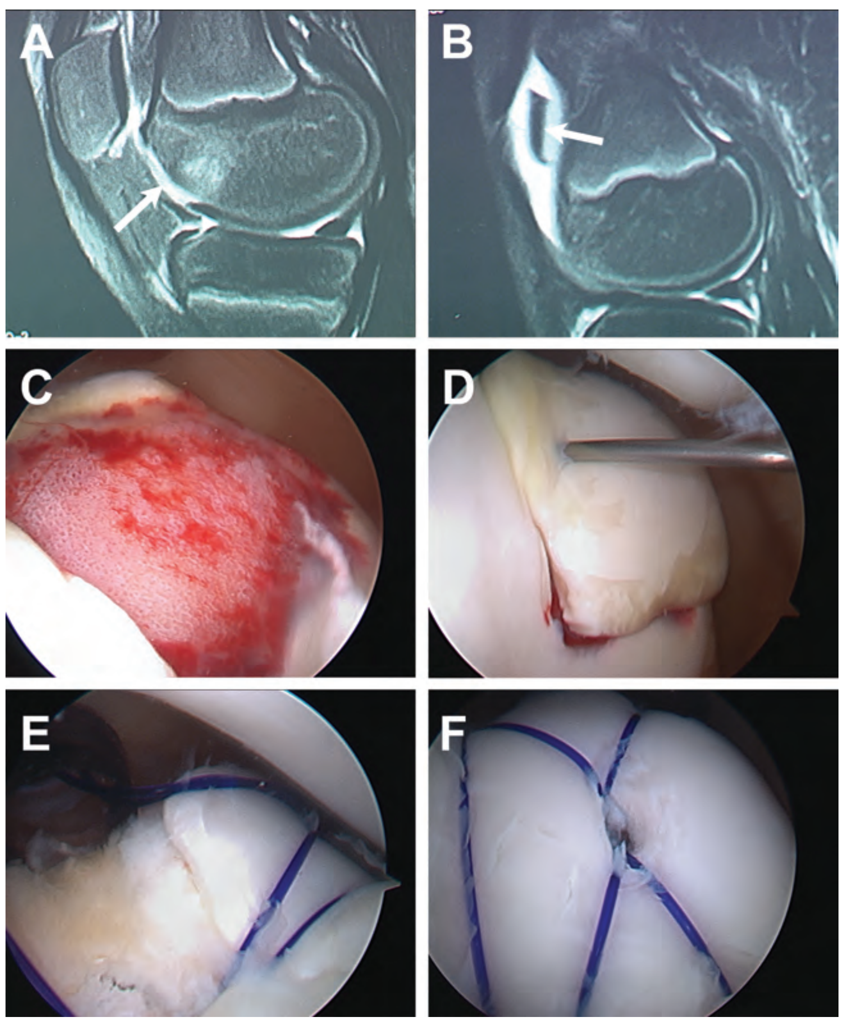

Figure 2. Case example of suture-bridge used to secure a large thinly delaminated osteochondral lesion. A 12-year-old male presented after minimal trauma to his left knee complaining of pain and mechanical symptoms. (A&B) Sagittal T2-weighted MRI imaging revealed a chondral delamination of the medial trochlea with an associated large loose body (arrows). (C&D) Intra-articular arthroscopic photos demonstrating the large lesion and provisional fixation of the large free fragment. (E&F) Arthroscopic photos at the anterosuperior edge and the center fixation points following secure fixation with 5 Pushlock anchors and 0 Maxon suture.

the edges of the lesion to stable vertical walls of surrounding articular cartilage. Multiple perforations were made in the base of the lesion with a 0.045 inch Kirschner wire. A probe was used to gently manipulate the loose body into position and a spinal needle was used to hold it reduced. (Figure 2D) With the knee in slight extension, a small accessory portal was created and a 2.9 mm Pushlock anchor (Arthrex,Naples,FL) preloaded with two number 0 monofilament absorbable sutures (Maxon, Covidien,Ireland) was then placed in the center of the fragment. This left four strands of suture exiting the central anchor point. A 5.5 mm cannula was then placed into the anteromedial portal. One of the central sutures was retrieved and threaded through a second 2.9 mm Pushlock anchor. This anchor was placed just over the fragment edge posteromedially. A second suture was retrieved from the center and passed to a third anchor placed just off the posterolateral corner of the fragment. The knee was brought into extension and an accessory superomedial portal created. Another 5.5 mm cannula was placed in this portal. A third central suture and the free strand from the posteromedial anchor were then retrieved and tensioned to a fourth Pushlock anchor placed in the anteromedial corner. This process was repeated for the last central suture and the free strand from the posterolateral anchor to a fifth Pushlock anchor at the anterolateral corner. (Figure 2 E&F) The knee was cycled through flexion and extension a number of times and adequate stability of the fragment was noted. The free ends of suture exiting the anterior anchors were cut flush.

