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Grand Rounds from HSS

MANAGEMENT OF COMPLEX CASES

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Each author certifies that Hospital for Special Surgery has approved the reporting of this case and that all investigations were conducted in conformity with ethical principles of research.

FROM THE EDITOR

The discussion of complex cases in *Grand Rounds from Hospital for Special Surgery* focuses on the application of sound principles in orthopaedic care. The principles emerging in the promising advances in knee joint restoration and preservation are evident in the first case: Scott Rodeo uses osteotomy and allograft transplants to restore alignment, the knee articular surface and meniscus in a young female athlete. The next case involves the knee of a patient with rheumatoid arthritis that is beyond preservation, with cyst formation and significant bone loss, successfully replaced by Amar Ranawat using a custom total knee implant.

Severe traumatic segmental tibial bone loss in a seventeen-year-old male represents a great challenge in limb salvage and tibial reconstruction. Roger Widmann is able to not only save the limb but successfully restore structural integrity with meticulously staged bifocal tibial transport. And in the final case, Federico Girardi demonstrates a novel approach to treat a condition that continues to pose a challenging problem for spine surgeons: high grade spondylolisthesis and spondylosis.

You may view this publication on www.hss.edu, where you will find additional images and references as well as links to related articles on topics such as joint preservation and the musculoskeletal specialists at HSS. We hope you find these cases to be of interest and the principles presented informative. Comments are always welcome at complexcases@hss.edu.

— Edward C. Jones, MD, MA, Assistant Attending Orthopaedic Surgeon

in this issue

CASE 1

Osteotomy and Allograft Transplants to Restore Knee Articular Surface and Meniscus

Case presented by Scott A. Rodeo, MD, and Clifford Voigt, MD

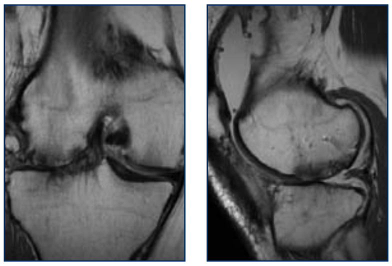

Figure 1: MRI of the right knee demonstrating incongruity of the lateral femoral condyle at the site of the prior osteochondral autograft with loss of articular cartilage. Attenuated lateral meniscus extruded into the lateral gutter. Deformity of the lateral tibial plateau with diminished articular cartilage.

Figure 2: Standing hip to ankle AP x-ray showing valgus alignment of the right knee.

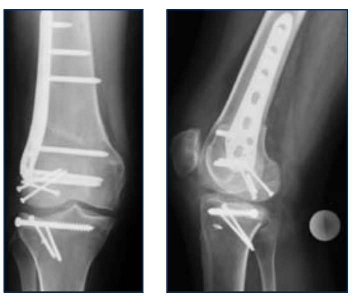

Figure 3: AP and lateral x-rays of the right knee after varus producing distal femoral osteotomy with osteochondral allograft resurfacing of the lateral femoral condyle as well as implantation of an osteochondral hemi-tibial plateau allograft with attached lateral meniscus.

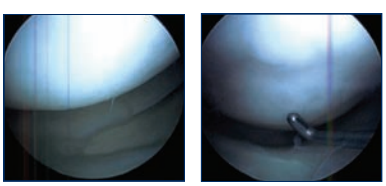

Figure 4: Arthroscopic views of the right knee demonstrate the lateral meniscus to have normal size, position, and morphology with intact horn attachments. The articular cartilage on the osteochondral allograft in both the lateral femoral condyle and the lateral tibial plateau appeared intact. The junction between the osteochondral plug in the lateral femoral condyle and the surrounding native articular cartilage could still be discerned.

CASE REPORT: A 25-year-old female basketball player presented to Hospital for Special Surgery (HSS) with pain localized largely to the lateral side of her right knee, made worse with stair climbing. The patient had undergone subtotal lateral meniscectomy 11 years prior, followed later by lateral meniscus transplantation as well as placement of two osteochondral autografts in the lateral femoral condyle. This procedure ultimately failed and she presented to HSS with complaints of persistent pain and swelling in the right knee.

