Intra-Articular Osteotomy for Genu Valgum in the Knee with a Lateral Compartment Deficiency

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Background: A deficiency of the lateral compartment of the knee, often in the setting of skeletal dysplasia, is an intra-articular deformity resulting in genu valgum. Historically, this abnormality has been treated using an extra-articular approach. Lateral hypoplasia of the femoral condyle can be treated with advancement of the lateral femoral condyle without creating a secondary deformity. The purpose of this study was to present the technique and results of lateral condylar advancement, with or without tibial hemiplateau elevation, in patients with intra-articular valgus deformity secondary to skeletal dysplasia.

Methods: A retrospective review of the cases of five patients, from seven to twenty-one years old, with skeletal dysplasia and unilateral or bilateral severe genu valgum deformity was performed. For all patients, the etiology of the deformity was a deficient lateral compartment of the knee—that is, lateral femoral condylar hypoplasia with or without concomitant lateral hemiplateau depression. Lateral femoral condylar advancement with or without lateral tibial hemiplateau elevation was performed in eight knees.

Results: The average tibiofemoral angle was 34.7° of valgus preoperatively and improved to 9.4° of valgus at the most recent follow-up. The average length of follow-up was 2.9 years (range, 1.0 to 5.2 years). The average range of motion at the time of final follow-up was an arc of 108° starting from full extension. All osteotomies healed uneventfully. All five patients were satisfied with both the cosmetic appearance and the function of the involved limb and were able to walk without assistive devices.

Conclusions: In patients with a deficient lateral compartment of the knee, lateral femoral condylar advancement with or without hemiplateau elevation allowed correction of severe genu valgum without the creation of an oblique joint line. This technique allows correction of the overall mechanical axis, restoring both function and the cosmetic appearance of the limb.

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

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Genu valgum may arise from extra-articular deformities originating from the distal end of the femur or the proximal end of the tibia, intra-articular deformities originating from the femoral condyle or the tibial plateau, joint laxity, or a combination of these factors. A deformity resulting from an intra-articular etiology is often harder to manage. Lateral compartment deficiency of the knee, for example, originating from lateral condylar hypoplasia with or without lateral tibial plateau depression, poses a great challenge to the orthopaedic surgeon. This deformity occurs most commonly in patients with skeletal dysplasia. Knee pain and instability are the primary symptoms. There is, however, a paucity of literature outlining techniques for the correction of lateral deficiencies in the knee. Reported techniques for correction of a

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hypoplastic lateral femoral condyle are largely directed toward treating patellar instability[1,2]. Opening-wedge, closing-wedge, and dome metaphyseal osteotomies have been described for the treatment of the valgus knee. These are successful techniques for extra-articular deformities. Condylar deficiency with or without plateau depression must be addressed differently. Employing extra-articular osteotomies to manage intra-articular abnormality will create an extra-articular deformity, an oblique joint with the resultant shear stresses, and often secondary instability.

Historically, intra-articular correction of the joint has been used to treat severe tibia vara with medial tibial plateau depression[3-8]. This procedure was reported as early as 1964 by Langenskioeld and Riska, who stated that this osteotomy should be used when there is excessive varus of the knee caused by extreme sloping of the medial tibial plateau[9]. This has eventually become part of the standard method of treatment for severe Blount disease. Paley described an intra-articular osteotomy of the femoral condyles to treat condylar deficiencies due to neonatal sepsis[10]. Genu valgum resulting from lateral femoral condylar hypoplasia with or without hemiplateau depression can be corrected by means of a similar technique. The purpose of the present report was to determine the results and describe the technique of lateral condylar advancement, with or without tibial hemiplateau elevation, in patients with intra-articular valgus deformity secondary to skeletal dysplasia.

Materials and Methods

The charts and radiographic studies of five patients (eight knees) with skeletal dysplasia and severe genu valgum associated with knee pain and instability were reviewed retrospectively in this institutional review board-approved study. Four patients had pseudoachondroplasia, and one had an unknown syndrome with an absent patella. We are aware of no classification system that grades lateral compartment deficiency, largely because this abnormality is uncommon. We classified the knees in our patients into two groups: types I and II. Type I included those with only isolated lateral femoral condylar deficiency, and type II included those with an associated lateral tibial plateau depression. Both groups required lateral femoral condylar advancement, but only type II required an additional lateral tibial plateau elevation prior to condylar advancement. All five patients were female and ranged in age from seven to twenty-one years at the time of surgical intervention. Patients typically underwent surgery after having reached skeletal maturity; however, one patient who had a more complex deformity underwent surgery prior to maturity. All eight knees had at least one year of follow-up, with an average duration of 2.9 years (range, 1.0 to 5.2 years) (Table I).

