Technical Note

Implant-Mediated Guided Growth for Coronal Plane Angular Deformity in the Pediatric Patient with Patellofemoral Instability

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Abstract: Pediatric patellofemoral instability is a complex problem, for which there are several anatomic risk factors. Coronal plane malalignment (i.e., genu valgum) is one cause of patellofemoral instability, and treatment of genu valgum has been associated with improved patellofemoral stability. Coronal plane angular deformity correction, typically achieved by distal femoral osteotomy in the adult population, can be achieved with less invasive surgical techniques in pediatric patients using implant-mediated guided growth. By temporarily tethering one side of an open physis to generate differential growth in the coronal plane, valgus malalignment can be corrected. We present our technique for medial distal femoral implant-mediated guided growth using tension band plating for treatment of pediatric patellofemoral instability associated with genu valgum. This technique is minimally invasive, has a low complication rate, and in conjunction with conventional treatment can reduce the risk of recurrent instability.

Patellofemoral instability has become increasingly common in the skeletally immature population.[1,2] Patellar dislocations can lead to cartilage injury and/or osteochondral fracture[3] resulting in pain, disability, and can potentially accelerate the development of degenerative arthritis.[4] Over half of patellar dislocations occur during athletic activities, and the incidence of patellofemoral instability is highest in the adolescent population.[5,6] Furthermore, the risk of recurrence is especially high in skeletally immature patients,[7-12] highlighting the need for an improved understanding of the underlying clinical and anatomic risk factors and unique surgical techniques that can be employed to address these risk factors to improve outcomes, minimize recurrence rate, and alter natural history of the disease.

Several anatomic pathologies are known to contribute to patellofemoral instability, including trochlear dysplasia, patella alta, axial malalignment (e.g., elevated tibial tubercle to trochlear groove [TT-TG] distance), coronal plane malalignment (specifically genu valgum), and soft tissue injury or laxity.[13-15] Various surgical procedures are performed to treat these pathologies, such as osteotomy, trochleoplasty, and medial patellofemoral ligament (MPFL) reconstruction; however, owing to the presence of open physes in skeletally immature patients, some procedures such as tibial tubercle osteotomy and distal femoral osteotomy are contraindicated, and others such as MPFL reconstruction must be modified.[16-19] Genu valgum has been frequently associated with patellar instability, and it is known that correction of valgus deformity leads to improved stability and symptomatic relief.[20-22] Coronal plane angular deformity correction, typically achieved by distal femoral osteotomy in the adult population, can be achieved with less invasive surgical techniques in

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pediatric patients using implant-mediated guided growth. By temporarily tethering one side of an open physis to generate differential growth, osseous correction can be performed with a low rate of complications.[23] Additionally, it is known that implant-mediated guided growth can correct both coronal plane angular deformity (valgus), as well as axial malalignment (e.g., elevated TT-TG).[23,24]

Implant-mediated guided growth, or temporary hemiepiphysiodesis, can be achieved using several types of implants, including percutaneous transphyseal screws[25] and tension band plating or stapling.[26] We present our technique for medial distal femoral implant-mediated guided growth using tension band plating for treatment of pediatric patellofemoral instability associated with genu valgum.

Preoperative Evaluation

Evaluation of pediatric patellar instability begins with a thorough history and physical examination to identify all contributory risk factors. Physical examination should include inspection of standing coronal alignment and limb length assessment, patellar height, and muscle bulk. Genu valgum can be clinically quantified on supine examination using the intermalleolar distance.[27] Rotational profile can be examined with the patient prone, where hip internal and external rotation, thigh-foot-angle, and transmalleolar axis should be assessed. Specific patellofemoral examination maneuvers should include the moving patellar apprehension test[28] and assessment of the J-sign for patellar tracking. In the setting of an acute dislocation, an effusion will be present, and focal tenderness over the MPFL, medial patellar facet, and/or lateral trochlea may be present.[9] Finally, evaluation of generalized ligamentous laxity using Beighton Score or the Brighton Criteria should be performed.[29]

Diagnostic imaging should include standing hip-to-ankle alignment film, using low-dose slot scanning technology if possible,[30] and a minimum of 3 plain radiographic views of the knee: anteroposterior, lateral, and Merchant view.[31] The standing alignment film allows detection and quantification of any coronal plane deformity by identifying any overall mechanical axis deviation and contributing factors, including mechanical lateral distal femoral angle and medial proximal tibial angle (Fig 1). In a neutrally aligned knee, the mechanical axis passes between the tibial spines (in valgus alignment it passes laterally), and both the mechanical lateral distal femoral angle and medial proximal tibial angle measure 87° with normative ranges of 85° to 90°. The lateral radiographic view at 30° knee flexion[32] is critical for assessment of patellar height, which may be measured using Caton-Deschamps index,[33] which has been shown to have the best interobserver reliability and is least affected by