Physical examination demonstrated valgus deformity of the right knee. There was a large effusion with full range of motion and lateral joint line tenderness. A Steinman test reproduced both pain and clicking. Ligament stability was intact. MRI demonstrated incongruity of the lateral femoral condyle at the site of the prior osteochondral autograft (Figure 1). Articular cartilage on the transplanted osteochondral plugs had been largely denuded. The transplanted lateral meniscus was diminutive and extruded into the lateral gutter. There was deformity of the lateral tibial plateau from excessive lateral placement of the lateral meniscus transplant bone slot. Our assessment at this time was early lateral compartment arthrosis in the setting of lateral meniscus deficiency and valgus malalignment in a young patient (Figure 2).

We reconstructed the lateral compartment by performing a single stage varus producing distal femoral osteotomy with osteochondral allograft resurfacing of the lateral femoral condyle as well as implantation of an osteochondral hemi-tibial plateau allograft with attached lateral meniscus. Post-operative radiographs have demonstrated complete allograft incorporation with no progressive lateral compartment arthrosis (Figure 3). The screws affixing the lateral tibial hemi-plateau allograft were removed at 15 months following the surgery, at which time arthroscopic inspection demonstrated the lateral meniscus to have normal size, position and morphology with intact horn attachments (Figure 4). The articular cartilage on the osteochondral allograft in both the lateral femoral condyle and the lateral tibial plateau appeared intact. The junction between the osteochondral plug in the lateral femoral condyle and the surrounding native articular cartilage could still be discerned. There were early degenerative changes in the medial and patellofemoral compartments. At her most recent follow-up two years after surgery, the patient had mild activity-related discomfort but is able to participate in light activities such as hiking.

DISCUSSION: Approximately 1.5 million arthroscopic knee procedures are carried out each year, with over 50 percent involving meniscal surgery. Meniscal preservation in the form of meniscal repair is favored over partial or total meniscectomy. Commonly, patients who have undergone meniscectomy have articular cartilage defects likely due to excessive articular cartilage contact stresses. Appreciation of the role of the meniscus in load transmission in the knee has led to an emphasis on meniscal preservation as well as possible meniscus allograft transplantation.

This case illustrates the combination of factors that must be considered in complex knee reconstruction; the primary factors include the status of: 1) articular cartilage; 2) meniscus; 3) axial alignment; and 4) ligament stability. Malalignment must be corrected in conjunction with or prior to any type of articular cartilage resurfacing or meniscus replacement. A varus-producing osteotomy was used here to correct the excessive valgus alignment.

The indications for meniscus transplantation include symptoms of early arthrosis in the setting of only early arthrosis. The knee should be stable and have appropriate alignment (i.e., a lateral meniscus should not be transplanted into a knee with excessive valgus alignment). The primary indication at this time for meniscus transplantation is to treat symptoms (typically pain and swelling); there is currently no evidence that meniscus transplantation can forestall or reverse progressive degenerative changes in the involved compartment. It is recognized that the transplanted meniscus may ultimately degenerate; thus, meniscus transplantation may be considered an interim step in joint preservation in young patients.

Meniscus transplantation can be done with or without bone attached to the anterior and posterior horns. Biomechanical studies demonstrate superior fixation using bone at the horn attachments. This can be done using either small, individual bone plugs on each horn or one common bone slot connecting the anterior and posterior horns. The bone slot technique requires that the recipient slot be made just adjacent to the anterior cruciate ligament (ACL) with care taken not to injure the ACL or to displace the slot too far into the lateral compartment. In this case it appeared that the bone slot used for the initial lateral meniscus transplantation was displaced into the lateral compartment, damaging the articular surface of the tibial plateau.

Article and references continued on back page.

CASE 2 Complex Primary Total Knee Replacement with Large Cystic Lesions

Case presented by Amar S. Ranawat, MD, and Morteza Meftah, MD

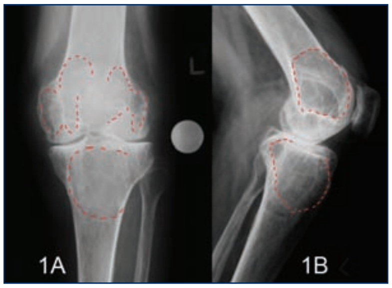

Figure 1: Antero-posterior (1A) and lateral (1B) pre-operative radiographs demonstrating diffuse joint space narrowing, joint effusion and large cystic lesions (red dots).

