Reattachment of the articular cartilage component of type 1 subchondral cystic lesions of the medial femoral condyle with polydioxanone pins in 3 horses

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EQUINE

Case Description—3 horses were referred for treatment of subchondral cystic lesions of 1 or both medial femoral condyles.

Clinical Findings—All horses had clinically apparent lameness confirmed to be due to a radiographically evident subchondral cystic lesion of the medial femoral condyle with a large articular component (> 15 mm) and shallow subchondral depth (< 10 mm). Arthroscopic assessment of affected cartilage revealed undulating cartilage with a relatively smooth surface and extensive residual perimeter attachment.

Treatment and Outcome—Resorbable polydioxanone pins were used arthroscopically to reattach the cartilage overlying the subchondral cystic lesions. A biologic graft (bone marrow aspirate concentrate or allogeneic chondrocytes) was injected into the depths of the cystic cavity following cartilage reattachment. Follow-up examination confirmed radiographic resolution of the lesion and elimination of clinical signs within the treated femorotibial joint.

Clinical Relevance—Lesions with a large area of affected articular cartilage have been associated with a decreased rate of return to athletic function following arthroscopic debridement, likely secondary to the loss of subchondral architecture and the production of imperfect fibrocartilage repair. Salvage of the affected cartilage in a select population of horses with progressively expanding but shallow subchondral cystic lesions of the medial femoral condyle is possible and may improve radiographic and clinical outcome. (*J Am Vet Med Assoc* 2011;238:636–640)

A 6-month-old Quarter Horse colt (horse 1) was referred for surgery following the identification of a progressive SCL within the MFC of the left pelvic limb. Survey radiographs taken 30 days prior to referral revealed the SCL, and follow-up radiography at the time of admission revealed cyst enlargement, prompting surgical intervention. A lameness evaluation identified a mild (1/5 grade)[1] left pelvic limb lameness with concurrent mild effusion of the left femoropatellar joint. Radiographic evaluation with lateromedial, caudolateral-craniomedial oblique, and caudocranial projections of the left stifle joint revealed a shallow SCL measuring 9 mm deep and extending 19 mm across the articular surface of the MFC (**Figure 1**). No other abnormalities were identified, nor were any signs of degenerative joint disease present.

An NSAID (phenylbutazone, 4.4 mg/kg [2.0 mg/lb], IV) and antimicrobials (potassium penicillin, 44,000 U/kg [20,000 U/lb], IV; gentamicin, 6.6 mg/kg [3.0 mg/lb], IV) were administered, and the horse was sedated with xylazine (1.1 mg/kg [0.5 mg/lb], IV) and butorphanol (0.01 mg/kg [0.005 mg/lb], IV) before surgery. General anesthesia was induced following the administration of ketamine (2.2 mg/kg [1 mg/lb], IV) and diazepam (0.1 mg/kg [0.045 mg/lb], IV) and maintained with isoflurane. The patient was positioned in dorsal recumbency with the left pelvic limb secured to an overhead hoist and positioned with 90° flexion of the stifle joint. During routine preparation of the left stifle joint for aseptic arthroscopy, a total of 60 mL of bone marrow aspirate in 2,000 U of preservative-free heparin was aseptically harvested from 2 sternebrae of the horse with a 12-gauge Jamshidi needle and prepared for concentration following the manufacturer's instructions.[a] Following distention of the left medial femorotibial joint, the cranial compartment of the joint was approached arthroscopically as previously described,[2] with the creation of a stab incision made between the lateral patellar ligament and the long digital extensor tendon, approximately 2.5 cm proximal to the insertion of the patellar ligaments on the tibial crest. The arthroscopic cannula and obturator were advanced medially through the incision and into the medial compartment of the femorotibial joint. Complete exploration of the joint revealed a 25 × 15- mm area of soft, depressible cartilage overlying the SCL located centrally in the weight-bearing portion of the MFC. The cartilage

Abbreviations

BMAC	Bone marrow aspirate concentrate
K-wire	Kirschner wire
MFC	Medial femoral condyle
SCL	Subchondral cystic lesion