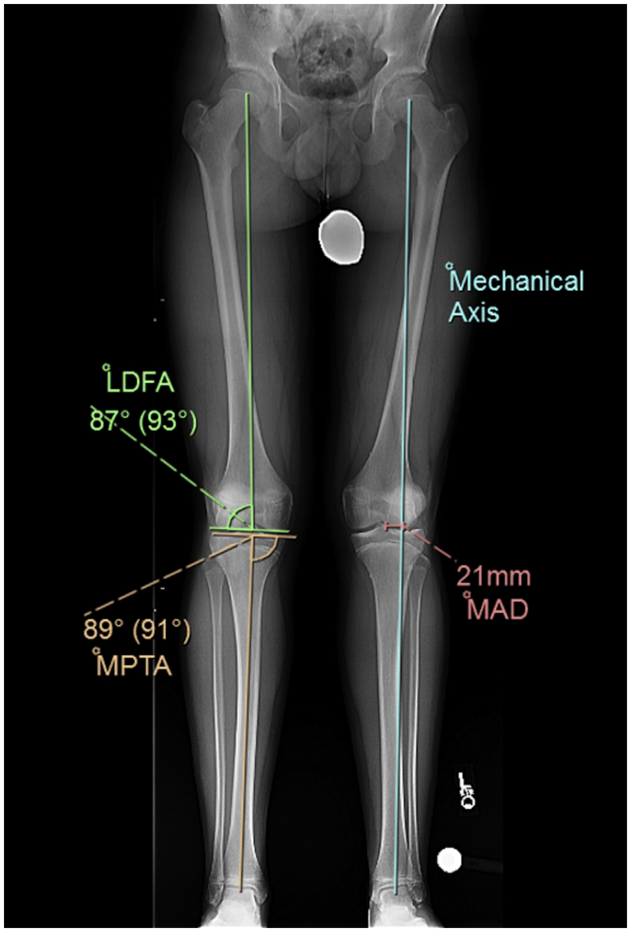

Fig 1. Evaluation of coronal plane angular deformity on standing hip-to-ankle alignment films. This is a representative example of left-sided genu valgum, with right lower extremity alignment within normal limits. Lateral mechanical axis deviation (MAD) of 21 mm is shown on the left. Normal mechanical lateral distal femoral angle (LDFA) and medial proximal tibia angle (MPTA) are shown on the right.

skeletal maturity.[33,34] The Merchant view,[35,36] with the patient supine, knee in 45° flexion, and radiograph beam angled 30° from horizontal (aiming cranial to caudal), allows assessment of patellofemoral morphology and tracking at low flexion angle,[31] as well as measurement of sulcus angle and patellar tilt. The sunrise view (with the knee flexed to 115°) is designed to evaluate for arthritis and is less useful for pediatric and adolescent patellar instability, which typically occurs at much lower degrees of knee flexion. In addition to lower extremity radiographs, the patient's skeletal age should be evaluated using a single radiographic view of the left hand[37] for calculation of remaining growth.[38]

Magnetic resonance imaging is a critical element to comprehensive evaluation of patellar instability. By using true axial imaging, the TT-TG and patellar tendon-lateral trochlear ridge can be measured and trochlear dysplasia can be more extensively

Table 1. Indications for Implant-Mediated Guided Growth in the Treatment of Pediatric Patellofemoral Instability

- Age ≥8 years (prior to which spontaneous correction may occur)
- Sufficient growth remaining to achieve desired correction
- Lateral mechanical axis deviation (mechanical axis line passes lateral to the lateral tibial spine on standing hip-to-ankle alignment radiograph)
- Genu valgum with ≥5° side-to-side difference → unilateral guided growth (represents asymmetric genu valgum, and the affected knee should be corrected)
- Genu valgum with <5° side-to-side difference → consider bilateral guided growth (represents symmetric genu valgum, and bilateral correction is considered for maintenance of symmetry)

appreciated. An additional measurement using magnetic resonance imaging is the tibial tubercle to posterior cruciate ligament distance to determine lateralization of the tibial tubercle. Finally, the integrity of the MPFL can be visualized, and any associated chondral defects or other intraarticular pathologies can be identified.[39,40]

