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CLINICAL RESEARCH

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Mosaic arthroplasty in equine stifle and fetlock joints: A retrospective study of 31 cases between 1998 and 2023

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Abstract

Objective: To evaluate the clinical application of equine mosaic arthroplasty for joint surface repair, including outcomes and complications.

Study design: Retrospective clinical study.

Animals: A total of 31 horses diagnosed with subchondral bone cysts (SBCs) in the femoral condyle (22/31), distal metacarpus (7/31), or metatarsus (2/31).

Methods: Medical records of horses that underwent autologous or allogeneic osteochondral graft transplantation were reviewed. Follow-up lasted at least 12 months. Success was determined in terms of improvements in lameness and post-surgical athletic performance, classified as successful, satisfactory, or unsatisfactory.

Results: In total, 68% (21/31) of horses regained soundness and resumed athletic performance at the same or higher level than before surgery. Furthermore, 22% (7/31) and 10% (3/31) exhibited satisfactory and unsatisfactory results, respectively. Seven horses underwent follow-up arthroscopy to treat complications or residual lameness. Among horses with femoral condyle SBCs, 68% (15/22) achieved successful outcomes, compared with 67% (6/9) of those with fetlock SBCs. Age (≤3 vs. >3 years) did not appear to influence outcomes in stifle cases. Horses receiving fewer implanted grafts showed a tendency toward better recovery.

Conclusion: Mosaic arthroplasty improved lameness in 90% of this mixed-age equine population, with 68% regaining soundness and successfully returning to athletic performance. Unlike other techniques reporting success primarily in 2- and 3-year-old horses, this method could provide an effective surgical alternative for both young and mature horses with SBCs.

Clinical significance: Mosaic arthroplasty may serve as a viable surgical option for managing SBCs.

Abbreviations: AAEP, American association of equine practitioners; MCIII, third metacarpal bone; MFC, medial femoral condyle; MFTJ, medial femorotibial joint; MTIII, third metatarsal bone; OATS, osteoarticular transfer system; SBC, subchondral bone cyst.

The preliminary case series documenting the initial clinical cases was published in Veterinary Surgery in 2004.

1 | INTRODUCTION

Subchondral bone cysts (SBCs) and weight-bearing articular cartilage defects are prevalent in equine athletes, often impairing performance.[1] SBCs, also termed subchondral cystic or osseous cyst-like lesions, have a multifactorial etiopathogenesis, potentially involving osteochondrosis and trauma.[2] The prognosis depends on cyst location, preexisting joint pathology, and the selected treatment approach.[3]

In young horses, SBCs may resolve without treatment.[4] Nonsurgical management, including restricted exercise and intra-articular medications, alleviates lameness in 45%–64% of medial femoral condyle (MFC) SBC cases, though recurrence is common.[5] Various surgical interventions have been developed over the past decades,[4] with success rates varying widely between treatments. These include corticosteroid injection into the cyst lining under arthroscopic guidance (77% success rate),[6] intralesional mesenchymal stem cell injection (84% success rate),[7] arthroscopic lesion debridement (69% success rate),[8] transcondylar screw placement (58%–75% success rate)[2,4,9] and composite bioabsorbable implants (91% success rate in the stifle).[10] Other promising alternatives for filling debrided SBC lesions include cancellous bone grafts,[1] growth factor-enhanced chondrocyte grafts,[11] parathyroid hormone peptide-enriched fibrin hydrogel,[12] and collagen sponge impregnated with bone morphogenetic protein 2,[13] with reported success rates of 74%–100%. In the distal metacarpus (MCIII) or metatarsus (MTIII), surgical approaches such as cyst debridement,[3] compacted bone or chondrocyte grafts, and augmented bone substitutes have demonstrated improvements in lameness and radiographic outcomes, though clinical experience with these techniques remains limited.[13,14]

The limited regenerative capacity of adult hyaline cartilage poses a significant challenge in managing chondral and osteochondral injuries on weight-bearing articular surfaces in orthopedic surgery.[15,16] Autologous osteochondral grafting, also known as mosaicplasty or autologous osteochondral transplantation, is a widely used surgical approach for treating focal full-thickness cartilage and osteochondral defects on weight-bearing joint surfaces in human patients.[15] This procedure entails harvesting multiple cylindrical osteochondral grafts from a low-weight-bearing articular surface and implanting them in a mosaic-like pattern to replace a focal lesion and restore the affected weight-bearing joint surface.[15] Remarkable outcomes, with reported success rates as high as 93%, have been documented, with minimal long-term donor-site morbidity in a clinical study involving 1097 human patients.[15]

Osteochondral graft transplantation has been documented in equine cases for treating subchondral cystic lesions in the tarsus and has been explored experimentally for joint resurfacing in the third carpal bone and distal MTIII.[17–19] The mosaicplasty technique was adapted to the equine stifle in 1998 and has since been refined and applied in clinical practice for managing SBCs and full-thickness cartilage defects in the stifle and fetlock joints.[20,21] Use of human mosaicplasty sets[18] or their modification,[17] as well as the osteoarticular transfer system (OATS)[19] has been reported in the literature, but no equipment designed for equine use is currently commercially available. Successful case reports of allograft transplantation have also been reported, offering a copious amount of high-quality donor tissue from young individuals, and eliminating potential donor-site morbidity.[17,22] To the best of our knowledge, autologous or allogeneic osteochondral transplantation remains the only technique for replacing damaged or destroyed cartilage with hyaline or hyaline-like tissue on weight-bearing joint surfaces in mature horses.

This multi-institutional study aimed to describe the experiences and outcomes of horses treated with mosaic arthroplasty for subchondral bone cysts in the stifle and fetlock between 1998 and 2023. This study provides a comprehensive overview of the procedural refinement process, incorporating data from 11 horses previously reported in an earlier study.[20]

2 | MATERIALS AND METHODS

2.1 | Study design and population

Medical records of horses that underwent mosaic arthroplasty at four institutions, performed by two authors between 1998 and 2023, were reviewed. Inclusion criteria were lameness, failure to respond to conservative treatment (including intra-articular corticosteroid injections), and a diagnosis of subchondral cystic lesion in the medial or lateral femoral condyle or the distal metacarpus or metatarsus. Lesions needed to be accessible via arthrotomy or arthroscopy. Data including the year of surgery, time from diagnosis to surgery, age, breed, sex, affected limb and joint, pre- and postoperative lameness grade, estimated lesion size from radiographs, size and number of implanted grafts, surgical approach, concurrent pathologies, postoperative complications, surgeon, institution, intra-articular treatments before and after surgery, and outcome were collected (Table 1). When available, lesion size estimates from diagnostic imaging reports were also included.