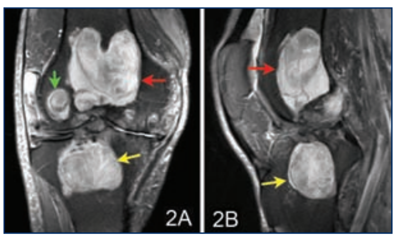

Figure 2: Coronal (2A) and sagittal (2B) T2 MRI images, demonstrating large lateral femoral condylar (green arrow), intercondylar (red arrow), and proximal tibial (yellow arrow) cysts.

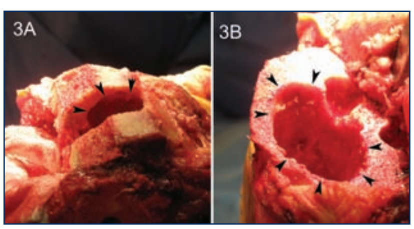

Figure 3: Intra-operative finding of the cystic lesions (black arrowheads) on femur (3A) and tibia (3B).

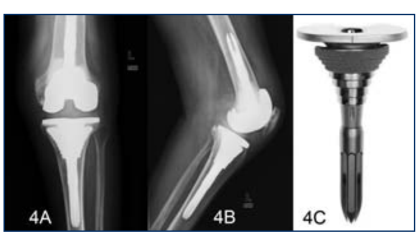

Figure 4: Antero-posterior (4A) and lateral (4B) radiographs two years post-operatively showing proper alignment and fixation of both components. A sample of the tibial sleeves is shown (4C).

CASE REPORT: A 60-year-old male presented with left knee pain of several years' duration that had been getting progressively worse and was causing him difficulty with his activities of daily living. He had trouble walking, negotiating stairs, squatting, and kneeling. His past medical history was significant for long-standing rheumatoid arthritis (RA) and diabetes, for which he was taking hydrochlorothiazide, methotrexate, prednisone and insulin.

On physical examination, the patient had an antalgic gait with an obvious varus deformity of his left knee. He had 115 degrees of flexion with a 10 degree flexion contracture. The knee was swollen with evidence of synovitis. There was also mild mediolateral instability.

Radiographs of the left knee demonstrated diffuse joint space narrowing, joint effusion and large cystic lesions both in the distal femur and proximal tibia consistent with rheumatoid arthritis (Figure 1). Based on the radiographic findings, an MRI was obtained. The MRI revealed large cysts with benign features in both the medial and lateral femoral condyles and the tibial plateau with relative preservation of the articular surfaces of the femoral condyles (Figure 2). A single-stage total knee replacement (TKR) was recommended to the patient.

At the time of surgery, all cystic lesions were curetted and cleaned (Figure 3). As a result of the large proximal tibial bone cyst, a non-cemented titanium metaphyseal sleeve tibial component was used. On the femoral side, there were several cysts proximal to the condyles with intact condylar bone. The decision was made to use cement to fill the defects. A hybrid fixation femoral component was used, cementing the condylar surface of the prosthesis and press-fit stem fixation to bypass the defects.

At two years follow-up, the patient was free of pain, walking without a limp, and demonstrating a range of motion of 0 to 125 degrees with good power. There was no instability upon physical exam. Radiographs showed good alignment and fixation of all components (Figure 4).

DISCUSSION: Management of complex primary TKR with significant bone loss can be challenging. Based on the Anderson Orthopaedic Research Institute (AORI) classification, this case would be considered type IIb bone loss where there are large bone defects in both condyles, requiring some type of augmentation (1). Adequate curettage and cleaning of all cysts with the use of a long femoral stem to bypass the defect and achieve proper metaphyseal/diaphyseal fixation is recommended. Historically, choices for filling these defects have included impaction bone grafting, structural allograft, and/or the use of cement. Bone graft is commonly used in contained defects and in younger patients (2). Concerns with allograft are the availability of proper size grafts, disease transmission, and the difficulty of graft preparation. In addition, long-term fixation and incorporation of these grafts remains controversial. Cement is inexpensive and can be used to fill in small gaps.