TABLE I Patient Demographics

Case	Age at Surgery *(yr)*	Diagnosis	Tibial Involvement	Follow-up *(yr)*	Complications
Type I					
1	17	Unspecified skeletal dysplasia with severe subluxation, genu valgum, and hypoplastic lateral femoral condyle	No	1.0	None
2*	8	Unspecified skeletal dysplasia with dislocated and hypoplastic right knee with compression of the peroneal nerve	No	3.2	None
3*	7	Unspecified skeletal dysplasia and severe deformity of the left knee with dislocation of the knee and inability to walk	No	3.9	Transient common peroneal nerve palsy
4†	21	Pseudoachondroplasia and hypochondroplasia with severe valgus deformity of the right lower extremity	No	1.0	Painful hardware
5†	21	Pseudoachondroplasia with severe deformity of the left knee and valgus deformity with lateral condylar deficiency	No	1.5	Painful hardware
Type II					
6‡	12	Pseudoachondroplasia and severe genu valgum	Yes	5.1	None
7‡	15	Pseudoachondroplasia and severe genu valgum	Yes	2.5	Medial propagation of the osteotomy intraoperatively
8	19	Pseudoachondroplasia with severe femoral condylar and lateral tibial plateau deficiency in the right knee as well as subluxation of the right knee in severe valgus	Yes	5.2	None

*Cases 2 and 3 were in the same patient. †Cases 4 and 5 were in the same patient. ‡Cases 6 and 7 were in the same patient.

Fig. 1-A

Fig. 1-B

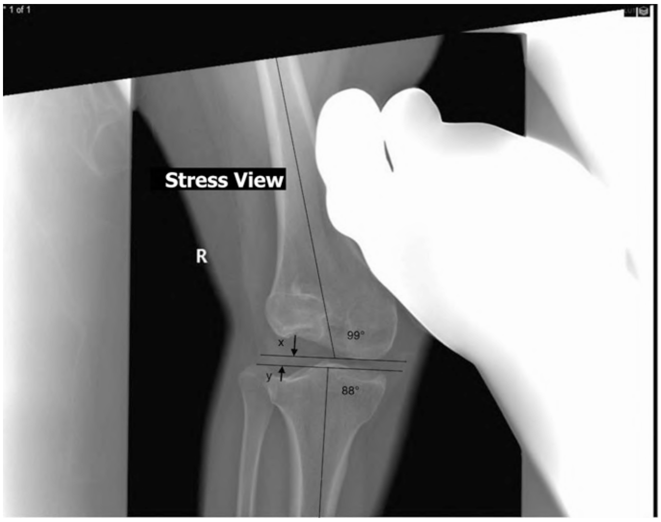

Fig. 1-C

Figs. 1-A, 1-B, and 1-C Case 8. A patient with severe genu valgum secondary to lateral femoral condylar hypoplasia and depression of the lateral plateau. **Fig. 1-A** Clinical standing photograph. **Fig. 1-B** Standing anteroposterior radiograph demonstrating severe genu valgum with collapse into the lateral compartment and opening of the medial joint space. **Fig. 1-C** Varus stress radiograph demonstrating lateral femoral condylar hypoplasia and lateral plateau depression with the anatomic medial distal femoral angle and medial proximal tibial angle based on the healthy medial femoral condyle and medial tibial plateau. This radiograph demonstrates the amount of condylar advancement and lateral plateau elevation required for surgical correction.

Preoperative Assessment

Patients were examined to determine the severity of the valgus deformity and instability. Standing radiographs were made to evaluate the deformity (Figs. 1-A and 1-B). These radiographs may suggest medial collateral ligament insufficiency. Additionally, a varus stress radiograph was made to confirm the location of the deformity (Fig. 1-C). This view was the most important study in determining the extent of the lateral plateau depression and femoral condylar hypoplasia.