TABLE 1 Pre- and postoperative data of horses operated with mosaic arthroplasty.

Horse No.	Age at surgery	Sex	Preoperative lameness out of 5	SBC location	Estimated lesion depth (mm)	Estimated lesion width (mm)	Implanted graft	Postoperative lameness out of 5	Outcome
1	12	S	3	Left MFC	ND	ND	6 × 6.5	1	Satisfactory
2	2	M	4	Left MFC	ND	ND	5 × 6.5	1	Satisfactory
3	3	S	2	Right MFC	ND	ND	6 × 6.5	0	Successful
4	10	S	4	Right MFC	20	30	4 × 6.5	0	Successful
5	3	M	3	Right MFC	8	10	1 × 8.5; 1 × 6.5	0	Successful
6	3	S	1	Left MFC	12	22	2 × 8.5	0	Successful
7	11	G	2	Left MFC	8	21	1 × 8.5; 1 × 6.5	0	Successful
8	11	G	3	Right MFC	11	20	2 × 8.5; 1 × 6.5	1	Satisfactory
9	4	S	2	Left MFC	8	14	1 × 8.5	0	Successful
10	14	G	2	Right MFC	14	25	2 × 8.5; 1 × 6.5*	1	Satisfactory
11	3	M	2	Right MFC	12	18	2 × 8.5; 3 × 6.5	0	Successful
12	9	M	2	Left MFC	17	35	2 × 8.5; 1 × 6.5	1	Satisfactory
13	3	M	1	Right MFC	14	16	1 × 8.5; 1 × 6.5	3	Unsatisfactory
14	3	M	3	Right MFC	16	20	2 × 8.5; 2 × 6.5	4	Unsatisfactory
15	7	S	3	Right MFC	18	18	3 × 8.5	0	Successful
16	3	S	2	Right MFC	14	21	3 × 8.5	0	Successful
17	7	G	3	Right MFC	18	25	2 × 6.5	0	Successful
18	6	M	3	Left MFC	ND	ND	2 × 8.5	0	Successful
19	1	S	4	Left LFC	ND	ND	4 × 6.5	0	Successful
20	3	M	3	Right MFC	ND	ND	1 × 6.5; 1 × 8.5	0	Successful
21	3	M	3	Right MFC	ND	ND	5 × 6.5	0	Successful
22	1	S	3	Left MC3	ND	ND	2 × 6.5	0	Successful
23	2	M	3	Left MC3	ND	ND	1 × 6.5	0	Successful
24	3	G	3	Right MT3	5	7	1 × 8.5	0	Successful
25	8	M	3	Right MT3	ND	ND	1 × 6.5	0	Successful
26	2	M	3	Left MC3	ND	ND	2 × 6.5	0	Successful
27	1	S	3	Right MC3	ND	ND	1 × 6.5	0	Successful
28	3	S	3	Right MC3	ND	ND	2 × 8.5	1	Satisfactory
29	8	M	2	Right MC3	ND	ND	2 × 8.5	1	Satisfactory
30	7	G	3	Right MC3	ND	ND	2 × 8.5	3	Unsatisfactory
31	8	G	2	Right MFC	15	20	1 × 10	0	Successful

Abbreviations: G, gelding; LFC, lateral femoral condyle; M, mare; MC3, metacarpus; MFC, medial femoral condyle; MT3, metatarsus; ND, no data; S, stallion; SBC, subchondral bone cyst.

2.2 | Preoperative procedures

Lameness was evaluated and scored on a 0–5 scale using the American Association of Equine Practitioners (AAEP) grading system.[23] Perineural or intrasynovial analgesia was administered to localize pain, and at least two radiographic projections were obtained to assess subchondral lucencies or osteoarthritic changes. Cyst size was estimated in cases with digital radiographs using JiveX Enterprise PACS Software (VISUS Health IT GmbH, Bochum, Germany), recording the largest measured width and depth. Ultrasonography was performed in selected cases to identify cystic lesions.

2.3 | Surgical technique

SBCs in the medial or lateral femoral condyle (Figure 1) or the distal MCIII or MTIII were surgically treated. Horses were fasted for 12 h before general anesthesia.

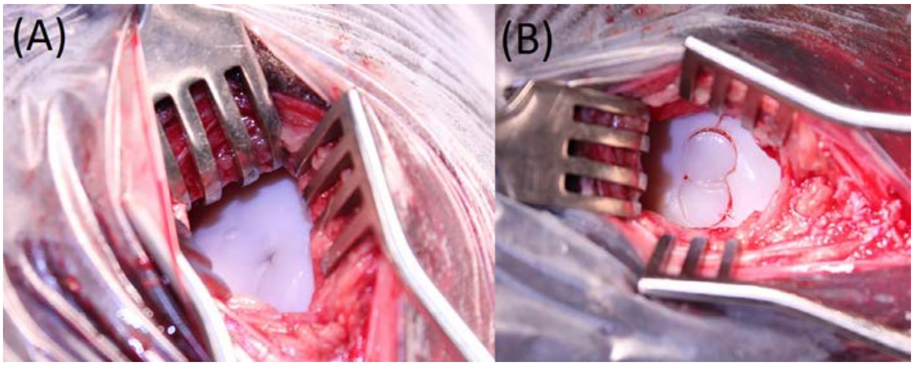

FIGURE 1 Intraoperative images of Horse 6. Arthrotomy incision exposing the medial femoral condyle (A) before and (B) after implantation. A star-shaped cyst opening is visible in (A).