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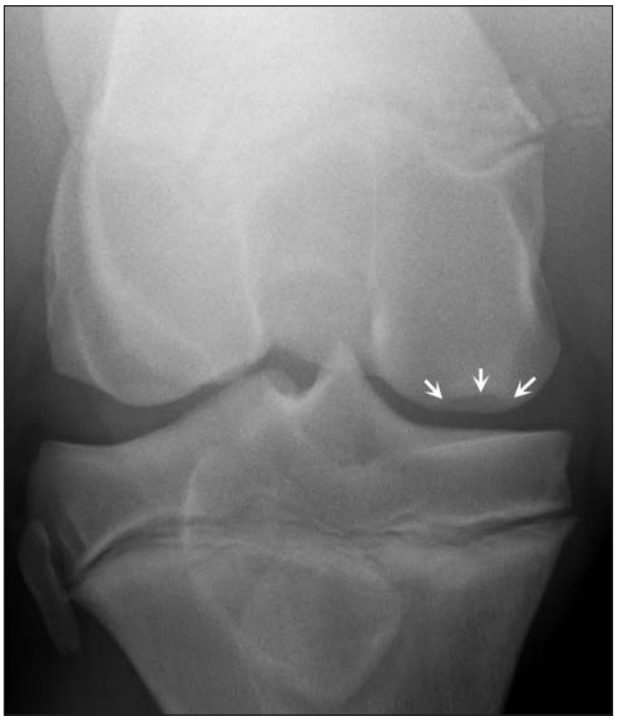

Figure 1—Caudocranial radiographic view of the left stifle joint of horse 1 acquired before surgery. A type 1 SCL is present (arrows) along the MFC.

was found to be relatively smooth but undulated when gently pressed with a blunt probe, indicating complete separation from the underlying subchondral bone. Because of the large surface area of the affected cartilage, its reasonably smooth surface, and the shallow area of subchondral lucency identified before surgery, the decision to salvage the cartilage rather than debride the area was made. The technique previously described for the reattachment of osteochondritis dissecans lesions with resorbable polydioxanone pins[3] was used to reattach the articular cartilage component of the MFC SCL. The appropriate location for a cranial instrument portal allowing for perpendicular access to the affected cartilage surface was identified with a 3.5-inch, 18-gauge spinal needle prior to creation of the portal incision. The polydioxanone pin kit[b] was used, and the provided 40-mm-long × 1.3-mm-diameter pins were cut in half to achieve a uniform length of 20 mm. A 1.3-mm-diameter K-wire (provided in the kit) inserted through an arthroscopic guide cannula was used to predrill areas of anticipated pin placement around the area of affected cartilage. The depth of the K-wire was set to terminate 1 mm short of the anticipated pin length, and multiple passes in the same plane were made to allow for ease of pin insertion. Following multiple passages of the K-wire (6 to 10/drill hole) and assurance that the depth was sufficient to allow for appropriate fixation, the 20-mm-long precut polydioxanone pin was inserted down the cannula and pushed into place with the obturator. Approximately 1 to 2 mm of the pin was left protruding from the cartilage surface to allow for flattening of the pin head level with the articular surface, providing adequate stabilization. Excess pin was removed with biopsy punch rongeurs. The procedure was repeated 5 times around the area of affected cartilage by changing the degree of joint flexion. Radiographs were obtained during surgery to confirm pin tracks spanned the entire lesion. The last pin was interrupted by the administration of a concentrated bone marrow aspirate graft (7 mL of BMAC and 700 U of thrombin [1,000 U/mL] injected simultaneously with a dual injection syringe) into the cystic cavity through the defect created with the K-wire prior to final pin placement **(Figure 2)**. The joint was thoroughly lavaged prior to instrument removal and skin closure with 0 monofilament suture.