Preoperatively, after thorough diagnostics, it is important to plan for the desired amount of correction. In boys with skeletal age less than 14 years and in girls with skeletal age less than 12 years, angular correction of 0.7° per month and 0.4° per month can be achieved at the distal femur and proximal tibia, respectively.[41,42] It is hypothesized that in older patients, correction is achieved more slowly, at 0.4° per month and 0.3° per month in the femur and tibia, respectively. A decrease in the valgus angle of the knee decreases the Q-angle, and thus the TT-TG distance as well. Trigonometric modeling has shown that with every 1° of correction

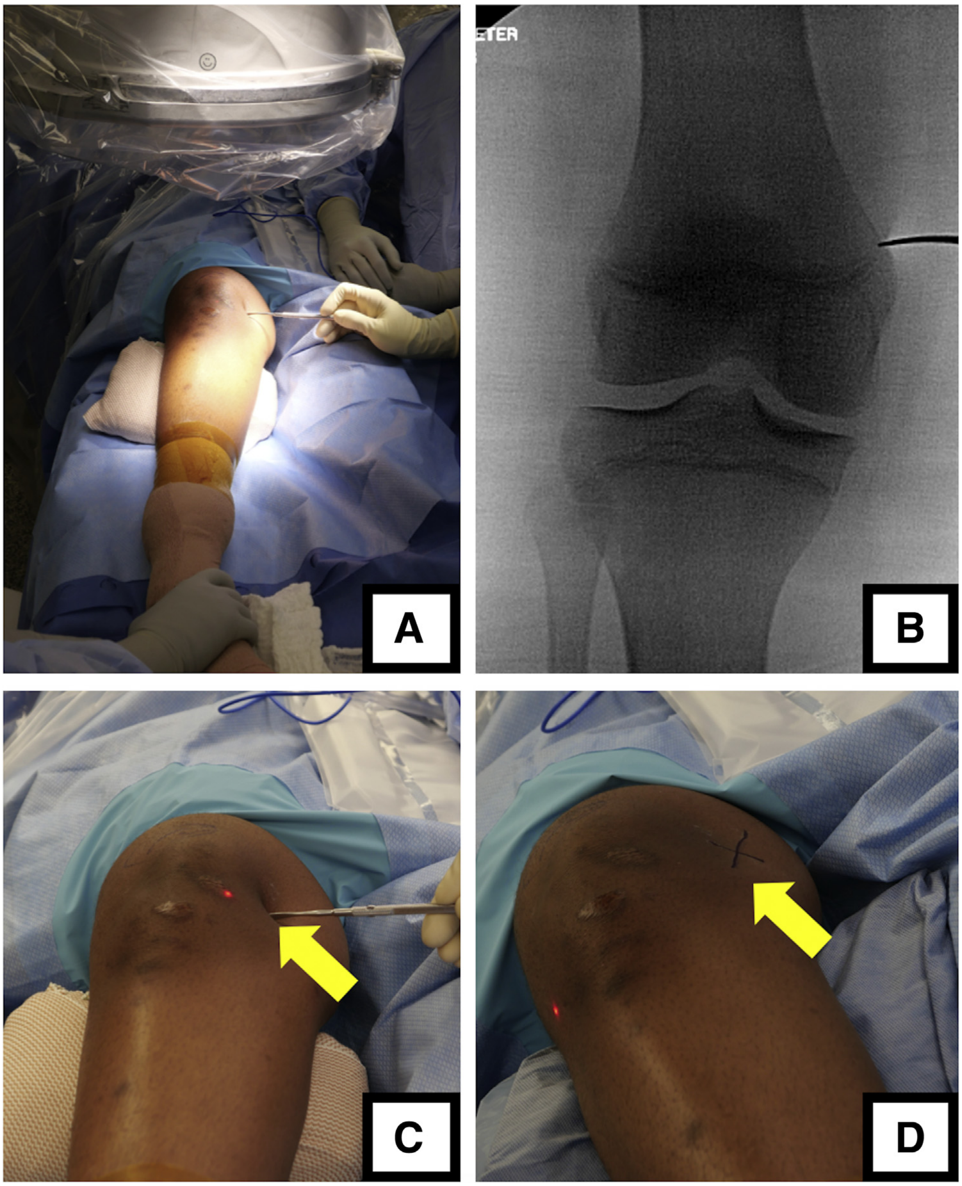

Fig 2. Patient positioning and fluoroscopic localization of incision. (A) The patient is positioned supine on a radiolucent table. The operative extremity is prepped and draped using sterile technique, with a nonsterile tourniquet applied to the proximal thigh (not typically inflated). Fluoroscopy is from the ipsilateral side, as the surgeon operates from the contralateral side to more easily access the medial side of the knee, and a sterile bump is placed under the knee for easier lateral fluoroscopic visualization. (B, C) The physis is marked on anteroposterior fluoroscopy and a horizontal line (identified by the arrow in panel C) is drawn. (D) The anatomic axis of the femur is marked on a lateral fluoroscopic view; the intersection of the horizontal and vertical lines (identified by the arrow) marks the midpoint of the physis in the sagittal plane, which is the center of the incision.