Preoperative antimicrobials included either amoxicillin (5.6 mg/kg IM) with potassium clavulanate (1.4 mg/kg IM) and gentamicin (6.6 mg/kg IV) or procaine penicillin (22 000 IU/kg IM) with dihydrostreptomycin sulfate (15 mg/kg IM). Phenylbutazone (2.2 mg/kg IV) was administered for analgesia.

After induction of general anesthesia and maintenance with isoflurane, horses with femoral condyle lesions were positioned in dorsal recumbency. Horses with distal MCIII or MTIII lesions were placed in lateral recumbency with the donor site uppermost.

Graft harvest

The cranial aspect of the medial femoral trochlea was used as the donor site in all cases. For stifle implantations, grafts were harvested from the contralateral femoropatellar joint. In horses with distal limb lesions, grafts were obtained from the uppermost femoropatellar joint while in lateral recumbency. The medial femoral trochlea was accessed with the limb at maximal extension. Initially, in six cases, a 30–40 mm arthrotomy incision was made between the medial and middle patellar ligaments to expose the donor site. This method was later replaced by an arthroscopic approach.[21] The arthroscopic portal was created between the lateral and middle patellar ligaments, midway between the tibial crest and the distal patella. The arthroscope was inserted, and the joint was distended before a harvesting portal was made proximal to the initial incision to access the medial femoral trochlea.

The first graft was harvested from the proximal aspect of the medial femoral trochlea using a mallet and a tubular chisel (manufactured by Metrimed Kft., Hódmezővásárhely, Hungary) with a diameter of 6.5, 8.5, or 10 mm, depending on the recipient site. Arthroscopic guidance ensured precise chisel alignment. After driving the chisel to the required depth (25–40 mm, marked on the chisel surface) with the mallet, a semi-circular motion separated and detached the graft (Figure 2).

Subsequent grafts were harvested approximately 5–10 mm apart by progressively flexing the joint using the same portals. In early cases, a human mosaicplasty system (Acufex Instruments, Smith & Nephew Endoscopy, Andover, New Jersey) was used, which was later gradually replaced by custom-made equipment designed by the last author and manufactured by Metrimed Kft (Hódmezővásárhely, Hungary) (Figure 3).

For femoral condyle implantation, 1–6 grafts (6.5, 8.5, or 10 mm in diameter) were used. One or two grafts (6.5 or 8.5 mm) were implanted in the MCIII/MTIII. All osteochondral cylinders were 15–40 mm long. Donor channels were left empty, and the arthrotomy or arthroscopic portals were routinely closed after femoropatellar joint lavage. Grafts were stored in sterile isotonic saline until implantation.

For Horse 10, in whom allograft transplantation was performed, fresh osteochondral grafts from the donor horse were rinsed and implanted within 2 h using the same technique as autografts. Donor selection criteria included being aged <36 months, with valid health documentation (including negative equine infectious anemia serology and equine influenza vaccination) and no femoropatellar joint disease. In this case, the donor was an 11-month-old colt from the same owner, undergoing castration and umbilical hernia repair under general anesthesia.

Medial or lateral femorotibial joint implantation

Graft harvesting and implantation were performed under the same general anesthesia as previously described.[20,21] For medial or lateral femoral condyle implantation, the horse was positioned in dorsal recumbency with the stifle flexed at approximately 90°. Initially, arthrotomy was used to expose the femoral condyle, but in the last decade, arthroscopic evaluation was performed before arthrotomy to rule out concurrent soft tissue injuries such as ligamentous or meniscal tears. Although three cases underwent arthroscopic implantation alone, arthrotomy was performed in most cases. A 5–7 cm arthrotomy incision was made between the medial and middle patellar ligaments over the MFC. The