Recently, metal augments, cones and sleeves have become readily available. These sleeves have a variety of sizes, provide rotational control of the construct by engaging the metaphyseal/diaphyseal cortical junction, allow immediate weight bearing, and can be used with or without cement (3). Although non-cemented titanium metaphyseal sleeves are usually reserved for revision knee surgeries, they can also be used in such cases of complex primary TKR with significant bone loss. In this case, the distal femoral condyles were preserved and cement was used to fill the defects, and on the tibial side a non-cemented metaphyseal sleeve was used.

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AUTHOR DISCLOSURES:

Dr. Ranawat does not have a financial interest or relationship with the manufacturers of products or services.

Dr. Meftah does not have a financial interest or relationship with the manufacturers of products or services.

CASE 3

Severe Traumatic Tibial Bone Loss and Bifocal Tibial Transport

Case presented by Roger F. Widmann, MD, Arkady Blyakher, MD, and Vladimir Goldman, MD

FIGURE 1

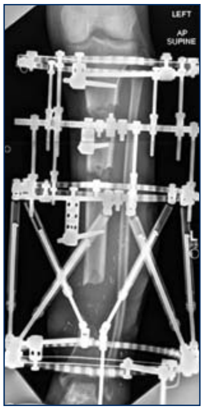

FIGURE 2

Figure 1: AP radiograph of left tibia demonstrating distal shaft bone loss and temporary fixation with monolateral external fixator system.

Figure 2: AP radiograph of left tibia demonstrating distraction at the two proximal tibial osteotomy sites and gradual transport of the tibial shaft toward the distal tibial segment. The distraction and transport are performed using the Ilizarov-Taylor Spatial Frame circular external fixator system.

FIGURE 3

FIGURE 4

Figure 3: AP radiograph of the left tibia demonstrates maturation of the regenerate bone at both transport sites as well as complete healing at the distal tibial docking site 18 months post injury.

Figure 4: Clinical picture of the patient at the end of treatment. Left lower extremity has excellent alignment, a plantigrade foot and equal leg length. The patient ambulates without orthotics or assistive devices.

CASE REPORT: A 17-year-old boy was driving an open-top jeep when he was struck by a drunk driver, causing his vehicle to roll over. He sustained an open Grade IIIb injury to his left tibia with approximately 10 cm of distal tibia shaft bone loss. He underwent immediate irrigation and debridement of the open wound at a local hospital with application of a temporary external fixator (Figure 1). The patient was then transferred to the HSS Orthopaedic Trauma Service for definitive management. The next day the patient underwent irrigation and debridement with placement of an antibiotic impregnated cement spacer in the intercalary defect site and temporary VAC closure. The loss of the anterior tibial artery as well as significant tibialis anterior muscle loss was noted. On post-injury day eight the patient underwent final irrigation and debridement as well as latissimus muscle vascularized free flap coverage of the tibia defect. The patient's overall status was stable and the affected limb was noted to be neurovascularly intact.

Four weeks post-injury, the patient was transferred to the HSS Pediatric Orthopaedic Service, and the frame was exchanged for a Taylor Spatial Frame and the cement spacer was removed. Definitive management of the bone defect was temporarily postponed to allow for complete soft-tissue healing.

At eight weeks post-injury, the patient underwent two-level tibial osteotomy, and bifocal bone transport was initiated seven days later with a transport rate of 1 mm per day at each site (Figure 2). After six weeks of transport, the distal docking site was opened, the bone ends were debrided and cancellous autologous iliac crest graft was placed; one more week of bone transport was performed, and the distal docking site was compressed. Excellent clinical alignment was achieved with 3 mm of medial translation at the docking site. The external fixator was removed nine months post-injury, and by 18 months postoperatively the patient was able to ambulate independently without assistive devices or orthotics (Figures 3 and 4).

DISCUSSION: Massive traumatic segmental bone loss in the lower extremity presents as a difficult clinical challenge. Management decisions are influenced by such factors as neurovascular status, medical comorbidities, the presence of infection, and social factors including patient compliance. Limb salvage in cases of lower extremity trauma with segmental bone loss is a long process with a high complication rate, and amputation should be considered especially in injuries with neurological or vascular compromise.

With smaller bone defects (<3 cm), acute shortening is an excellent option. It has a fast recovery period with few complications. Residual length discrepancy can be addressed later if clinically significant.

