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Osteochondral Allograft Transplantation for Femoral Trochlear Dysplasia

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Background: The risk factors for patellofemoral joint instability include laxity of medial patellar restraints, abnormal limb geometry, femoral and tibial malrotation, patella alta, and trochlear dysplasia. Femoral trochlear dysplasia is characterized by a hypoplastic or shallow trochlear groove.

Case Report: We report the case of a 31-year-old female with trochlear dysplasia and recurrent patella dislocations, laxity of the medial patellofemoral ligament (MPFL), and high-grade chondromalacia of the trochlea and the patella. Surgical treatment goals were to re-create a trochlear groove, restore bony restraint, and realign and offload the patella. First, a triplane tibial tubercle osteotomy (TTO) was performed, and the patella was everted 360° with a subvastus approach. The MPFL was reconstructed using a gracilis allograft. A fresh osteochondral allograft transplant trochlea was sized, and a 35-mm diameter graft was transplanted to re-create the groove. The TTO was secured in a new anterior, medial, and distal position. The patient was braced for 6 weeks and completed a rehabilitation protocol. At 9-month follow-up, she had made significant gains in range of motion (0°-140°) and activity compared to her preoperative status. She reported no pain or recurrent dislocations.

Conclusion: This case demonstrates a viable surgical option for treatment of instability resulting from trochlear dysplasia with patellofemoral chondromalacia. The osteochondral allograft transplantation surgery technique allows patients to have a stable, pain-free knee joint and participate in activities compared to nonoperative management. However, the long-term outcomes of this procedure are unknown.

Keywords: *Chondromalacia patellae, osteoarthritis–knee, patellar dislocation, patellofemoral joint*

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INTRODUCTION

Patellofemoral joint instability is a common problem affecting young patients.[1] The risk factors for patellofemoral joint instability include laxity of medial patellar restraints, abnormal limb geometry, femoral and tibial malrotation, patella alta, and trochlear dysplasia.[2] Femoral trochlear dysplasia (FTD), a common condition present in 85% of patella dislocations,[3] is characterized by an abnormally shaped and hypoplastic or shallow trochlear groove.[4] FTD can lead to instability of the patellofemoral joint with recurrent patella dislocations, chondromalacia, osteoarthrosis, and chronic pain.[5-8] In many cases, FTD interferes with the activities of daily living and participation in sports.[5-8] The literature offers many strategies and operative techniques for treatment of patellofemoral joint instability resulting from trochlear dysplasia in children and adults. However, this condition remains a treatment challenge, especially when associated with chondromalacia and arthrosis. The current treatment options include combinations of deepening trochleoplasty, osteochondral allograft transplantation surgery (OATS), tibial tubercle osteotomy (TTO), and medial patellofemoral ligament (MPFL) reconstruction. We report the case of a female with trochlear dysplasia, chondromalacia of the trochlear groove, and recurrent patella dislocations with lack of static medial patellar constraints.

CASE REPORT

A 31-year-old female with chronic knee pain most of her life presented with worsening pain, resulting in an inability to work and perform activities of daily living. She had a history of congenital patella subluxation bilaterally (Figure 1A) and trochlear dysplasia (Figure 1B) and tolerated this condition until 10 years of age when she started having regular patellar dislocations. The dislocations prevented her from participating in sports both in school and recreationally. She underwent bilateral extensor mechanism realignment surgery at the age of 16 years. The records from these surgeries are unavailable, but current radiographs demon-