After surgery, NSAID (phenylbutazone, 2.2 mg/kg, PO, q 12 h) administration was continued for 3 days and the horse was confined to strict stall rest until suture removal (14 days after surgery). Following suture removal, the horse began a controlled exercise program consisting of gradually increasing periods of hand walking until 6 weeks after surgery, at which point the horse was allowed turnout in a 30 × 30-foot pen. Four months following surgery, the horse was allowed free exercise in the form of pasture turnout.

Radiographs of the left stifle joint acquired 3 and 6 months **(Figure 3)** after surgery revealed 75% and 90% resolution of the previous subchondral lucency, respectively. No further lameness or joint effusion was identified at the 3- and 6-month examinations, and the horse went on to successfully compete in cutting events.

A second horse, a 12-month-old Quarter Horse filly (horse 2), was evaluated because of a 3-week history of left pelvic limb lameness and stifle joint effusion. Further examination identified bilateral pelvic limb lameness, worse in the left (grade 3/5) than the right (grade 1/5) limb, and bilateral moderate femoropatellar joint effusion. Radiographic evaluation of both stifle joints identified osteochondritis dissecans of both trochlear ridges within the left stifle joint and a shallow SCL within the MFC of the right stifle joint. Measurement of the MFC SCL in the right stifle joint identified a subchondral depth of 6 mm and an articular surface width of 16 mm. Arthroscopy of both stifle joints was performed, and the lesions on both trochlear ridges within the left stifle joint were reattached by use of the previously reported method for arthroscopic application of polydioxanone pins.[3] Similar to the findings in horse 1, the undermined, fluctuant, articular cartilage component overlying the SCL in the right stifle joint was relatively smooth with an intact periphery and was reattached with five 20-mm-long polydioxanone pins and a BMAC graft as described for horse 1. The same postoperative recommendations were made as for horse 1. Radiographic evaluation of the right stifle joint at 4 and 8 months after surgery revealed 50% and 75% resolution of the SCL, respectively. No further lameness or effusion was identified at the 4-month examination, and at 20 months after surgery, the horse successfully entered training for reining.

A third horse, a 21-month-old Quarter Horse filly (horse 3), was evaluated because of a 3-week history of bilateral pelvic limb lameness attributed to bilateral MFC SCLs, which was diagnosed radiographically by the referring veterinarian. Further examination at the time of admission confirmed the presence of bilateral pelvic limb lameness, which was worse in the left (grade