For larger bony defects several options have been described. All treatment options require prolonged treatment, and all are associated with complications such as delayed consolidation, nonunion, refracture, and donor site morbidity. Autologous bone grafting with cancellous bone obtained from the iliac crest can be used to fill segmental defects up to 4 cm (1). Transfer of either the ipsilateral (2) or contralateral (3) fibula to the defect can be used to reconstruct segmental defects in the tibia. Fibula transfer has the advantage of being a vascularized autograft. However, vascularized fibulas may take several years to hypertrophy enough for unsupported weight bearing (4).

Bone transport, as used in this case, is an excellent option for the treatment of large segmental defects in the tibia. It has become a widely utilized treatment option for segmental bone loss in both adult and pediatric patients. Bifocal bone transport allows more rapid transport compared with monofocal techniques, and was therefore chosen in this case (5).

Disadvantages to bone transport include the long duration of treatment, complexity of the technique, and the need for multiple operations. However, when open bone grafting of large segmental tibial defects was compared with bone transport, bone transport was found to have a shorter period of disability (6). Docking site malalignment is another common complication of bone transport, with an incidence of 32 percent in one series (7). Residual malalignment may decrease the union rate and also increases the refracture risk.

This case demonstrates the utility of bifocal distraction osteogenesis in the treatment of massive segmental tibial bone loss in a pediatric patient. Use of bifocal bone transport may significantly decrease the duration of disability.

References located on back page.

AUTHOR DISCLOSURES:

Dr. Widmann does not have a financial interest or relationship with the manufacturers of products or services.

Dr. Blyakher does not have a financial interest or relationship with the manufacturers of products or services.

Dr. Goldman does not have a financial interest or relationship with the manufacturers of products or services.

CASE 4

Management of High Grade Spondylolisthesis

Case presented by Federico P. Girardi, MD, Fred Mo, MD, and Stephanie Ihnow, BA

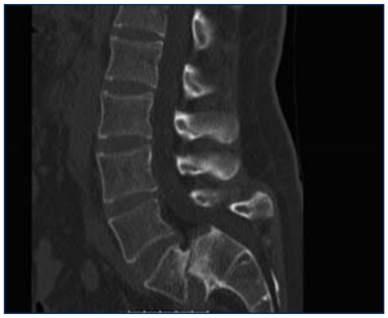

Figure 1: Pre-operative sagittal CT scan showing Grade III spondylolisthesis.

Figure 2: Post-operative CT image highlighting the cage position traversing L5-S1.

Figure 3: Post-operative lateral x-ray of final construct from L4-S1 and posterior cage.

Figure 4: Postoperative AP x-ray of final construct.

CASE REPORT: A 31-year-old male presented with 10 years of progressive low back pain. The patient noted exacerbation of pain with prolonged walking, standing and sitting. He also reported a sense of trunkal imbalance, feeling it difficult to hold himself upright and a tendency to lean to the right when walking. He denied numbness or weakness in his lower extremities and had no history of bowel or bladder incontinence. The patient tried physical therapy without improvement of his symptoms. Past medical history was significant for Best's Disease (macular dystrophy). He also had a 14-year history of cigarette smoking, which he discontinued three years ago.

At 5'4" tall and weighing 170 pounds, the patient stood with slight flexion at his lumbosacral junction and was hyperlordotic in the lumbar spine. He had a normal gait and could heel and toe walk without difficulty. There was an obvious step off at the L5-S1 area on manual palpation, and L5 sensation was decreased on the right. The patient showed no signs of motor deficit and was normoreflexic. Conventional radiographs demonstrated a Grade III spondylolisthesis with marked degeneration of the L5/S1 disc space. CT scan further demonstrated erosion of the anterior aspect of S1 (Figure 1). CT scan also confirmed bilateral L5 spondylolysis and bilateral foraminal stenosis with mild degenerative disc disease at L3-4 and L4-5.

Due to the chronic, debilitating nature of the patient's pain, as well as the lack of improvement noted with non-surgical modalities, the decision was made for surgical intervention.

A standard posterior approach was performed, exposing the lumbosacral junction. A cage with iliac crest bone graft was inserted through S1 into the L5 body from posterior to anterior using an image intensifier (Figure 2). A posterior lumbar decompression of L4-S1 was performed as well as posterolateral instrumented fusion using pedicle screws at L4-S1 (Figures 3 & 4). Eight months postoperatively, the patient had marked improvement of his preoperative lower back pain and was able to walk, stand, sit and lie in the supine position comfortably.