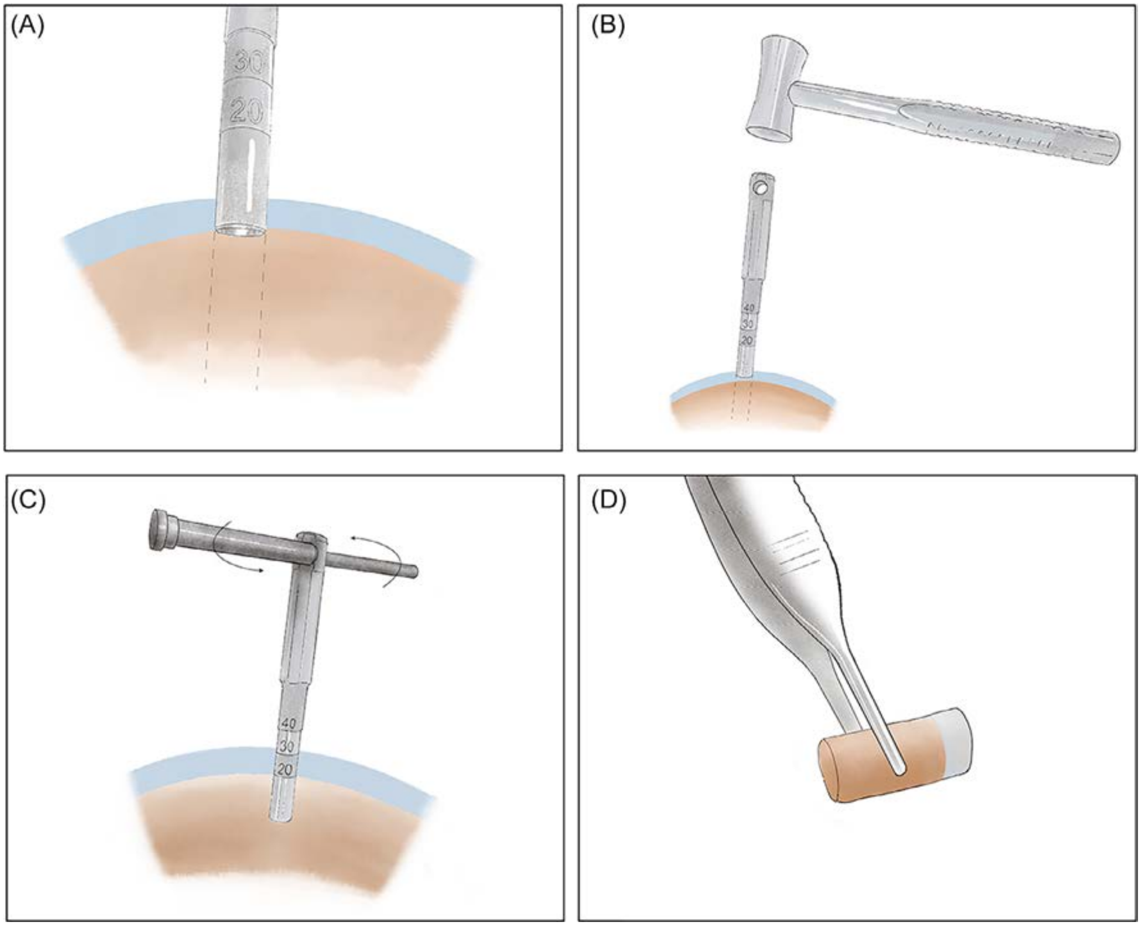

FIGURE 2 Graft harvest procedure. (A) The chisel is inserted on the articular surface. (B) The chisel is driven to the desired depth. (C) Semi-circular movement of the instrument is applied to detach the graft. (D) Osteochondral graft following harvest.

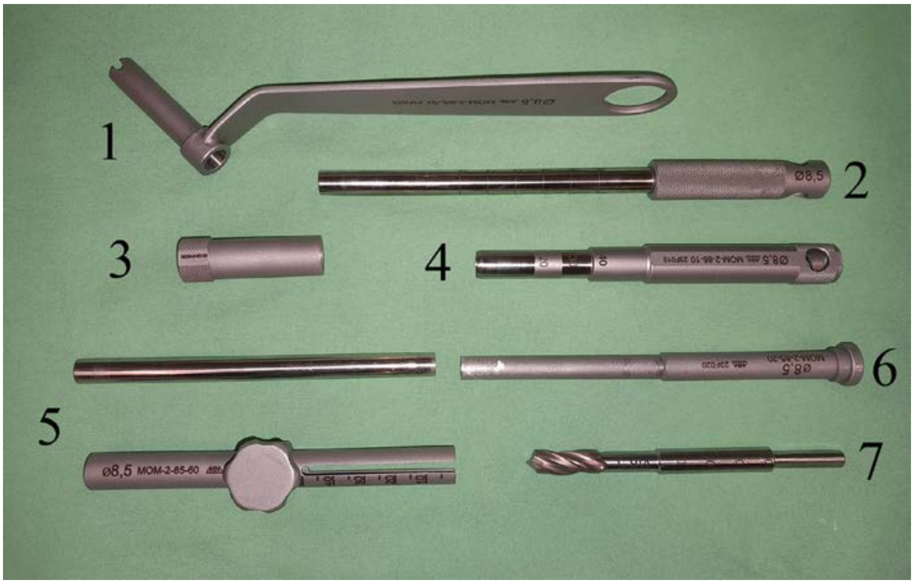

FIGURE 3 Mosaicplasty instrument kit (8.5 mm diameter). 1 = drill guide (l = 50 mm, d = 9.1 mm), 2 = dilator (l = 185 mm, d = 8.5–8.9 mm), 3 = chisel guard, 4 = harvesting chisel (l = 130 mm, d = 8.5 mm), 5 = measuring and adjusting device (l = 120 mm, d = 9.3–8.5 mm), 6 = delivery tamp (l = 140 mm, d = 8.3 mm), 7 = drill bit (l = 88 mm, d = 8.5 mm). Manufacturer: Metrimed Kft. l, length; d, diameter.

subcutaneous tissue and superficial and deep fascia were incised, followed by the excision of the femoropatellar fat pad. The joint capsule was then incised to expose the articular surface (Figure 1).

The SBC opening was identified on the MFC surface and drilled 8–10 mm deeper than its cavity using a 6.5, 8.5, or 10 mm drill bit, depending on defect size and graft dimensions (Figure 4). The fibrous lining was completely