TABLE II Radiographic Measurements

	Mechanical Axis Deviation *(mm)*		Tibiofemoral Angle *(deg)*		Lateral Condylar Deficiency *(mm)*		
Case	Preop.	Postop.	Preop.	Postop.	Preop.	Postop.	Postop. aLDFA* *(deg)*
Type I							
1†	6.2	6.0	6	5	2.4	0	83
2†	–	5.1	–	14	20.8	3.7	81
3	63.8	11.2	41	0	24.2	0	83
4	60.6	38.1	30	17	4.9	0	86
5	29.2	4.2	22	15	3.6	0	88
Type II							
6	107.2	6.4	48	8	17.5	0	88
7	75.9	9.1	26	7	10.3	0	88
8	122.0	3.6	70	9	16.1	0	80

*aLDFA = anatomic lateral distal femoral angle. †The knee had a rotatory subluxation. The preoperative mechanical axis deviation and tibiofemoral angle in one knee (Case 2) could not be measured because of the rotatory subluxation and therefore the measurements are not included.

Surgical Technique

Patients were positioned supine on a radiolucent table. An intraoperative arthrogram was performed prior to surgical correction in order to confirm joint morphology. All arthrograms demonstrated a preserved medial compartment with a deficient lateral compartment secondary to hypoplasia of the lateral femoral condyle. In some knees, a depressed lateral tibial plateau was seen as well (Fig. 2). In these knees, a line tangent to the medial plateau was used to quantify the lateral depression.

Once the extent of the deformity was determined, the osteotomy was performed. An external fixator was applied, with two half-pins placed into the proximal, lateral aspect of the femur and two pins placed into the medial aspect of the tibia. The joint was then reduced into anatomic alignment, and the external fixator was adjusted to maintain this alignment while the osteotomies were performed. The joint line deformity was analyzed to determine the source of the gap in the lateral compartment of the knee. The line tangent to the medial plateau line was drawn. If this line passed directly on the surface of the lateral plateau, then the lateral femoral condyle was the sole source of the valgus deformity. When the lateral plateau was depressed below this line, a lateral tibial plateau elevation was required.

An incision was made on the distal aspect of the thigh anterolaterally approximately 8 cm proximal to the proximal pole of the patella and was extended distally to the proximal pole. The incision then curved posteriorly across the fibular neck, ending approximately 5 cm distal to the tip of fibular head, allowing visualization and subsequent decompression of the peroneal nerve, which was done routinely as part of the procedure. The nerve was identified and decompressed at the posterolateral aspect of the knee and was then traced around the fibular neck into the lateral compartment of the leg, and the lateral intermuscular septum was released. The iliotibial band was isolated from the surrounding fascia, detached from its proximal soft-tissue attachments, and incised several centimeters proximal to the joint. The distal attachments were left intact, allowing for later reconstruction. The iliotibial band was then peeled away from the lateral aspect of the knee proximally to distally to provide better visualization of the lateral condyle.

When deemed necessary, the lateral plateau elevation was performed through an extension of the aforementioned incision. The proximal aspect of the fibula was osteotomized just distal to the tibiofibular joint at the level of the tibial plateau elevation. As the peroneal nerve had previously been decompressed in this region, the proximal tibiofibular joint was opened and externally rotated through the joint, exposing the lateral side of the proximal part of the tibia. In addition to protecting the peroneal nerve, care was taken posteriorly to protect the anterior tibial artery as it traversed from posterior to anterior through the interosseous membrane. A Kirschner wire was used to guide the hemiplateau elevation. The osteotomy was performed with a

Fig. 2

Intraoperative arthrogram confirming lateral femoral condylar hypoplasia and lateral plateau depression.

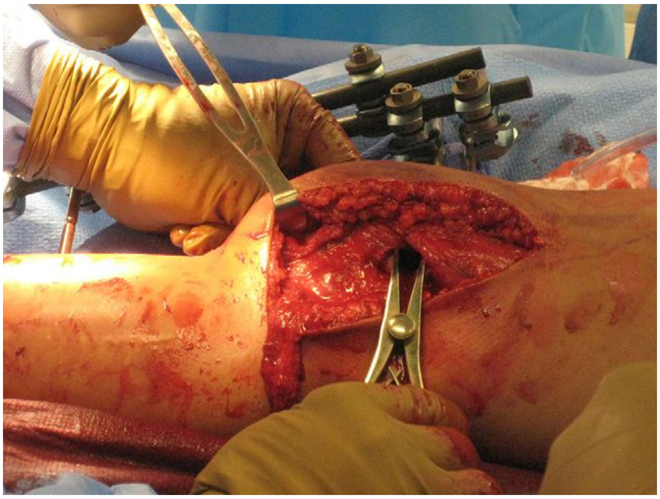

Fig. 3
Lamina spreader in the transverse osteotomy site displacing the osteotomized fragment distally.