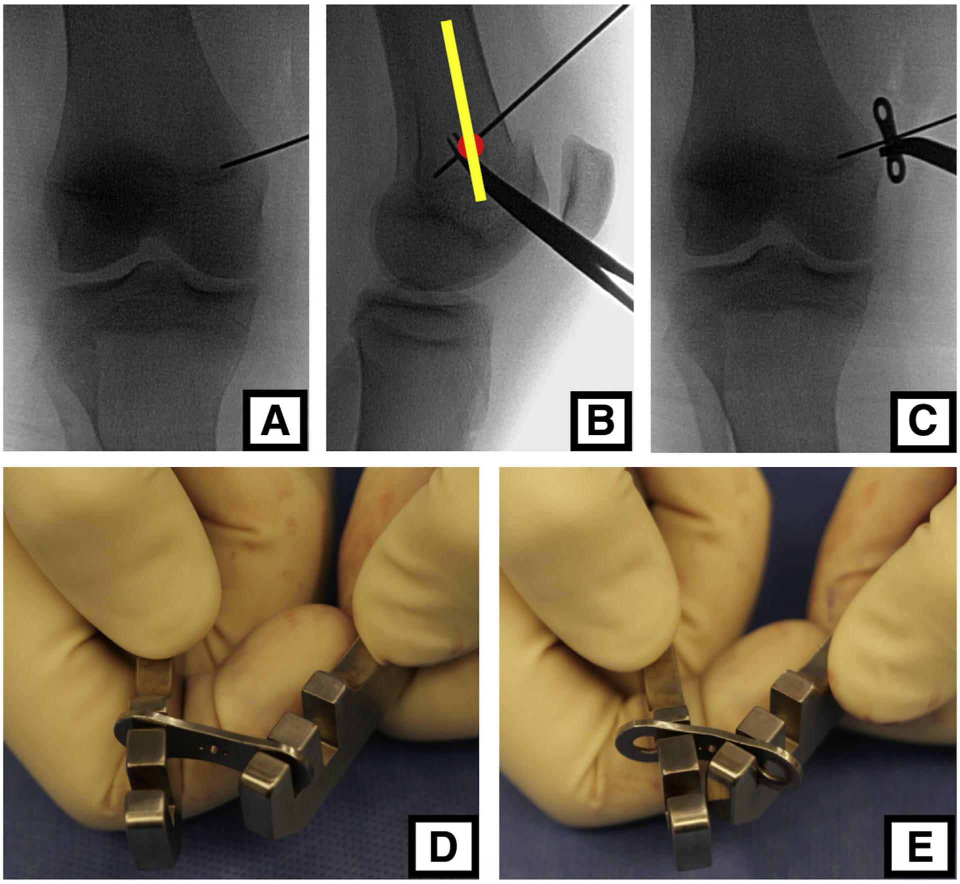

Fig 3. Localization of medial distal femoral physis and plate preparation. (A, B) After surgical exposure, a K-wire is placed in the distal femoral physis in line with the anatomic axis of the femur on the lateral fluoroscopic view. The yellow line and red dot in panel B represent the sagittal anatomic axis and the sagittal midpoint of the distal femoral physis at the location of guidewire entry, respectively. (C) A 2-hole Pedi Plate (OrthoPediatrics) is placed over the centering K-wire. (D, E) Prior to placement of the plate, it is contoured using bending irons to achieve anatomic fit to the medial distal femur.

achieved, the tibial tubercle is medialized by 1 mm in relation to the trochlear groove.[24] Therefore using the 0.7° per month projection for distal femoral guided growth, correction over 12 months can lead to an 8.4 mm translation of the tibial tubercle with medial distal femoral hemiepiphysiodesis alone; additional correction can be achieved if also performing medial proximal tibia hemiepiphysiodesis.