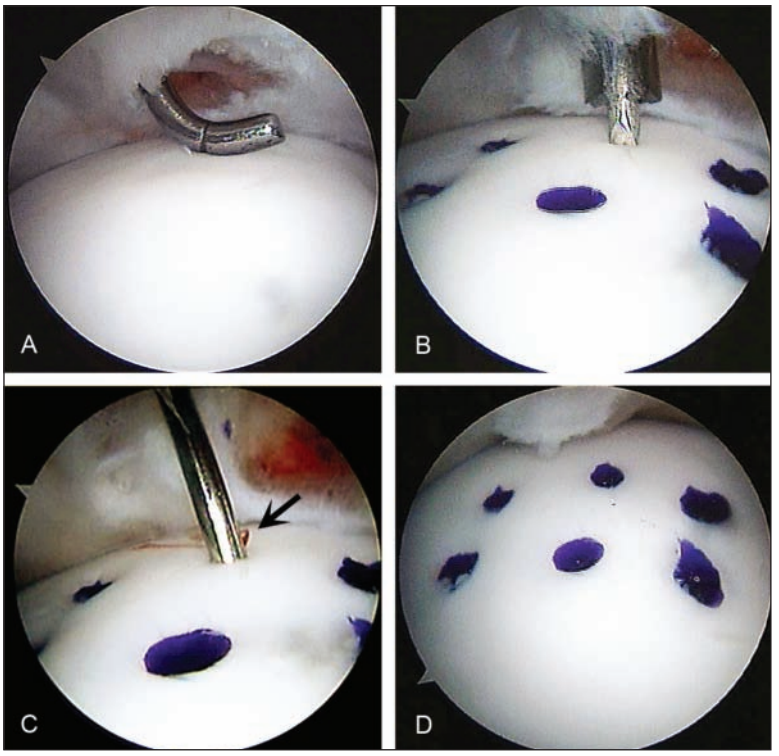

Figure 2—Arthroscopic appearance of the articular cartilage component of the type 1 SCL present over the left MFC in horse 1. A—Gentle pressure with the underside of a blunt probe (top of the image) reveals the characteristic undulation of the undermined cartilage. Notice the otherwise smooth articular surface of the affected cartilage and complete peripheral attachment. B—Drilling of the last glide hole with a 1.3-mm-diameter K-wire to a depth of 19 mm. C—Injection of the BMAC biologic graft material (arrow) through the last glide hole and into the cystic cavity. D—Final appearance of the reattached cartilage component of the SCL in the left MFC of horse 1 with six 20-mm-long polydioxanone pins.

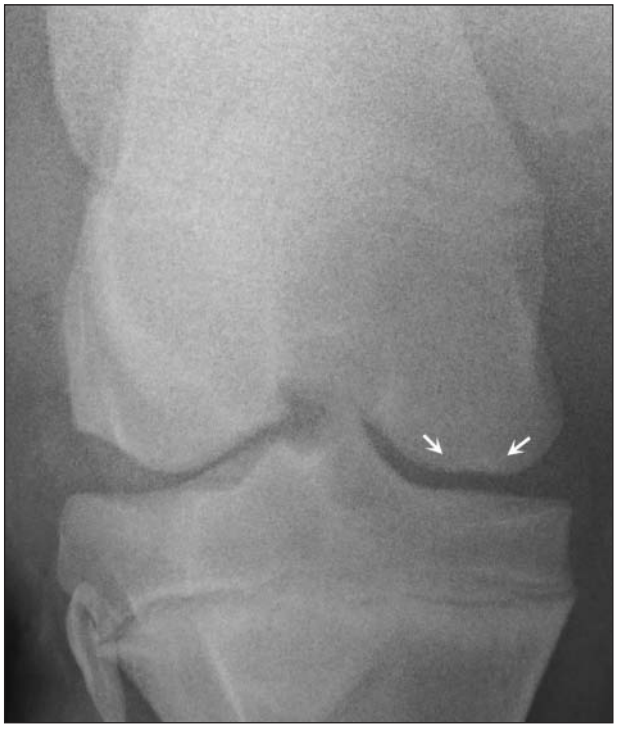

Figure 3—Caudocranial radiographic view of the left stifle joint of horse 1 acquired 6 months after surgery. The previous area of the MFC SCL (arrows) shows marked resolution of subchondral lucency and minimal architectural change to the subchondral contour. No evidence of degenerative joint disease is present radiographically.

4/5) than the right (grade 1/5) limb. Radiographic evaluation of both stifle joints at referral confirmed not only the presence of bilateral MFC SCLs, but also the progression in cyst dimension. Radiographic evaluation of the left stifle joint revealed 3 large areas of subchondral lucency that had coalesced into 1 large subchondral lucency with a wide articular communication. Within the right stifle joint, a shallow subchondral lucency extending to a depth of 4 mm and spanning 18 mm across the articular surface of the MFC was observed. Both medial femorotibial joints had changes consistent with moderate osteoarthritis. Surgical treatment of both SCLs was performed. The large lesion within the left stifle joint was treated with arthroscopic debridement and the application of an allogeneic chondrocyte graft. The lesion within the right stifle joint, however, was treated by reattachment with four 20-mm-long polydioxanone pins as described for the other 2 horses. Contrary to the other 2 horses, horse 3 received an allogeneic chondrocyte graft injection beneath the reattached cartilage surface of the right MFC cyst cavity in place of the bone marrow aspirate graft, since chondrocytes were available following repair of the more severely affected left stifle joint. This graft consisted of 6 million allogeneic chondrocytes in 0.1 mL of autologous fibrinogen, with 10 µg of recombinant human insulin-like growth factor-I, and clotted with 100 U of thrombin. The postoperative rehabilitation program for horse 3 was similar to programs for the other 2 horses. Postoperative follow-up radiographs obtained at 14 months revealed minimal change of the large SCL within the left MFC and mild progression of radiographic evidence of osteoarthritis. The horse remained lame (grade 3/5) on the left pelvic limb. Within the right stifle joint, however, complete resolution of the SCL was identified. The horse did not reach its intended athletic potential because of continued left pelvic limb lameness.