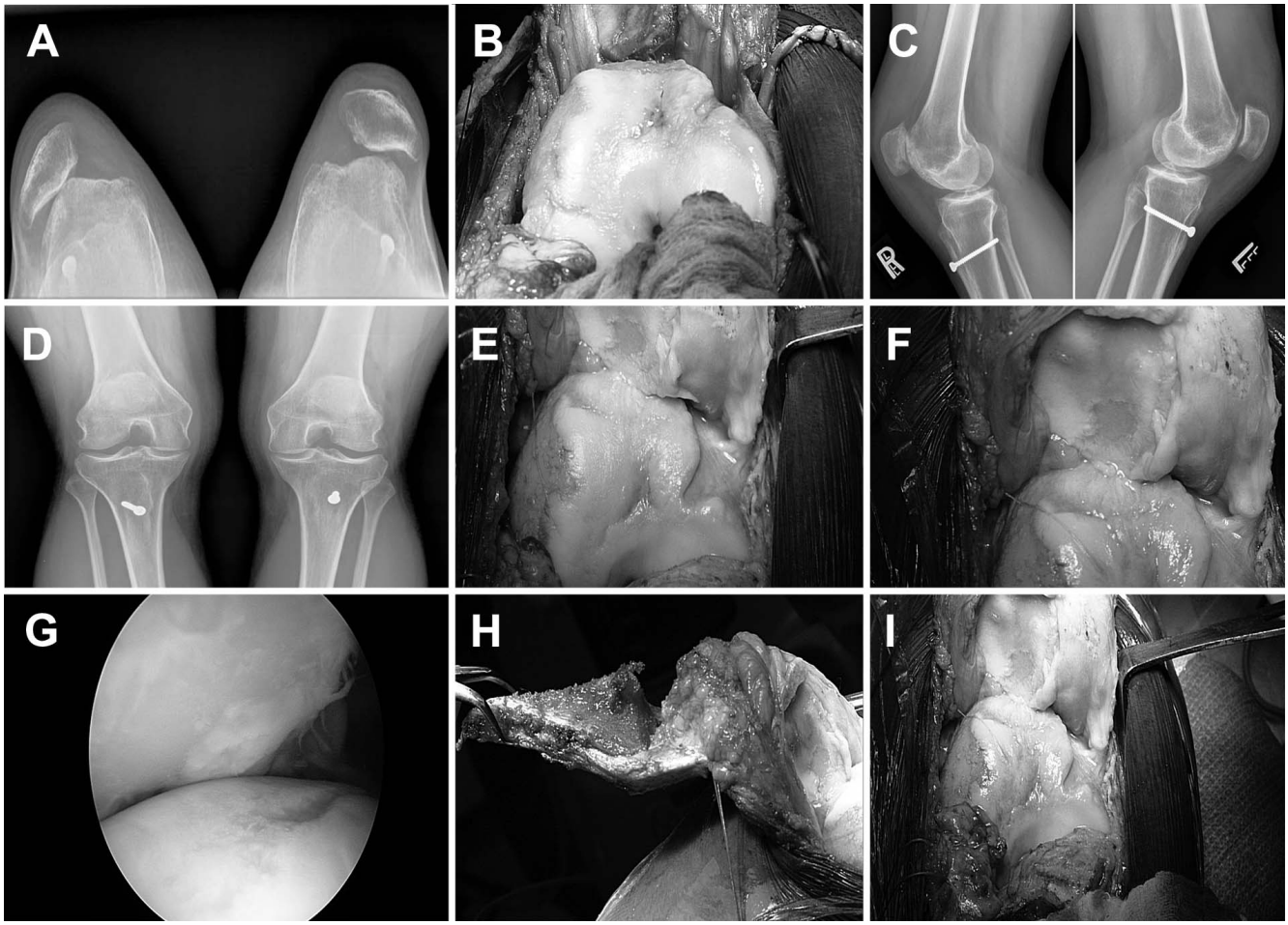

Figure 1. A: Merchant view x-rays of bilateral knees demonstrate the dislocated right patella and subluxated left patella. B: Severe trochlear groove dysplasia with chondromalacia. C: Bilateral Rosenberg view x-ray demonstrates the previous tibial tubercle osteotomy (TTO). D: Bilateral lateral view x-ray demonstrates the previous TTO. E: High-grade chondromalacia of the trochlear groove along with severe dysplasia. F: High-grade chondromalacia of both patellar facets. G: Arthroscopic view from the anterior medial portal demonstrates the dislocated patella with high-grade chondromalacia. H: TTO everted 360° to access the knee joint. I: Full access to the knee joint after 360° patella eversion.

strate a likely medialization of the tibial tubercle (Figures 1C and 1D). The patient tolerated this procedure well, but after some years, she again started having recurrent patellar instability and increasing pain. Prior to her visit with the operative surgeon for the realignment surgery, she had gone through multiple rounds of physical therapy and activity modification and had taken nonsteroidal antiinflammatory medications. Conservative treatment had failed to provide sustained relief. She continued to experience patellar instability and pain.