Indications

Our indications for implementing guided growth in the setting of patellofemoral instability are presented in Table 1. Although beyond the scope of this review, it should be emphasized that in addition to correction of coronal plane angular deformity, it is recommended that additional anatomic abnormalities contributing to patellofemoral instability be addressed accordingly when possible. Severe patella alta is treated using tibial tubercle osteotomy with distalization in adults; however, in skeletally immature individuals this procedure is not considered until the tibial tubercle apophysis is closed. For substantial rotational deformity, derotational osteotomy should be considered, although definitive indications and thresholds for surgical treatment have not yet been described in the pediatric literature. Furthermore, these procedures have much greater morbidity than implant-mediated guided growth, which is a powerful procedure that can be performed through a minimally invasive approach. Whether to perform a concomitant or staged MPFL reconstruction (e.g., at the time of plate removal) is at the discretion of the treating surgeon, as there is no documented clinical superiority of one treatment strategy over another.

Surgical Technique

The preferred surgical technique of the senior author (P.D.F.) begins with the patient placed supine on a radiolucent table while ensuring that all bony prominences are well padded. An examination under anesthesia is performed to assess for preoperative knee effusion, range of motion, stability, and the degree of patellar translation. A tourniquet may be applied to the proximal thigh to reduce blood loss and improve visualization, although is typically not inflated during the case. After the extremity is prepped and draped in a standard and sterile fashion, preoperative antibiotics are appropriately dosed, and a surgical time out is performed.

Anteroposterior and lateral fluoroscopy is used to identify critical landmarks in the knee, particularly the distal femoral physis (Fig 2). A 3- to 4-cm, longitudinal skin incision is then made, centered over the medial extent of the physis, and oriented along the anatomic