curved osteotome. The plateau was elevated, and an iliac-crest wedge allograft was then used to fill the osteotomy site. The graft was maintained in position with an antiglide screw and a washer.

An anterolateral arthrotomy was performed to gain access to the lateral femoral condyle. A vertical osteotomy was then made through the femoral notch. A corresponding extra-articular transverse osteotomy was made approximately 3 to 4 cm proximally to form a so-called box cut, creating a free fragment on the lateral aspect of the distal end of the femur consisting of the lateral femoral condyle. Care was taken to ensure that the horizontal limb of the osteotomy was extended only halfway across the width of the femur. To avoid devascularizing the free fragment, the lateral and posterior soft-tissue attachments were left intact.

The free fragment was then advanced distally, utilizing the lateral tibial plateau as a guide for the amount of advancement required. Alignment of the limb was assessed on fluoroscopic images of the hip, knee, and ankle joints using the cautery cord, being certain to measure the medial proximal tibial angle and the mechanical lateral distal femoral angle[11] with the cord. A lamina spreader was used proximally to maintain the advancement (Fig. 3). A rectangular iliac-crest allograft, approximately 30 to 45 mm in length, was then used to fill the resulting gap. Adequate joint line correction was confirmed with fluoroscopy. The osteotomy was fixed with a five-hole 3.5-mm Limited Contact Dynamic Compression Plate (LC-DCP; Synthes), and a 6.5-mm cannulated screw was inserted from proximal-medial to distal-lateral or distal-lateral to proximal-medial for added fixation (Fig. 4). The external fixator was then removed.

Each knee was then taken through the range of motion, and an assessment of stability with varus and valgus stresses was performed. Overall alignment was also noted both clinically and radiographically. Once stability was ensured and the mechanical axis was corrected, 5 mL of demineralized bone matrix putty was placed around the lateral osteotomy site. The iliotibial band was used as a fascial cover to protect the joint and hardware, and an extra-articular drain was placed to prevent postoperative hematoma formation.

Postoperative Protocol

Patients received perioperative antibiotic prophylaxis for twenty-four hours. The drain was removed on postoperative day 1 or 2, depending on output. The knee was immobilized in the immediate postoperative period. Foot-flat 30-lb (13.5-kg) weight-bearing with axillary crutches was allowed. On postoperative day 7, range of motion as tolerated was initiated, allowing the wound adequate time to heal before doing so. At six weeks, patients were permitted to bear weight as tolerated. A return to full activity was allowed at three months.

Source of Funding

There was no external source of funding.

Results

All eight knees were treated with lateral femoral condylar advancement. Three knees also had a lateral tibial hemiplateau elevation to correct an associated lateral proximal tibial depression. At the time of the most recent follow-up, all knees were able to achieve full extension. The average knee range of motion was an arc of 108° (range, 90° to 120°), starting from full extension. The mechanical axis deviation[11] improved from an average of 66.4 mm (range, 6.2 to 122 mm) preoperatively to 10.5 mm (range, 3.6 to 38.1 mm) at the most recent follow-up. The tibiofemoral angle improved from an average of 34.7° (range, 6° to 70°) of valgus preoperatively to an average of 9.4° (range, 0° to 17°) at the most recent follow-up. The average lateral condylar deficiency was 12.5 mm (range, 2.4 to 24.2 mm) preoperatively and 0.46 mm (range, 0 to 3.7 mm) postoperatively. The average anatomic lateral distal femoral angle at the time of the most recent follow-up was 84.6° (range, 80° to 88°) (Table II). Type-II

Fig. 4
Intraoperative radiograph demonstrating the completed hemiplateau elevation and lateral femoral condylar advancement after placement of hardware.