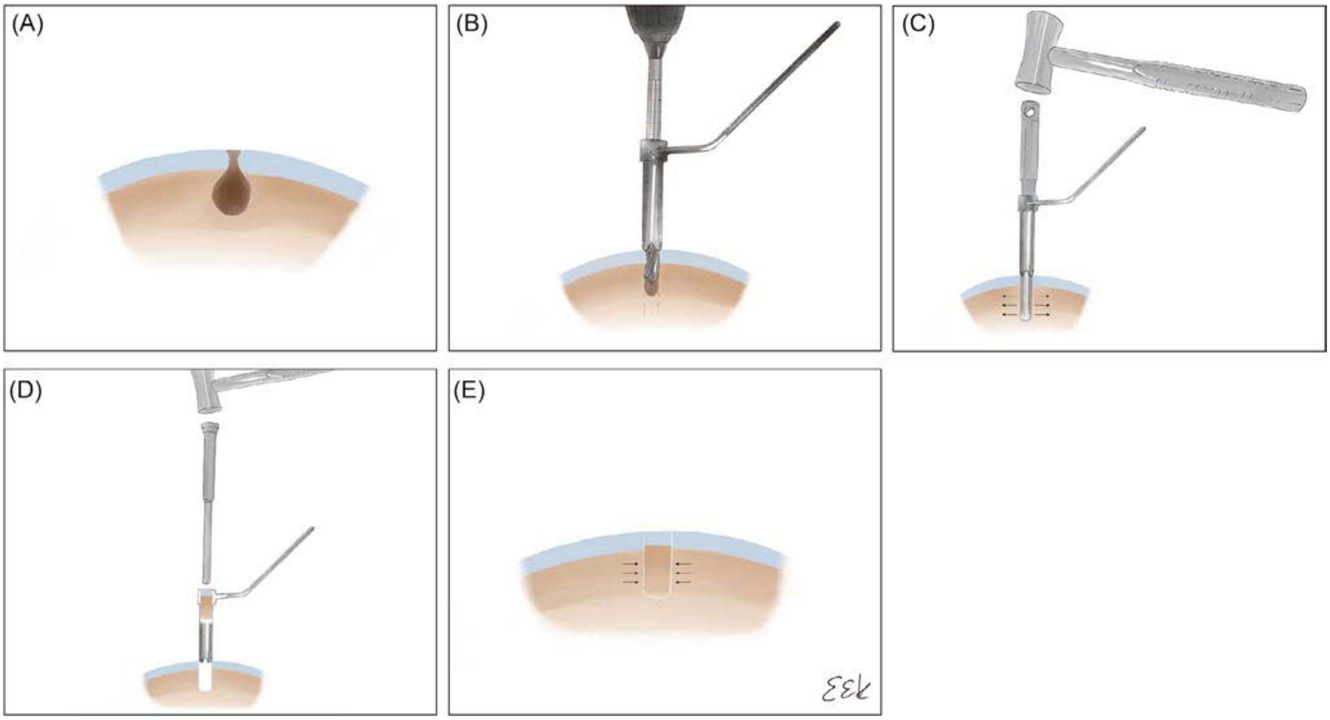

FIGURE 4 Graft implantation procedure. (A) Subchondral bone cyst. (B) Drilling the cyst cavity. (C) Dilator tamp applied to dilate the drilled hole. Black arrows indicate force acting on the host bone during dilation. (D) Implantation of the graft to fill the drilled hole. (E) Host bone engaging the graft. Black arrows indicate force acting on the implanted graft.

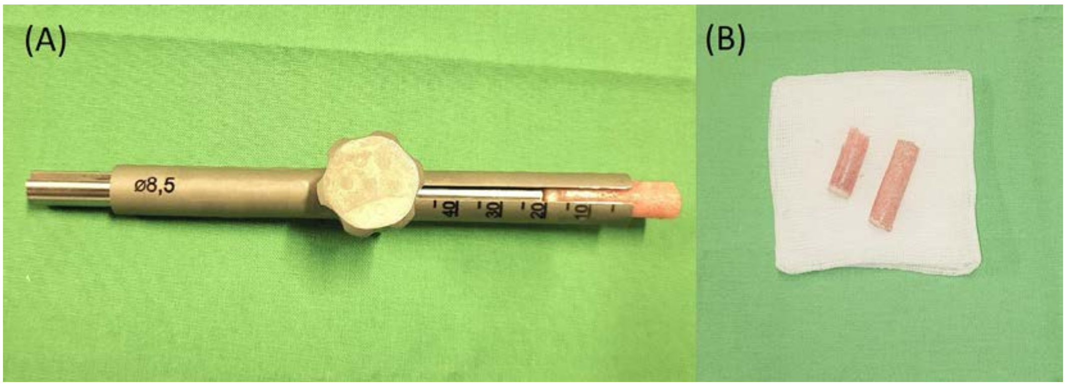

FIGURE 5 (A) Measuring and adjusting device with a graft prepared for cutting to the measured length. (B) Freshly harvested osteochondral grafts (8.5 mm diameter).

removed with a bone curette. The arthroscope was inserted into the drilled canal to check for residual fibrovascular tissue. After flushing and temporarily dilating the recipient hole by 0.2–0.4 mm with a tapered dilator, a custom measuring and adjusting device (manufactured by Metrimed Kft) was used to determine the recipient hole depth and trim the graft to an appropriate length (Figure 5). Grafts were then inserted using a press-fit technique with a drill guide and graft tamp (Acufex Instruments, Smith & Nephew Endoscopy and Metrimed Kft), ensuring surface congruency and a precise fit between the graft and host bone.[24] Additional holes were drilled as needed, and the procedure was repeated until the cyst cavity was completely filled. The grafts were positioned adjacent to each other (Figure 1) or one or two millimeters apart. The joint was lavaged, and the surgical wound was closed in five layers, followed by stent bandage application. For arthroscopic implantation, portals were closed in two layers with simple interrupted sutures.

Metacarpophalangeal or metatarsophalangeal joint implantation

For fetlock joint implantation, a 3–5 cm arthrotomy over the dorsal joint surface enabled visualization of the cyst opening on the weight-bearing surface of the distal MCIII or MTIII. The joint was maximally flexed to optimize access. The cyst was identified, drilled, and implanted following the same procedure used for the stifle. In Horse 25, insertion was performed under arthroscopic guidance. The arthrotomy was closed in four layers, and a Robert Jones bandage was applied.

Postoperative care

Horses received antibiotics postoperatively: either amoxicillin trihydrate (5.6 mg/kg IM) with potassium clavulanate (1.4 mg/kg IM) and gentamicin (6.6 mg/kg IV) once daily for 5 days or procaine penicillin (22 000 IU/kg IM) with dihydrostreptomycin sulfate (15 mg/kg IM) once daily for 7 days. Phenylbutazone (2.2 mg/kg orally twice daily) was administered for 7 days. Postoperative radiographs were taken 7–14 days after surgery. Horses remained hospitalized with bandages changed every 2–3 days until suture removal at 14 days. For stifle procedures, the surgical site was covered with Snögg Animal Polster dressings (Norgesplaster AS, Norway) and changed regularly until suture removal. Rehabilitation protocols have evolved over the years, with increasing use of stall confinement. Initially, horses underwent 1 week of box rest, followed by 2 weeks of hand walking before paddock turnout. Since 2005, based on human studies,[15] stall confinement for 2 months has been recommended, followed by daily hand-walking. Paddock exercise was initiated 3–4 months postoperatively, accompanied by follow-up physical and radiographic evaluations by the referring veterinarian or in the hospital. If lameness persisted at 4–5 months, a single intra-articular injection of 10–15 mg triamcinolone acetonide and hyaluronic acid was advised. Follow-up arthroscopy was suggested for persistent lameness or suspected additional pathology. In uncomplicated cases, horses resumed work as early as 6 months postoperatively.

2.4 | Follow-up evaluation

All patients had a minimum follow-up of 12 months. Long-term assessments included clinical and radiographic evaluations, second-look arthroscopy, owner or referring veterinarian observations, and competition records (www.dijugratas.hu, www.kincsempark.hu, www.fogatsport.hu). Postoperative lameness was scored on the AAEP 5-grade scale,[23] and performance was evaluated.