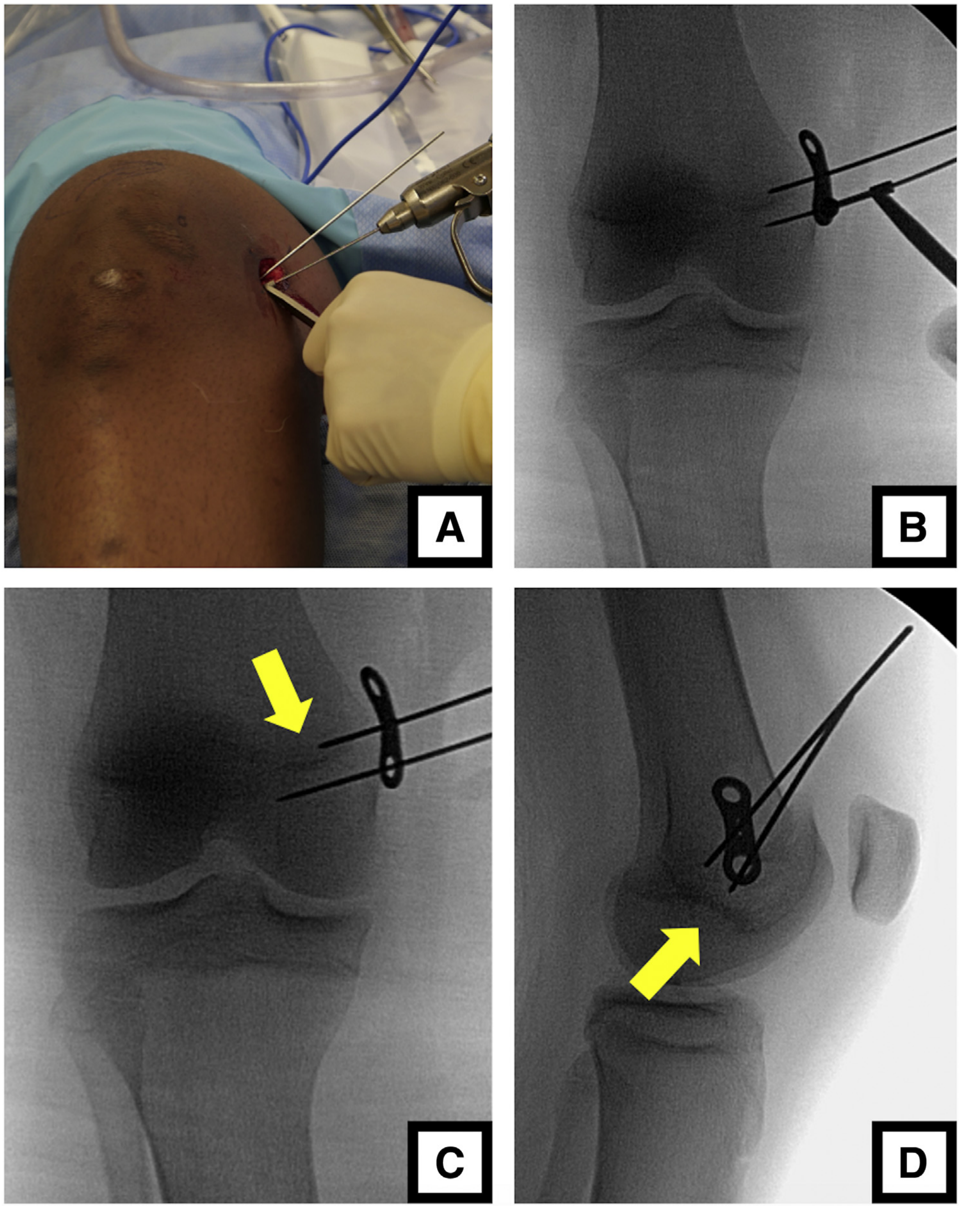

Fig 4. Provisional plate fixation and guidewire placement. (A, B) A centralizing multiangle drill guide is used to place a guidewire in the epiphyseal screw hole. (C) Care is taken to ensure that the guidewire is inferior to the physis (arrow) on the anteroposterior view. (D) The long axis of the plate overlies the anatomic axis of the distal femur on the lateral fluoroscopic projection, and the distal tip of the guidewire must be anterior to the Blumensaat line on the lateral view (arrow).

axis of the femur. Subsequent soft tissue dissection, with meticulous hemostasis, is carried down to the level of the vastus medialis fascia, which is then incised in line with its fibers. Special care is taken to ensure that the underlying periosteum and ring of Lacroix are not disturbed.

At this stage, a K-wire is inserted into the medial extent of the physis in the midsagittal plane to guide positioning of the center of the plate (Fig 3). Care is taken to avoid anteriorization, which can lead to inadvertent sagittal plane deformity (recurvatum). Fluoroscopy is employed to ensure proper orientation of the K-wire along the physeal tissue. A 2-hole guided growth plate (O-plate, OrthoPediatrics, Warsaw, IN) is contoured and passed over the wire and positioned along the anatomic axis of the femur such that the center of the plate rests over the distal physis. A multiaxial drill guide and terminally threaded guidewire are then inserted in both the metaphysis and epiphysis under fluoroscopic guidance (Fig 4). The surgeon should confirm that neither guidewire violates the joint space nor the physis before proceeding further. The distal (epiphyseal) guidewire should be directed toward the intersection of the Blumensaat line and the projection of the deepest part of the trochlear sulcus on the lateral view (Fig 4). Each guidewire is subsequently measured, drilled with a 3.2 mm cannulated drill bit, and then removed to allow for 4.5-mm solid screws (OrthoPediatrics) to be advanced into place (Fig 5). Solid screws are preferred to prevent