TABLE III Tibial Radiographic Measurements in Type-II Knees

Case	Postop. MPTA* *(deg)*	Lateral Tibial Plateau Depression *(mm)* Preop.	Postop.
6	101†	22.3	0
7	92	6.2	3.2
8	89	13.0	0

*MPTA = medial proximal tibial angle. †Elevated MPTA was secondary to an extra-articular valgus deformity of the tibial metaphysis.

knees had an average medial proximal tibial angle of 94° (range, 89° to 101°)[11] and an average hemiplateau depression of 1.1 mm (range, 0 to 3.2 mm) at the most recent follow-up. One type-II knee (Case 6) had an extra-articular valgus deformity of the proximal tibial metaphysis resulting in an elevated medial proximal tibial angle (Table III). Two knees (Cases 1 and 2) had a rotatory subluxation. The preoperative mechanical axis deviation and tibiofemoral angle in one of these knees could not be measured because of the subluxation and therefore it is not included in the relevant average measurements. All five patients were satisfied with both the cosmetic appearance and the function of the involved limb(s). All were able to walk without assistive devices at the most recent follow-up. Complications included a transient common peroneal nerve palsy in one knee in the immediate postoperative period that was managed with maintenance of the knee in flexion and resolved completely. Medial propagation of the osteotomy occurred intraoperatively in one knee and necessitated internal fixation of the medial metaphysis during the index operation. Two knees required removal of painful hardware at an average of twelve months after the index procedure (Table I).

Discussion

Genu valgum may occur secondary to lateral femoral condylar hypoplasia with or without lateral tibial hemiplateau

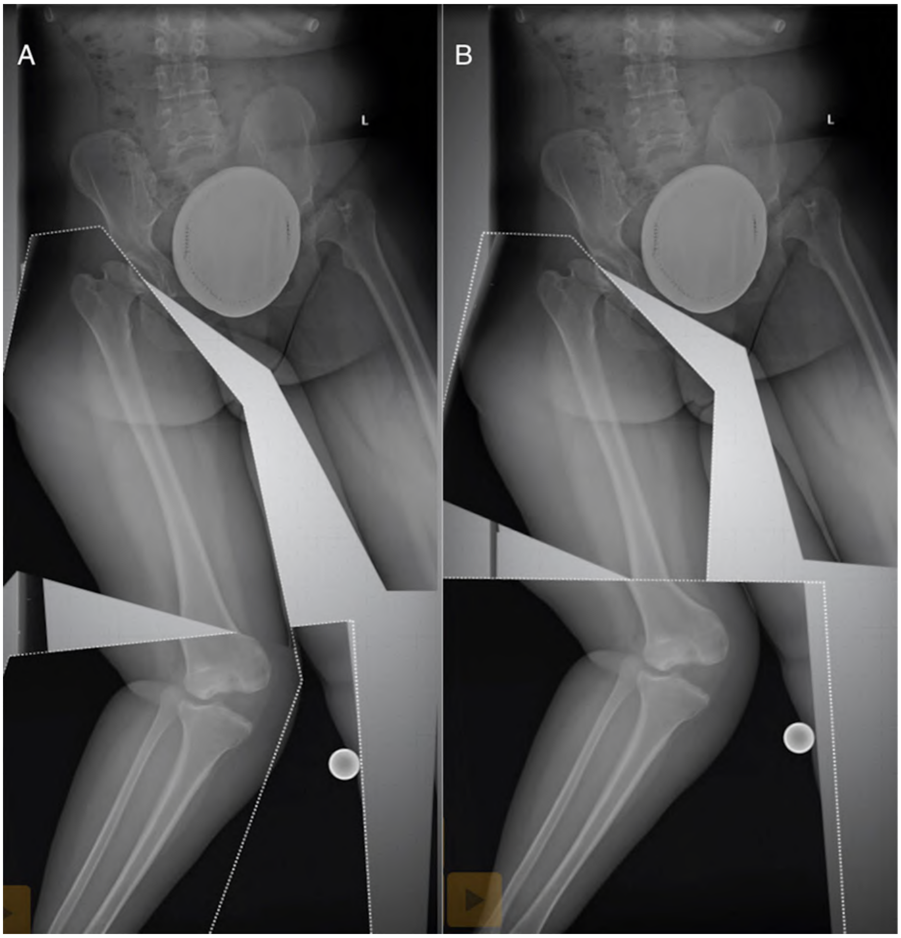

Fig. 5
Preoperative standing anteroposterior radiograph using cutouts to demonstrate the results of both extra-articular lateral opening-wedge (**Fig. 5-A**) and medial closing-wedge (**Fig. 5-B**) osteotomies of the distal end of the femur, creating a deficient medial femoral condyle.