The patient's medical history was significant for anemia, hyperlipidemia, and hypothyroidism. She had had a thyroidectomy and bilateral knee surgeries as mentioned above. She was taking levothyroxine (Synthroid) regularly along with fish oil, was a nonsmoker, and did not consume alcohol.

During physical examination of the knee joint, the patient did not have any erythema, soft tissue edema, or joint effusion. Surgical scars from the previous surgeries were noted. She was tender to palpation around the patella, especially the lateral patellar border/facet. She did not have any patellar apprehension or grind but did have passive lateral tilt and abnormal tracking (Figure 1A). The patella glided 4 quadrants in the medial and lateral directions. The patient had 0°-130° range of motion (ROM), and the patella could be dislocated laterally and stay dislocated throughout the ROM (Figure 1A). The patella could be reduced to midline but dislocated laterally during ROM if not held in the midline position with assistance. In addition, patella alta and an abnormal quadriceps angle (q-angle) were present. Collateral, cruciate, and meniscal knee examinations were normal.

The patient was prepped and draped in standard orthopedic fashion. An arthroscopy confirmed global grade 3-4 chondromalacia of the trochlear groove (Figure 1E) and grade 4 chondromalacia of the central and medial facet of the patella (Figures 1F and 1G). A triplane TTO was performed as demonstrated by Fulkerson[9] using an AMZ guide system (DePuy Synthes Companies). Unlike the standard technique, the osteotomy was completed to allow