A successful outcome was defined as the horse being lameness-free and returning to the same or higher level of activity. A satisfactory outcome was defined as lameness improvement but a return to a lower level of activity. An unsatisfactory outcome was recorded if lameness remained unchanged or worsened. Postoperative radiographs were taken at the clinic or by referring veterinarians at least 10 months after surgery. Lesion width and depth were measured using JiveX Enterprise PACS Software (VISUS Health IT GmbH, Bochum, Germany) or estimated on radiographs provided by referring veterinarians by comparing the condyle width and remaining lesion size on caudocranial or dorsopalmar/dorsoplantar projections.

3 | RESULTS

3.1 | Clinical data

Medical records of 33 horses that underwent mosaic arthroplasty were reviewed. Two horses with non-SBC lesions were excluded, leaving 31 cases: 11 stallions, seven geldings, and 13 mares (Table 1). The median age was 3 years (range: 1–14 years). The study included 16 Warmbloods, five Standardbreds, four Arabians, three Thoroughbreds, two Quarter Horses, and one pony. Each horse had a single affected joint. Lesions included 14 SBCs in the MFC of the right hindlimb, seven in the MFC of the left hindlimb, and one in the lateral femoral condyle of the left hindlimb. Nine horses had cyst-like lesions in the distal MCIII ($n = 7$) or distal MTIII ($n = 2$).

All horses presented with lameness (median grade: 3/5, range: 1–4), and none showed long-term improvement with conservative or intra-articular treatments. Preoperative intra-articular treatment records were available for 25 cases, with 17 receiving corticosteroid injections. Time from diagnosis to surgery was recorded for all cases except for one case, with a median of 4 months (range: 1–10 months).

3.2 | Intraoperative observations

For MFC or LFC lesions, a median of three grafts (range: 1–6) were inserted in a mosaic-like pattern. In distal MTIII or MCIII cysts, one graft was implanted in four horses, whereas five received two grafts. Graft diameters varied between 6.5, 8.5, and 10 mm, depending on defect size and conformation. In the initial decade, graft insertion challenges occurred in three cases due to inaccurate recipient hole depth measurement, leading to grafts protruding above the joint surface. To correct this, surgeons overdrilled the site and replaced the graft with another of the same size. This issue was resolved following the introduction of a new measuring and adjusting device with well-marked graduations (Figure 5).

3.3 | Concurrent pathology

Concurrent joint pathology was identified in 25.8% (8/31) of horses through radiographic ($n = 6$) and/or intraoperative ($n = 5$) evaluation. In stifle joints ($n = 22$), arthroscopy revealed medial meniscal fibrillation in two cases and cranial meniscotibial ligament injury in one case. Radiographic findings consistent with degenerative joint disease were observed in four cases, including tibial plateau modeling, periarticular osteophytes on the proximomedial tibia, and an irregular MFC.

In fetlock joints ($n = 9$), radiographs showed concurrent osteochondrosis in two cases and periarticular osteophytes in one. Intraoperatively, osteochondrosis dissecans ($n = 1$) and cartilage injury ($n = 1$) were also detected.

3.4 | Postoperative complications

Postoperative complications occurred in 16% (5/31) of cases. Minor complications included seroma formation at the surgical site (Horse 15) and arthrotomy wound dehiscence (Horses 16 and 22). These issues were resolved with seroma drainage or repeated wound closure. Septic complications occurred in Horses 13 and 14, leading to graft necrosis. Mild effusion was noted in donor femoropatellar joints in the early postoperative weeks, but no long-term complications were observed. In recipient femorotibial joints, early postoperative effusion was accompanied by mild-to-moderate lameness (2–3/5), which improved significantly within 4 weeks.

3.5 | Postoperative follow-up and outcome

All patients had a minimum follow-up of 12 months (range: 12–120 months, median: 24 months, mean: 33.3 months). Lameness improved in 90% of cases, with 68% (21/31) returning to their previous or higher activity. Of these 21 horses, 15 (71.4%) had stifle lesions, and six (28.6%) had fetlock lesions. Of the 31 horses, seven (22%) improved but were limited to breeding or light riding. Notably, 10% (3/31) showed no improvement (1/31) or worsening lameness (2/31). Among 22 horses with medial or lateral femoral condyle SBCs, 68% (15/22) had a successful outcome 1 year postoperatively. Their median age was 3.5 years (range: 1–14 years). Less than three grafts were implanted into the femoral condyle in 10 horses with stifle SBC (10/22), with successful and unsatisfactory outcomes in 90% ($n = 9$) and 10% ($n = 1$), respectively. Three or more grafts were implanted in 12 horses with stifle SBC (12/22), with successful, satisfactory, and unsatisfactory outcomes in 50% ($n = 6$), 42% ($n = 5$), and 8% ($n = 1$), respectively. A successful outcome was recorded in 72.7% (8/11) and 63.6% (7/11) of horses aged ≤ 3 and >3 years, respectively, following mosaic arthroplasty in the stifle. Of the nine horses with SBC in the distal MCIII or MTIII, six (66.7%) regained soundness and remained competitive, with a median age of 3 years (range: 1–10 years). All horses with a single graft in the fetlock joint ($n = 4$) achieved a successful outcome. Among the horses with two grafts implanted into the distal MCIII or MTIII ($n = 5$), 40% ($n = 2$), 40% ($n = 2$), and 20% ($n = 1$) exhibited successful, satisfactory, and unsatisfactory outcomes. Postoperative intra-articular treatment data was available for all except for one horse. A total of 10 horses received corticosteroid injections into the operated joint postoperatively, and six of these underwent follow-up arthroscopy. Out of the four horses diagnosed with coexisting medial femorotibial joint pathology, 25% ($n = 1$) and 75% ($n = 3$) exhibited successful and satisfactory outcomes, respectively. Out of the four horses with identified concurrent fetlock joint pathology, 75% ($n = 3$) achieved successful and 25% ($n = 1$) had unsatisfactory outcomes.