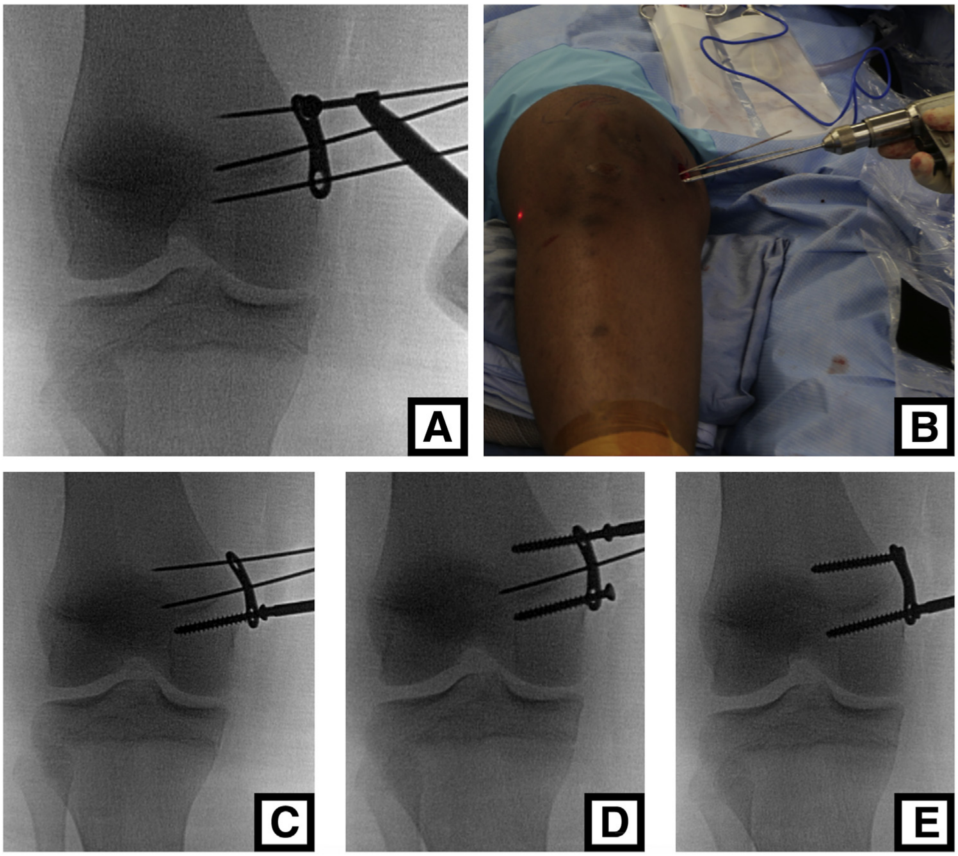

Fig 5. Cannulated drilling and solid screw application. (A) The metaphyseal guidewire is placed using the multiangle drill guide. (B) The epiphyseal screw is drilled in cannulated fashion. (C) The epiphyseal guidewire is removed, and a solid screw is placed but not fully tightened. (D) The metaphyseal screw is then similarly drilled and applied but not fully tightened. By using this sequence, there are always at least two points of fixation in the plate, which prevents it from rotating out of position during drilling, wire removal, and screw application. (E) The central physeal K-wire is then removed and sequential tightening of the screws is performed to allow the plate to lie anatomically along the cortex without tilt or elevation.

screw fracture and implant failure, which happens most frequently with cannulated screws in the metaphysis of overweight patients.[43,44] Both screws are then provisionally tightened down to the plate. After removal of the central guidewire holding the plate in place, additional tightening of the screws is performed until adequate purchase is obtained and the plate is visually seen to be down on the periosteum (Fig 5). The knee is fully cycled 20 times to release any entrapped soft tissue, and the screws are then finally tightened prior to obtaining final fluoroscopic imaging (Fig 6).

At this stage, the option is available to perform an MPFL reconstruction with or without a medial plication of the extensor mechanism, or a medial retinacular repair or plication in isolation with an option to perform an MPFL reconstruction in a staged fashion if instability persists despite coronal plane deformity correction. If the surgeon elects to perform a concomitant MPFL reconstruction, the femoral tunnel is posterior to the guided growth implant, which should not interfere with tunnel placement (Fig 7). However, one should exercise caution when planning subsequent plate removal after MPFL reconstruction as the graft typically overlies the distal extent of the guided growth plate. In a medial retinacular plication, the medial retinaculum is closed and tightened with 0-Ethibond suture in a "pants-over-vest" fashion. The subsequent shortening of the retinacular tissue enables the patella to return to anatomic alignment and track normally within the trochlear groove. Final examination of the patella is performed with the knee in full extension and at 30 degrees of knee flexion to ensure sufficient plication and reduction in patellar translation.

The surgical field is then irrigated thoroughly, the incision closed in a layered fashion, and the knee is sterilely dressed and placed in a postoperative brace, if desired.

Postoperative Management

Immediate postoperative weightbearing and range of motion is dependent on soft tissue procedures that are performed in addition to the guided growth procedure. In the case of isolated implant-mediated guided growth, full weightbearing and range of motion is allowed as tolerated. At 2 weeks postoperative, patients are advanced to nonimpact strengthening, with continued emphasis on full range of motion. By 6 weeks, patients are typically started on a graduated return to sports physical therapy protocol. Objective return to sport criteria are used, such as the limb symmetry index.[45] Straight line jogging is allowed at 70% limb symmetry, jumping and landing at 90% limb symmetry, with gradual return to full sport activities.