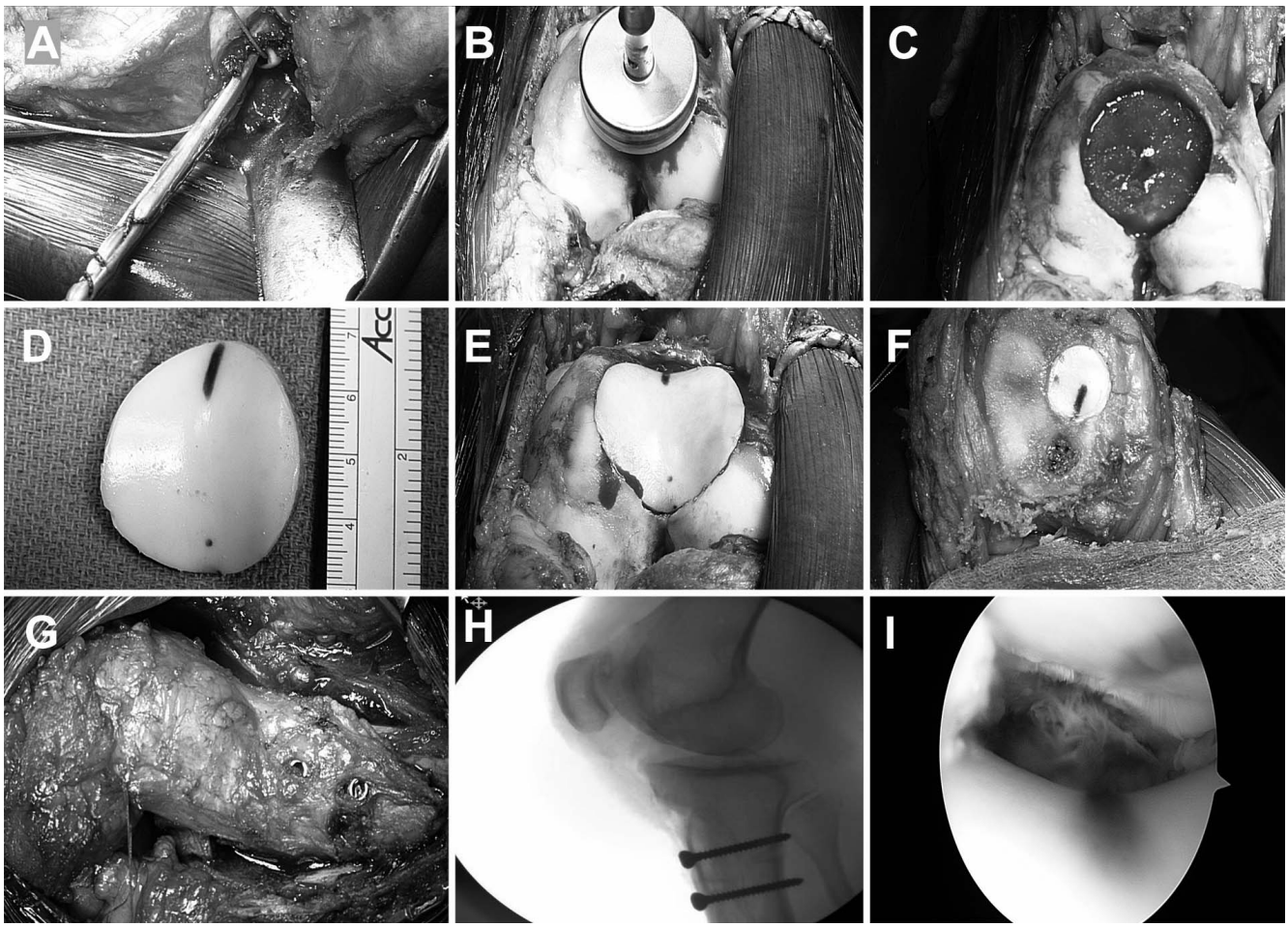

Figure 2. A: Medial patellofemoral ligament graft fixation at the anatomic insertion site with Bio-Tenodesis screw. B and C: Native trochlear groove measured 35 mm in diameter and 10 mm in depth. D: The osteochondral allograft transplant measured 35 × 10 mm. E: Allograft transplant secured in the native trochlea with the press-fit technique. F: Osteochondral allograft transplant and microfracture of patella measuring 10 × 10 mm. G: Tibial tubercle osteotomy secured with large compression screws. H: Patella in appropriate location bisecting the Blumensaat line on lateral fluoroscopic view. I: Arthroscopic view of the patellofemoral joint demonstrates patella midline in the groove. The trochlea demonstrates the osteochondral allograft transplant graft.

360° eversion of the patella (Figure 1H). Release of the anterior intermeniscal region and a subvastus approach allowed full access to the knee joint (Figure 1I).

The MPFL was anatomically reconstructed using a gracilis tendon allograft oversewn with a baseball stitch using a FiberLoop suture (Arthrex, Inc.). The graft was secured at its anatomic insertion site on the femur as described by Schöttle et al[10] with a Bio-Tenodesis screw (Arthrex, Inc.) (Figure 2A). The graft was then shuttled to the proximal third pole of the patella in a plane just superficial to the joint capsule but was not secured on the patella. Next, the size of the dysplastic trochlear lesion was measured at 35 mm in diameter (Figures 2B and 2C). A fresh osteochondral trochlear graft from an allograft distal femur by RTI Surgical was sized, and a 35 × 10-mm graft was obtained (Figure 2D). The graft was transplanted in the native knee, re-creating the groove, and secured by the press-fit technique (Figure 2E). Next, the patellar lesions were addressed with a 10 × 10-mm diameter graft obtained and secured in the same fashion and with microfracture of a 5 × 5-mm lesion (Figure 2F). Next, the tibial tubercle was reduced to a new position 1 cm anterior, medial, and distal to the osteotomy site (Figure 2G) and was secured using 4.5 × 38-mm compression screws (Figure 2H). C-arm fluoroscopy guidance was used to ensure that the patella was in the appropriate location and that the inferior pole bisected the Blumensaat line on the lateral projection with the knee in 30° of flexion (Figure 2H). The osteotomy fixation site was packed with autograft and with a cortical fibers allograft (Musculoskeletal Transplant Foundation). In the final step, a LUPINE double-loaded anchor (DePuy Synthes Companies) was used to secure the MPFL reconstruction graft to the patella in 30° of knee flexion. Arthroscopic guidance was used to ensure proper reduction and midline tracking of the patella in the groove (Figure 2I). Care was taken to not tension the graft. Next, an intraoperative examination was performed. The patella glide was 1 quadrant in the lateral and 2 quadrants in the