Isometric quadriceps strengthening and continuous passive motion was started immediately after surgery. He was instructed to remain non-weight bearing for six weeks following surgery and then gradually return to full weight bearing over the course of the next six weeks. He limited strenuous bent knee activities for 3-4 months post-operatively. By six weeks after surgery, he was pain free with no effusion and had achieved full active and passive knee range of motion. He returned to sports at about 6 months following surgery, and at 24 months was still pain free and participating in sports without any swelling or mechanical problems.

Discussion

The goal of osteochondral fragment fixation is to restore anatomic articular surface congruity and ensure complete osseous and cartilage healing. To do this and allow for immediate rehabilitation of the knee, fragment fixation must provide adequate compression and rigid stabilization of the fragment to permit early range of motion and promote healing.

Bio-absorbable pins and screw fixation have been described for fixation of these lesions with good results[5,6]. Advantages of these types of fixation are that the bio-absorbable implants do not necessitate removal, and they are compatible with post-operative MRI. The disadvantages are possible fragmentation during screw insertion, abrasive wear of the articular surface, osteolysis around the implants, and the possibility of implant loosening and dislodging back into the joint[9,10].

The suture-bridge fixation technique described is in keeping with the essential principles of osteochondral fracture fixation and because the suture bridge technique does not require fixation based on the integrity of the subchondral bone on the free piece, it is a useful technique for thinly delaminated osteochondral fragments, or osteochondral pieces where the integrity of the subchondral bone has been compromised in traumatic conditions[7,8]. The suture bridge technique produces compression over a large area of the free fragment to facilitate healing. Suture traversing the edge of the fragment to the surrounding unaffected articular cartilage at multiple points can provide a more uniform transition to prevent catching and residual step-off at the repair site. Despite the fact that there is suture at the articular surface with this technique, in clinical practice, the size of the suture is significantly less than the step-off that can be present at the edge of the repair site using current fixation devices. The technique described also slightly countersinks the suture into the cartilage, which makes this technique most useful in younger patients with thicker more pliable cartilage.

In 2008, Bowers et al[7] described the suture bridge technique with successful results in the knee joint in 2 skeletally mature patients using an arthroscopically assisted open approach. Sodl et al[8] described a similar technique for successful fixation of a capitellar osteochondral sheer fracture. This is the first report, to our knowledge, of successful suture bridge fixation of an osteochondral fracture of the knee joint through an all-arthroscopic approach in a skeletally immature athlete. We believe that, compared with open approaches, the all-arthroscopic technique provides the classically described advantages of arthroscopy including improved postoperative pain profile and earlier rehabilitation.

The main theoretical disadvantage of the suture bridge technique is that suture drapes over the free fragment at the articular surface. Because permanent non-absorbable suture material may cause abrasive wear on the apposing articular surface over time, absorbable suture is recommended. Bowers et al[7] have argued that a braided absorbable suture is more advantageous for an articular cartilage suture bridge construct because of its dissolution characteristics. In tissue, the braided absorbable suture Polyglactin 910 (Vicryl) retains about 65% of its tensile strength at 14 days[11]. It undergoes minimal absorption for 40 days then undergoes rapid complete hydrolysis by 56-70 days[11]. In tissue, the monofilament sutures Polydioxanone (PDS II) and polytrimethylene carbonate (Maxon) have a similar strength retention time line, retaining 70% of their tensile strength at 14 days and providing enough strength to support wound closure past 6 weeks[11]. Absorption is minimal for about the first 3 months, and is complete by 6 months[11]. No studies exist evaluating the strength retention characteristics or the dissolution time of these sutures in the intra-articular environment, however both braided and monofilament sutures seem to have sufficient longevity to allow for fragment healing. It is likely the size, and thus the initial strength, of the suture that makes the biggest difference. We chose monofilament suture because of its lower coefficient of friction in the intraarticular environment and its decreased propensity to induce an inflammatory reaction[11].