depression. Procedures for treating extensor mechanism instability by restoring the height of the lateral condyle and thereby deepening the femoral trochlea have been reported. Marti and Beimers described an opening-wedge osteotomy just proximal to the articular surface and angled toward the trochlea[2]. This procedure allowed increased height of the lateral femoral condyle and deepening of the trochlea. In their series of eight patients, they found that all of the osteotomies healed and the trochlear depth was improved.

Puddu et al. described an opening-wedge lateral femoral osteotomy for the treatment of the painful valgus knee[12]. This osteotomy was created in a slightly oblique direction, from proximal-lateral to distal-medial, with a 1-cm medial hinge. In their series of twenty-one patients, all had improvement with respect to pain and knee function. However, in all of these cases, the entire distal end of the femur was in valgus, and simple correction of the mechanical axis was achieved with a distal metaphyseal osteotomy.

For our patients, the drawback of the previously mentioned procedures is that an extra-articular approach is used to address an intra-articular deformity. As a result, these osteotomies are not optimum for intra-articular deformities because they create an oblique joint line and a deficient medial femoral condyle (Fig. 5); an intra-articular osteotomy was needed.

Fig. 6
Postoperative radiograph showing corrected mechanical axis (dashed line) and mechanical axis deviation (solid line indicated by arrow) in the presence of hip subluxation.

Performing radiographic analysis of the deformity for patients with a deficient lateral compartment poses a unique challenge as the anatomic and mechanical lateral distal femoral angles rely on normal femoral condyles and plateaus and so cannot accurately be measured prior to surgical correction. We suggest that the reliable measurements to assess this abnormality are the mechanical axis deviation and the anatomic tibiofemoral angle. Neither measurement is affected by the deficiency of the femoral condyles or tibial plateau: the mechanical axis deviation relies on the hip and ankle joints (Fig. 6); the anatomic tibiofemoral angle is independent of the joint line, depending solely on the anatomic axes of the femur and the tibia.

Assuming the medial femoral condyle is normal, we can rely on the anatomic medial distal femoral angle to evaluate the degree of femoral deficiency. This angle is assumed to be 99° in a normal knee[11]. Drawing this angle orients the surgeon to the extent of the lateral femoral condylar deficiency. More importantly, this angle defines the relationship of the medial condyle to the lateral condyle and can be used as another method to measure the amount of lateral femoral condylar advancement that is required. The same analysis can be performed to assess lateral tibial plateau depression, using an angle of 88° between the anatomic axis of the tibia and the normal medial tibial plateau (Fig. 1-C)[11]. Although all necessary information for joint analysis and deformity correction was obtained from radiographs, arthrograms, and the varus stress radiographs, a computed tomography scan could be utilized on a case-by-case basis if the surgeon believes it to be helpful in further preoperative planning.

Lateral condylar advancement osteotomy for the treatment of valgus deformity and instability secondary to lateral femoral condylar hypoplasia has been mentioned, as far as we know, only in the study by Paley on intra-articular osteotomies in the hip, knee, and ankle[10]. To our knowledge, no study has investigated the results of this technique. We performed this procedure on eight knees in five patients, and all had excellent clinical outcomes. Although the osteotomy was through the trochlear groove, the patients did not experience patellofemoral pain or subluxation postoperatively. Intra-articular osteotomies are technically demanding and may be prone to complications. A thorough preoperative analysis of the deformity should precede operative correction by this method to ensure the best possible outcome and minimize the likelihood of complications. The indications for correction should be clearly delineated. It is essential to determine that the genu valgum is indeed secondary to a deficient lateral compartment. An extra-articular osteotomy remains the primary option if it will achieve the desired correction without creating an oblique joint line or a deficient medial condyle. However, given the nature and location of this deformity, an extra-articular osteotomy would likely fail to achieve these goals. Therefore, lateral femoral condylar advancement with or without lateral plateau elevation is necessary and is both a well-tolerated and effective procedure for correction of genu valgum secondary to hypoplasia of the lateral compartment of the knee. ■

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