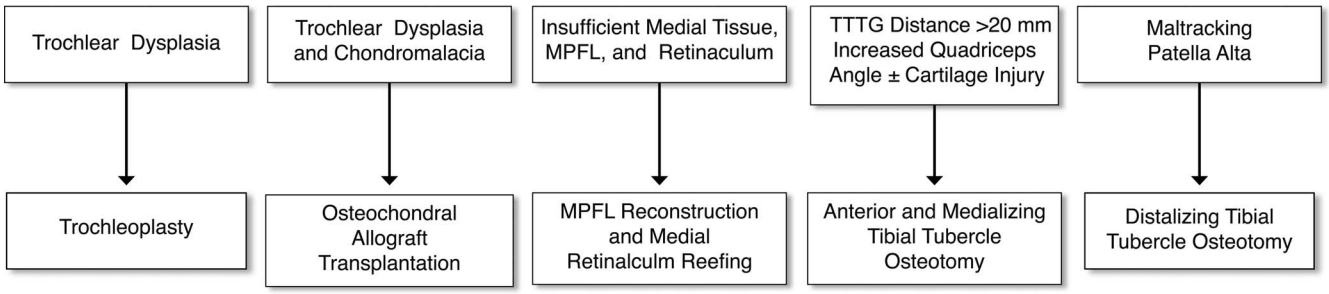

Figure 3. Treatment algorithm for patellofemoral joint instability. MPFL, medial patellofemoral ligament; TTTG, tibial tubercle-trochlear groove.

medial direction at 30° of flexion. With the knee in full extension, the patella glide was 2 quadrants laterally and medially. The incision was closed in layered fashion and dressed in standard fashion.

The knee was secured in a hinged brace that was locked in −10° hyperextension and allowed to flex to 45°. Physical therapy was started within 1 week. The patient was allowed 0°-45° ROM for the first 2 weeks, 0°-60° for weeks 3 and 4, 0°-90° for weeks 5 and 6, and full flexion by week 8. Weight-bearing was protected, and the patient was allowed toe-touch weight-bearing activity for the first 6 weeks with the brace locked in full extension for gait, followed by 50% partial weight-bearing at 6 weeks and then weight-bearing as tolerated by 8 weeks. The patient was not allowed to do open-chain exercises for 6 months after surgery. At 9-month follow-up, the patient had made significant gains in ROM (0°-140°) and activity compared to her preoperative status. She had no pain with the activities of daily living and no recurrent patella dislocation since surgery and was able to walk, jog, and ride a bike without issues.

DISCUSSION

The stability of the patellofemoral joint depends on the complex interplay of bony anatomy and soft tissue restraint.[8] Understanding all the factors that drive knee instability, pain, and loss of function is important.[8] Knee femoral trochlear dysplasia and its sequelae remain a complex problem. As this case demonstrates, no single surgical treatment option is adequate. Instead, in many cases, a combined approach is necessary to have a stable, pain-free, and functional knee joint depending on the pathology present (Figure 3). Our patient underwent an osteochondral allograft transplantation of the trochlear groove to treat dysplasia and chondromalacia as well as a triplane TTO to correct the q-angle and patella alta and to offload the transplant. In addition, the MPFL was reconstructed to stabilize the patella and re-create the medial patellar checkrein.