Discussion

Subchondral cystic lesions are a frequent cause of pelvic limb lameness in young horses and are most frequently encountered along the MFC.[2,4–6] Just as the pathogenesis of SCLs remains conjectural, definitive treatments also vary widely. Proposed management of MFC SCLs includes both conservative and surgical treatments. Conservative management of SCLs has been successful in resolving radiographic evidence of disease, particularly in young horses.[6] Conservative treatment includes prolonged stall rest and anti-inflammatory agents administered systemically, intra-articularly, or both.[6] Surgical options are generally reserved for horses with worsening radiographic lesions and refractory lameness attributable to the SCL, both of which occurred in these 3 horses. Surgical treatment has included intralesional injection of corticosteroids,[7] autologous osteochondral graft transfer (ie, mosaicplasty),[8] and arthroscopic de-

bridement,[2,4,9] alone or combined with microfracture[10] or biologic grafts.[11–13] The multitude of treatment modalities that exist for the treatment of SCLs likely is a result of the varied pathogenesis of the disease processes as well as the wide variety of MFC SCL severity and shape encountered in practice. More recently, efforts have shifted toward the development of surgical treatments aimed at preserving or restoring the articular cartilage component of SCLs.[11–13] This trend follows a recent study[14] that reports a poor prognosis (30% of horses going on to start a race) for future athletic performance in horses that have undergone arthroscopic debridement of MFC SCLs measuring > 15 mm of articular surface involvement. Debridement of SCLs with a large articular cartilage component results in the formation of imperfect fibrocartilage repair tissue and, potentially, a permanent defect within the subchondral bone plate. This fact may lead to not only the perpetuation of degenerative joint disease, but also to damage to the medial meniscus.[15] The width of the lesions in the affected horses in the present report and the progression of clinical signs led to surgical intervention. The decision for polydioxanone pin reattachment was then made intraoperatively on the basis of the quality of overlying cartilage, despite the substantial subchondral bone lysis.

A classification system[4] has been developed not only to describe the radiographic appearance of SCLs, but also to guide the clinician toward specific treatment modalities. By use of this system, lesions extending ≤ 10 mm in depth and appearing as shallow, saucer, or dome-shaped concave defects on the weight-bearing surface of the MFC are classified as type 1 lesions. Similarly, lesions extending > 10 mm in depth and appearing typically domed, conical, or spherical are considered type 2 lesions, and those lesions having a flattened or irregular contour of the subchondral bone at the distal aspect of the MFC are classified as type 3 lesions.[4] Generally, type 3 lesions are unlikely to manifest clinically and are typically not treated by surgical intervention.[4] Conversely, type 2 lesions are a common cause of refractory pelvic limb lameness, and intervention is common. For these lesions, the appearance of the articular component, or subchondral bone cloaca, may help guide the surgeon toward the most appropriate treatment modality. For those type 2 lesions having a narrow cloaca (type 2a), arthroscopic injection of corticosteroids into the fibrous tissue provides an 83% success rate in young horses.[7] Type 2 lesions with a wide articular component (type 2b)[7] may be treated surgically with intralesional corticosteroid injection or debridement with or without biologic grafting, depending on the appearance and integrity of the articular cartilage surface and surgeon's preference.[4,7,9,11,13,14] Type 1 lesions are often considered early or precursor forms of SCL, and progression to a deeper SCL (type 2) is common and can be precipitous.[16] It is our contention that progression to fulminant type 2 lesions can be prevented by cartilage reattachment to reunite the cartilage to the underlying bone. This stabilization likely quelled the subchondral bone cytokine reaction that leads to cyst expansion, and thereby halted progression of the disease process. The results of this report suggest that type 1 lesions having an articular surface component of > 15 mm with a relatively smooth articular cartilage surface and attached periphery should be considered candidates for arthroscopic reattachment with polydioxanone pins.[3]