DISCUSSION: Spondylolisthesis is most commonly seen at the lumbosacral junction (1). Along with low back pain, there may be L5 radiculopathy secondary to nerve root compression as the upper most vertebral body advances forward. In addition, callous formation contributes to foraminal stenosis. There are many reasons as to why this develops; Wiltse offered a classification system based on etiology including degenerative, traumatic, pathologic, dysplastic and isthmic categories (2). Isthmic spondylisthesis is by far the most common, defined by a defect in the pars interarticularis (spondylolysis). Isthmic spondylolisthesis develops in younger patient populations while degenerative spondylolisthesis, most commonly at L4-5, occurs typically in patients older than 65 years old. Degenerative spondylolisthesis is attributed to incompetence of the facet and intervertebral disc rather to the pars interarticularis. Displacement of the vertebral bodies is seen on a standing lateral radiograph. The Meyerding classification describes the percentage of vertebral displacement (3). Further imaging including CT and MRI may aid in the surgical decision-making.

The majority of patients with lower grade spondylolisthesis respond favorably to physical therapy, bracing and other conservative treatments (4). However, progressive deformity, pain and worsening neurologic function requires more aggressive management. In Grade I and II slips with normal or near normal adjacent disks, single level fusions have been shown to have substantial fusion rates and satisfactory clinical outcomes. Where spondylolisthesis is above 50 percent (Meyerding Grades 3-4), good results have been shown with two level fusions with or without interbody fusion (5). Anterior interbody fusions have been used in the treatment of spondylolisthesis due to the added biomechanical advantages it affords. Both anterior as well as posterior interbody approaches have been described; however, there are a host of potential complications which are characteristic in both. In our case the interbody fusion was performed from a posterior approach. By bridging the L5-S1 disk space, intervertebral disk height is maintained or increased which may aid in decompression of the neuroforamen and therefore the exiting nerve root. In cases of high grade spondylolisthesis, the angle of approach for entering the L5-S1 disc may make the approach unfeasible. Controversy exists regarding reduction of high grade slips. Theoretically, reduction offers improved biomechanics in regards to fusion, decompression as well as reduction of coronal and saggital balance. Reduction, however, must be weighed against the risks of neurologic injury. Even in the setting of neuromonitoring, bladder dysfunction, paralysis and L5 nerve root injury have been reported (5).

Article and references continued on back page.

AUTHOR DISCLOSURES:

Dr. Girardi does not have a financial interest or relationship with the manufacturers of products or services.

Dr. Mo does not have a financial interest or relationship with the manufacturers of products or services.

Ms. Ihnow does not have a financial interest or relationship with the manufacturers of products or services.

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CASE 1 CONTINUED

In summary, this case demonstrates the use of allograft tissue to restore articular surface and meniscus. We recognize that we cannot fully restore normal anatomy or joint kinematics, and progressive arthrosis is likely to occur. However, by restoring joint alignment and architecture, we hope to both treat current symptoms and slow the progression of joint degeneration.

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AUTHOR DISCLOSURES:

Dr. Rodeo does not have a financial interest or relationship with the manufacturers of products or services.

Dr. Voigt does not have a financial interest or relationship with the manufacturers of products or services.

CASE 3 CONTINUED

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CASE 4 CONTINUED

In the treatment of this patient, we used a modification of a technique described by Bohlman, who, after performing a posterior decompression, inserted bilateral fibular dowel grafts into the sacrum and disk space ending in the L5 vertebral body (7). In our case, a titanium mesh cage filled with iliac crest bone graft was inserted from posterior to anterior in a similar fashion.

High grade spondylolisthesis and spondylosis continue to pose a challenging problem for the spine surgeon today, however, with thoughtful selection of surgical technique and the achievement of surgical goals, patients can have an excellent outcome.

References for Case 4 appear online at www.hss.edu/complexcases.

DESIGN/PRODUCTION:
Marcia Ennis | Director, Education Publications & Communications

Hospital for Special Surgery is an affiliate of NewYork-Presbyterian Healthcare System and Weill Cornell Medical College.

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