The treatment options for trochlear dysplasia include deepening trochleoplasty and osteochondral transplantation. Various trochleoplasty techniques have been described,[4,11,12] but the technique modification described by Dejour and colleagues[4] and Bereiter and Gautier[12] remains popular. This technique involves elevation of an osteochondral flap and reshaping the trochlea by removing/remodeling excess bone and creating a groove. The osteochondral flap is reduced and secured in the new groove, creating an anatomic trochlea. The results of trochleoplasty are mixed but encouraging. Von Knoch et al found no recurrent dislocation with radiographic re-creation of the groove in 94% of patients at a mean follow-up of 8 years but observed degeneration of the patellofemoral joint in 30% of the knees.[13] In addition, pain improved only in 49% of the patients and worsened in 33% of the patients. Schöttle and colleagues used a similar technique and reported improvement in Kujala scores from 56 to 80 and no dislocations, but 26% of patients continued to have pain.[14] Blnd and Haugegaard have described new arthroscopic trochleoplasty techniques showing good results.[15] The presence of chondromalacia with dysplastic trochlear groove presents an additional problem. Deepening trochleoplasty restores stability and improves patellar tracking but is not likely to produce predictable pain relief because of preexisting degeneration. Our patient had dyplasia along with grade 3-4 chondromalacia of both the trochlea and the patella. To address both problems, OATS was selected instead of trochleoplasty. Currently, no large studies demonstrate long-term outcomes of treating trochlear dysplasia with OATS. Brucker and colleagues showed good outcomes of large-size OATS procedures in the knee femoral condyle.[16] They showed that at mean follow-up of 55 months, the Lysholm knee score improved from 62 to 81 ($P<0.001$), and 90% of patients had high subjective satisfaction rates.[16]

Lateral patella dislocations injure the MPFL.[17] The MPFL is the primary medial restraint to lateral patella displacement from 0°-30° of knee flexion and provides >60% of soft tissue restraint against patella lateralization.[18-21] Our patient had poor/underdeveloped medial restraint that allowed the patella to subluxate laterally, and by reconstructing the MPFL, the checkrein to lateral subluxation was restored. Longo et al[8] and Nelitz el al[22] demonstrated in their systemic review and case series that reconstructing the MPFL in conjunction with TTO or trochleoplasty leads to good clinical outcomes and low rates of failure.

Abnormal geometry is another reason for patella instability[23] and was present in this patient. Increased q-angle with an abnormally lateralized tibial tubercle leads to increased tibial tubercle-trochlear grove (TTTG) distance.[23] TTTG distance is an important parameter for quadriceps muscle lateral force vector, with normal values being <15 mm.[3,24]

Patients with TTTG values >15 mm benefit from medializing or anteromedializing the osteotomy as described by Fulkerson.[9] Medialization of the tibial tubercle restores the abnormal q-angle, anteriorization decreases the compression forces experienced by the patella through the ROM,[9] and the anteromedialization offloads any cartilage restoration as in this case. In our case, the TTO was completed—unlike the classic description of this procedure[9]—to gain full access to the patellar surface for the OATS procedure. The osteotomy was repaired in a new position: anterior, medial, and distal to its native footprint. Distalizing the tubercle also addressed the patella alta present in our patient. Patella alta is a developmental condition that contributes to patellofemoral dysplasia resulting from insufficient trochlear loading during childhood.[25] Buuck and Fulkerson report good to excellent results in >86% of patients who underwent anteromedialization of the tibial tubercle, with improvement in the modified Lysholm score on long-term follow-up at 8.2 years.[26] Palmer et al evaluated 107 knees after TTO at a mean follow-up of 5.6 years and found good to excellent results in 79% of patients.[27]

CONCLUSION

This case demonstrates a viable surgical option for treatment of instability resulting from trochlear dysplasia with patellofemoral chondromalacia for patients who have failed conservative treatment. Surgical treatment must be individualized to address each factor contributing to patellofemoral joint instability and pain. The treatment of trochlear dysplasia with OATS allows patients to have a stable, pain-free knee joint and participate in activities compared to nonoperative management. However, the long-term outcomes of this procedure are unknown, and studies are needed.

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