3.6 | Follow-up arthroscopy

Follow-up arthroscopy was performed on seven medial femorotibial joints (MFTJs) between 1 and 6 months postoperatively due to either persistent low-grade lameness (five horses) or septic complications (two horses). The five non-septic joints had each received three or more osteochondral grafts. Macroscopic evaluation of these joints revealed generally congruent articular surfaces. The transplanted cartilage appeared shiny and smooth, with some graft-host interfaces remaining intact and others showing mild fibrillation. Marginal deformation of the hyaline cartilage caps was noted in Horse 2.

Additional findings included medial meniscus injury in Horse 1 and fibrillation of the medial meniscotibial ligament in Horse 10. These soft tissue lesions were not present at the time of the initial surgery, which was performed via arthrotomy. Of the seven horses undergoing follow-up arthroscopy, only Horse 3 achieved a successful clinical outcome. The two septic joints

(Horses 13 and 14) exhibited partial graft necrosis and required three additional arthroscopic procedures each for debridement and lavage.

3.7 | Radiographic findings

Preoperative radiography included at least two projections of the affected joint, with SBCs identified by decreased radiopacity and a sclerotic rim. Osteoarthritis was observed in 16% (5/31) of cases, including MFTJs ($n = 4$) and a fetlock joint ($n = 1$). Lesion width and depth were measured in 16 horses using digital caudocranial or dorsoplantar radiographs. Stifle lesions ($n = 15$) measured 8–20 mm wide (median: 14 mm) and 10–30 mm deep (median: 20 mm). A 5 × 7 mm lesion was recorded in one metatarsophalangeal joint.

The graft site was assessed in 16 horses using available radiographs obtained at least 10 months postoperatively. However, inconsistencies due to variations in image quality, radiographic settings used by field veterinarians, and radiographic positioning hindered the objective assessment of the surgical sites. Radiologic resolution was observed in 10 of 16 horses (5 fetlock joints and 5 stifles) (Figure 6). Among the remaining six cases, three showed cyst size reduction, one remained unchanged, and the two septic cases exhibited cyst enlargement.

3.8 | Necropsy findings

A single horse with an operated metacarpal joint (Horse 22) was euthanized for unrelated reasons 2 years postoperatively. Necropsy revealed a smooth, shiny transplanted cartilage surface that was congruent with the surrounding cartilage. Histological evaluation confirmed intact hyaline cartilage, with good bone incorporation and remodeling of the implanted grafts.

4 | DISCUSSION

This study presents outcomes of osteochondral graft implantation for repairing weight-bearing surfaces in fetlock and stifle joints of 31 horses. Mosaic arthroplasty was recommended as a one-step procedure in these cases, as it does not rely on biologics or cells and replaces damaged cartilage with mature articular cartilage. Our results suggest that the removal of abnormal tissue and replacement with stable osteochondral grafts can be effective in both young and mature horses. Fewer implanted grafts may provide an advantage, but a prospective trial would be required to control variables which may have affected the outcomes.

Comparing success rates across studies on MFC SBCs is challenging due to varying definitions of success and differences in patient age distribution. Arthroscopic lesion debridement alone achieved a 69% success rate in horses aged <3 years, but only 35% in older horses.[8] Transcondylar screw placement, which improves trabecular bone stress and healing, exhibits a 58%–77% success rate (soundness and cyst size reduction), with poorer outcomes in horses aged >3 years.[2,4,9] These studies highlight the difficulty of treating older horses, which have reduced intrinsic cartilage repair capacity and are more prone to early degenerative joint changes on presentation. While not identified in a previous report,[11] preexisting osteoarthritis with coexisting soft tissue lesions or cartilage defect on the weight-bearing surface appeared to influence outcomes in our study population.

In this mixed-age population, 72.7% (8/11) and 63.6% (7/11) of horses aged ≤3 and >3 years, respectively, achieved a successful outcome following stifle mosaic

FIGURE 6 Radiographs of the left stifle of Horse 9. (A) Caudocranial preoperative radiograph showing a cystic lesion in the medial femoral condyle (white arrow). (B) Postoperative caudocranial radiograph at 8 weeks. (C) Postoperative radiograph at 5 years, the cyst is no longer visible.

arthroplasty for SBC repair. This suggests that replacing osteochondral defects with mature cartilage and bone, rather than relying on intrinsic repair, may benefit adult and middle-aged horses. These results align with prior reports on SBC management, with success rates of 58%–91%.[2,4,7,10,11]

Mosaic arthroplasty in horses has evolved markedly over the past 25 years. While human mosaicplasty sets and the osteoarticular transfer system (OATS)[19] have been used in horses, a custom-made, durable instrument set has been developed by the last author and his research group. Instruments designed for humans lacked the necessary length and robustness for equine surgery[25] and were not suitable for equine use. Until 2000, only 6.5 mm instruments were available; however, larger 8.5 mm and 10 mm instruments capable of harvesting long grafts (35–40 mm) were needed to effectively fill defects in the dense equine bone.

The harvesting chisel was modified by expanding the inner and outer blade edges to improve graft separation and detachment from the parent bone. Previously, harvesting required multiple forceful sideways rotations, sometimes causing marginal damage to the graft's hyaline cap. Additionally, a more precise graft-measuring device was developed to prevent mismatches between drill hole depth and graft length during insertion (Figure 5). This innovation eliminated graft protrusion, avoiding the need for overdrilling and replacement.

Experimental results in pigs suggest that fewer grafts and those of larger diameter exhibit better fixation.[24] Over the past few decades, larger graft sizes with fewer total grafts have been favored in horses to enhance stability. Initially, in 1998, 6.5 mm diameter grafts (30–40 mm length) were used. By 2000, 8.5 mm grafts were introduced, and more recently, 8.5 mm or 10 mm grafts are implanted, with smaller grafts implanted around them to fill the remaining cyst cavity. These grafts are larger and longer than those used in other equine osteochondral graft studies (4.5, 6, or 6.5 mm diameter; 15 mm length).[17–19] Smaller grafts may allow curved surfaces for better joint congruency but can be fragile and less stable due to smaller contact interfaces with the host bone bed.[24] In this study, horses treated for fetlock SBCs with a single graft ($n = 4$) achieved successful outcomes, whereas those receiving two grafts into the distal MCIII or MTIII ($n = 5$) exhibited variable outcomes. Among horses with stifle SBCs, those with ≤ 2 implanted grafts showed a better outcome than those with ≥ 3 grafts implanted into the femoral condyle (90% vs. 50%). This may be attributed to the easier and more complete replacement of smaller lesions, which require fewer grafts. A larger defect requiring more grafts may heal less efficiently due to decreased stability in the surrounding native bone.[26] Based on our experience, 8.5 mm diameter grafts provide excellent surface congruency in the MFC and MCIII/MTIII condyles. Typically, one large and one smaller graft are sufficient for smaller cysts. Spacing of grafts might also influence biomechanics and healing of the implantation site.[15] Improper placement can result in decreased stability, remodeling of the graft-recipient site and fibrocartilage development between grafts.[15,27] We believe that placing grafts in close proximity may enhance structural support at the implantation site.