All 3 horses included in this report with type 1 radiographic evidence of MFC SCLs treated with polydioxanone pin reattachment and biologic grafting had radiographic resolution of the lesion after surgery, as well as rapid resolution of clinical signs associated with the lesion, suggesting advantages over other commonly used treatments. The immediate stabilization of the undermined articular cartilage likely resulted in the resolution of clinical signs associated with the cyst. Similarly, the application of biologic grafts (BMAC or allogeneic chondrocytes) within the cystic cavity may have provided not only anti-inflammatory effects, but also progenitor cells capable of enhancing subchondral bone healing.[11,13] Unlike previously published results of subchondral microfracture and forage, the placement of polydioxanone pins in these 3 horses did not result in propagation of the cyst, but rather resulted in the rapid radiographic and clinical resolution. Because of the small number of horses in this report, interpretations of the safety and efficacy of this procedure should be made with caution and case selection should be strict. Nonetheless, this report supports the premise that arthroscopic reattachment of the articular cartilage component of type 1 MFC SCLs in horses should be considered to minimize possible progression to larger SCLs and to hasten resolution of clinical and radiographic signs.

a. Harvest Technologies, Smartprep 2 BMAC Procedure Packs, Plymouth, Mass.
b. Orthosorb pins, DePuy ACE, Wilmington, NC.

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From this month's *AJVR*

Tear, cornea, and aqueous humor concentrations of ciprofloxacin and moxifloxacin after topical ocular application in ophthalmologically normal horses

Hans D. Westermeyer et al

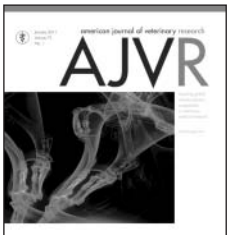
Objective—To determine ocular tissue drug concentrations after topical ocular administration of 0.3% ciprofloxacin and 0.5% moxifloxacin in ophthalmologically normal horses.

Animals—28 ophthalmologically normal adult horses.

Procedures—0.3% ciprofloxacin and 0.5% moxifloxacin solutions (0.1 mL) were applied to the ventral conjunctival fornix of 1 eye in each horse as follows: group 1 (n = 8) at 0, 2, 4, and 6 hours; group 2 (8) at 0, 2, 4, 6, and 10 hours; and group 3 (8) at 0, 2, 4, 6, 10, and 14 hours. Tears, cornea, and aqueous humor (AH) were collected at 8, 14, and 18 hours for groups 1, 2, and 3, respectively. Drug concentrations were determined via high-performance liquid chromatography.

Results—Median (25th to 75th percentile) concentrations of ciprofloxacin for groups 1, 2, and 3 in tears (μg/mL) were 53.7 (25.5 to 88.8), 48.5 (19.7 to 74.7), and 24.4 (15.4 to 67.1), respectively; in corneal tissue (μg/g) were 0.95 (0.60 to 1.02), 0.37 (0.32 to 0.47), and 0.48 (0.34 to 0.95), respectively; and in AH were lower than the limit of quantification in all groups. Concentrations of moxifloxacin for groups 1, 2, and 3 in tears (μg/mL) were 188.7 (44.5 to 669.2), 107.4 (41.7 to 296.5), and 178.1 (70.1 to 400.6), respectively; in corneal tissue (μg/g) were 1.84 (1.44 to 2.11), 0.78 (0.55 to 0.98), and 0.77 (0.65 to 0.97), respectively; and in AH (μg/mL) were 0.06 (0.04 to 0.08), 0.03 (0.02 to 0.05), and 0.02 (0.01 to 0.04), respectively. Corneal moxifloxacin concentrations were significantly higher in group 1 than groups 2 and 3.

Conclusions and Clinical Relevance—After topical ocular administration, fluoroquinolones can reach therapeutic concentrations in tears and corneal tissue of horses, even when there is an intact epithelium. (*Am J Vet Res* 2011;72:398–403)



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