While this report primarily highlights a technique for osteochondral free fragment fixation, to our knowledge, it is also the second report of successful healing of a chondral delamination. Conventional teaching has purported that chondral fragments devoid of bone have minimal likelihood of successful healing. Some argue that chondral avulsions in children universally have microscopic amounts of bone on the undersurface, which allows for more unique healing properties in young patients. It could be that lack of healing in young and old patients alike was in part due to the lack of fixation devices sufficient to create a stable healing environment. With improved fixation methods, including the suture-bridge methods described here, this notion may be challenged.

At the latest follow-up contact, after about 24 months, this patient had retained full painless knee range of motion and returned to competitive sports. However, despite his early good clinical result, we feel more patients with long-term clinical and radiographic follow-up are needed to further document safety and efficacy of this technique. MRI could be used in evaluating the status of the articular cartilage and prevent the need for second look arthroscopic or histological evaluation[12-14]. Future evaluation will also center on the effect of the suture draped over the articular surface. Nevertheless, the suture bridge technique of osteochondral fragment fixation employs all the essential principles of traumatic osteo-articular fixation allowing immediate knee motion without associated risks of open surgery. In keeping with prior publications by others at this institution regarding suture bridge chondral fixation we believe that the all arthroscopic suture bridge technique is a viable alternative for treatment of traumatic osteochondral fractures of the knee.

References:

1. **Buckwalter JA, Mankin HJ.** Articular cartilage. Part II : degeneration and osteoarthrosis, repair, regeneration, and transplantation. *J Bone Joint Surg Am.* 1997;79;612-32.
2. **Magnussen, R. A.; Carey, J. L.; and Spindler, K. P.** Does operative fixation of an osteochondritis dissecans loose body result in healing and long-term maintenance of knee function? *Am J Sports Med,* 37(4): 754-9, 2009.
3. **Jani, M. M., and Parker, R. D.** Internal Fixation Devices for the Treatment of Unstable Osteochondritis Dissecans and Chondral Lesions. *Oper Tech Sports Med,* 12: 170-1175, 2004.
4. **Lewis PL,Foster BK.** Herbert Screw fixation of Osteo-chondral fractures about the knee. *Aust NZ J Surg.* 1990;60:511-513.
5. **Mashoof AA, Scholl MD, Lahav A, Gries PE, Burks RT.** Osteochondral injury to the mid-lateral weight bearing portion of the lateral femoral condyle associated with patella dislocation. *Arthroscopy.* 2005;21:228-232.
6. **Nakamura N , Horibe S, Iwahashi T, Kawano K, Shino K and Yoshikawa H.** Healing of a Chondral fragement of the knee in an adolescent after internal fixation *j Bone Joint Surg Am* 2004;86:2741-46.
7. **Bowers, A. L., and Huffman, G. R.** Suture bridge fixation of a femoral condyle traumatic osteochondral defect. *Clin Orthop Relat Res,* 466(9): 2276-81, 2008.
8. **Sodl, J. F.; Ricchetti, E. T.; and Huffman, G. R.** Acute osteochondral shear fracture of the capitellum in a twelve-year-old patient. A case report. *J Bone Joint Surg Am,* 90(3): 629-33, 2008.
9. **Kendra L. Millington, Jay P. Shah, Diane L. Dahm, Bruce A. Levy and Michael J. Stuart.** Bioabsorbable Fixation of Unstable Osteochondritis Dissecans Lesions *Am J Sports Med* 2010 38: 2065.
10. **Larsen MW, Pietrzak WS, DeLee JC.** Fixation of osteochondritis dissecans lesions using poly(1-lactic acid)/poly(glycolic acid) copolymer bioabsorbabale screws. *Am J Sports Med* 2005;33:68-76.
11. **Lai SY, Becker DG, Edlick RF.** Sutures and Needles. *eMedicine*, downloaded from http://emedicine.medscape.com/article/884838 on 3/31/2011
12. **Adachi, N.; Motoyama, M.; Deie, M.; Ishikawa, M.; Arihiro, K.; and Ochi, M.** Histological evaluation of internally-fixed osteochondral lesions of the knee. *J Bone Joint Surg Br,* 91(6): 823-9, 2009.
13. **Touten Y, Adachi N, Deie M, Tanaka N, and Ochi M.** Histologic evaluation of osteochondral loose bodies and repaired tissues after fixation. *Arthroscopy,* 23(2): 188-96, 2007.
14. **Potter HG, Foo LF.** Magnetic resonance imaging of articular cartilage: trauma , degeneration and repair. *Am J Sports Med.* 2006;34:661-677.