Preoperative arthroscopic evaluation of stifles represents an important refinement as arthroscopy allows for direct visualization of intra-articular structures, providing a more comprehensive assessment of joint integrity before proceeding with graft implantation. The early detection of meniscal or ligamentous injuries is particularly relevant, as undiagnosed soft tissue damage can affect long-term joint stability and surgical outcomes. In our study, pre-existing lesions—including such soft tissue injuries—appeared to negatively influence outcomes. Although arthroscopy is preferred in human surgery for implantation,[28] arthrotomy offers a more extensive approach to ensure complete debridement and better lesion assessment. Furthermore, it allows for precise three-dimensional adjustment of graft congruency. Therefore, in our practice, arthrotomy remains the preferred technique for stifle and fetlock joint implantations.

In this study, complications occurred in 5/31 cases. Seroma formation or wound dehiscence was observed exclusively in arthrotomy wounds, typically resulting from surgical dead space, or movement at the incision site. Horse 14 developed an infection 14 days post-surgery during an equine herpesvirus-1 outbreak, presenting with a 40°C rectal temperature, unilateral corneal opacity, distention of the right medial femorotibial joint, and severe lameness. Two of the four grafts underwent necrosis, likely due to compromised vascularity of the host bed from viral microvasculitis[29,30] requiring partial debridement via follow-up arthroscopy. Horse 13 developed iatrogenic septic arthritis following an intra-articular corticosteroid injection administered in the field 4 months postoperatively. Intra-articular postoperative steroid injections are recommended in justified cases only, if lameness persists. Despite repeated arthroscopic lavages, these two horses remained lame.

Donor site morbidity in human patients ranges from 5.9% to 19.6%, with complications including patellofemoral disturbances, crepitation, knee stiffness, recurrent swelling, painful hemarthrosis, and persistent pain.[31] In our patients, only minor donor site-related complications, such as slight femoropatellar joint distention were observed early postoperatively, which resolved within weeks. The use of larger allografts is a promising alternative, offering ample donor tissue while avoiding donor site issues. Horses aged >11 years are not ideal candidates for autograft implantation due to graft fragility and fracture risk.[32] Selecting donor animals (<36 months) is a critical factor, as younger cartilage generally has better regenerative potential. For Horse 10, the donor was an 11-month-old colt undergoing castration and umbilical hernia repair under the same general anesthesia. The donor recovered uneventfully, showing no donor-site morbidity over a 6-year follow-up. Osteochondral allografts were successfully used in one case; however, optimal harvesting and storage conditions for equine osteochondral allografts remain undetermined.[22]

Several technical challenges may occur during mosaic arthroplasty. Care must be taken during graft harvesting to prevent penetrating into adjacent sites, which can lead to shorter or incompletely harvested grafts. Graft breakage was occasionally observed, particularly in older horses, typically occurring 3–5 mm below the cartilage layer, rendering the graft unsuitable. During implantation, striking the graft too forcefully to sink it to the surface level, especially if it is improperly sized, can result in a proud surface, leading to intra-articular soft tissue damage. Errors may also increase plug micromotion and loading, impairing incorporation and causing chondral or subchondral necrosis.[27] If a step remains on the articular surface, the protruding graft should be overdrilled and replaced rather than forced deeper. Precise, perpendicular drilling during implantation is essential for optimal graft integration.

The limitations of this study include its retrospective design, lack of standardized surgical techniques due to procedural evolution, and incomplete postoperative data. Furthermore, variability in conventional and digital radiographs hindered consistent lesion size measurement and limited pre- and postoperative comparisons. The need for custom instruments, which are not commercially available currently, as well as limited allograft donor access, further restrict the implementation of this surgical procedure. Moreover, outcome evaluations rely partly on owner and veterinarian observations, which may introduce subjectivity and recall bias. Finally, the study's sample size remains a limiting factor, reducing statistical power.

In our experience, mosaic arthroplasty may be a valuable surgical alternative for treating SBCs in the equine stifle and fetlock joints. This technique eliminates the fibrous cyst lining, fills the cavity with stable trabecular bone, and restores a hyaline or hyaline-like weight-bearing surface. Larger grafts may offer advantages, and allograft implantation is a feasible alternative. Our findings revealed successful mosaic arthroplasty in both young and mature horses, demonstrating its effectiveness in treating subchondral cystic lesions.

AUTHOR CONTRIBUTIONS

Pál Z, DVM: Contributed to patient preparation and surgical management of the cases, collected data, and drafted and revised the manuscript. Tuska P, DVM: Assisted in surgery, postoperative care, patient follow-up, and manuscript preparation. Vásárhelyi G, MD: Contributed to surgical technique development and data interpretation. Hangody L, MD: Assisted in surgical procedure development, data interpretation, and manuscript writing and revision. Hurtig M, DVM, MVSc, DACVS: Contributed to development of the surgical technique, managed cases, and contributed to manuscript preparation, revision, and scientific editing. Kaposi AD, PhD: Conducted data analysis and statistical evaluation and contributed to manuscript preparation and revision. Bodó G, DVM, PhD, DECVS: Executed and developed the surgical procedure, participated in patient selection, data collection and interpretation, and manuscript preparation and revision.

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CONFLICT OF INTEREST STATEMENT

The authors are involved in developing new instrument sets, which are not yet commercially available but are expected to be trademarked in 2025.

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