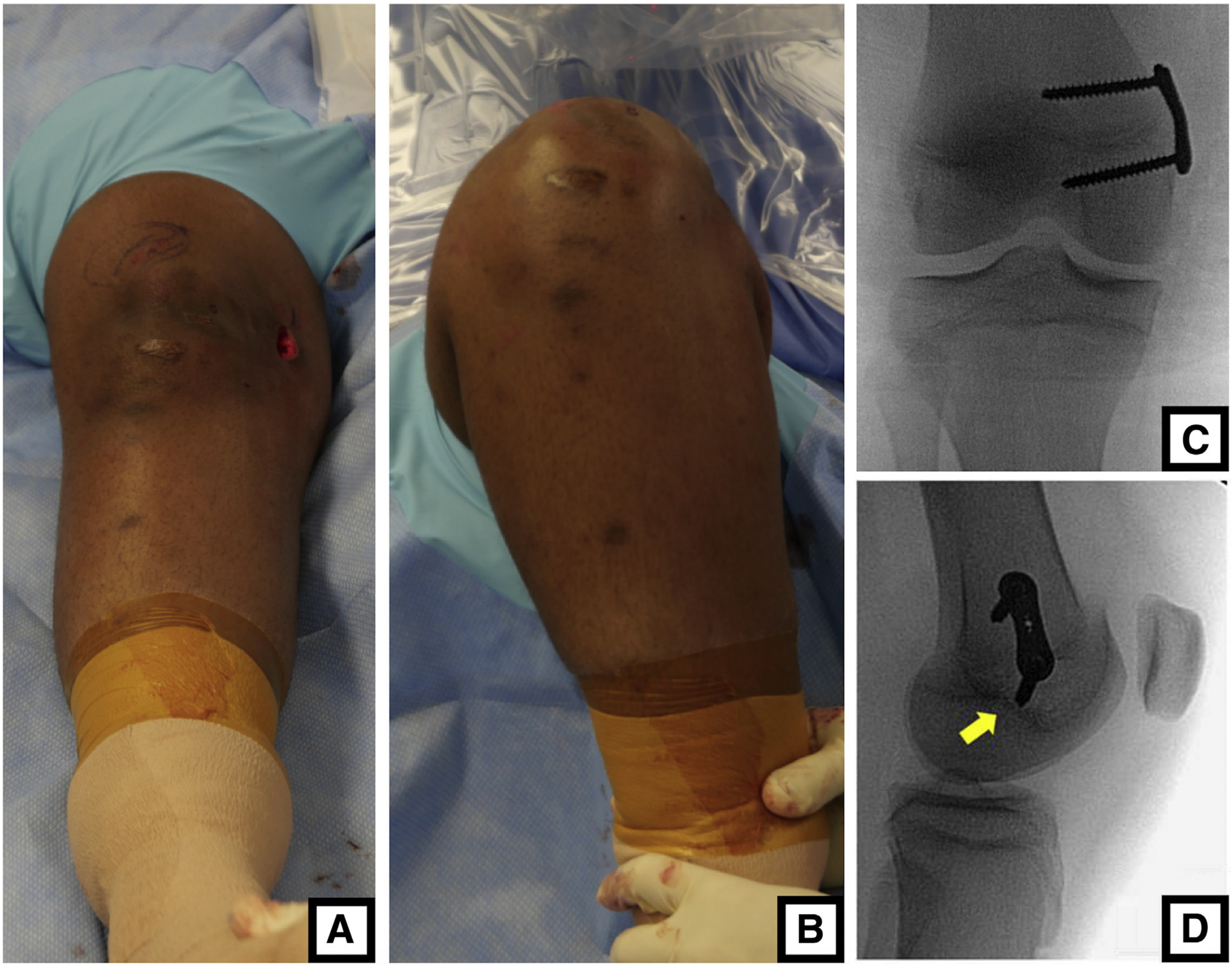

Fig 6. Intraoperative examination and final radiographic images. (A, B) The knee is taken through complete range of motion from terminal extension to terminal flexion to ensure no entrapment of soft tissue underneath the plate, which could lead to inadvertent capturing of the knee and resultant stiffness. (C, D) Final anteroposterior and lateral radiographs are taken, showing plate placement centered over the physis, with the plate aligned to the sagittal anatomic axis of the distal femur, without screw penetration into the intercondylar notch (tip of inferior screw is anterior to the Blumensaat line, depicted by yellow arrow).

This protocol is modified to accommodate for healing after concomitant procedures such as MPFL reconstruction and medial retinacular plication, as appropriate. However, it does not alter the postoperative protocol for those soft tissue procedures as if they had been performed in isolation. For instance, after concurrent MPFL reconstruction, range of motion is initially restricted to 0 to 30°, and advanced to 90° at 2 weeks. By 6 weeks, range of motion restrictions are lifted, and focus is placed on gradual initiation of functional strengthening, with emphasis on maintenance of the reconstruction. Continued range of motion, proprioceptive, and strengthening exercises with graduated resistance and impact are begun at week 12, and objective return to sport criteria, such as limb symmetry index guide full return to sport, at approximately 5 months postoperatively, depending also the amount of residual on coronal plane angular deformity.

An illustrative case example is presented in Table 2 and shown in Figure 8.

Discussion (With Video Illustration)

The use of implant-mediated guided growth for correction of pediatric deformity is reported in the literature to have good outcomes and minimal complications.[23,46,47] Genu valgum is frequently associated with patellar instability, and it is known that correction of valgus deformity reduces the risk of recurrent instability; however, the current literature is largely limited to the use of osteotomy for deformity correction.[20-22] In the skeletally immature population,

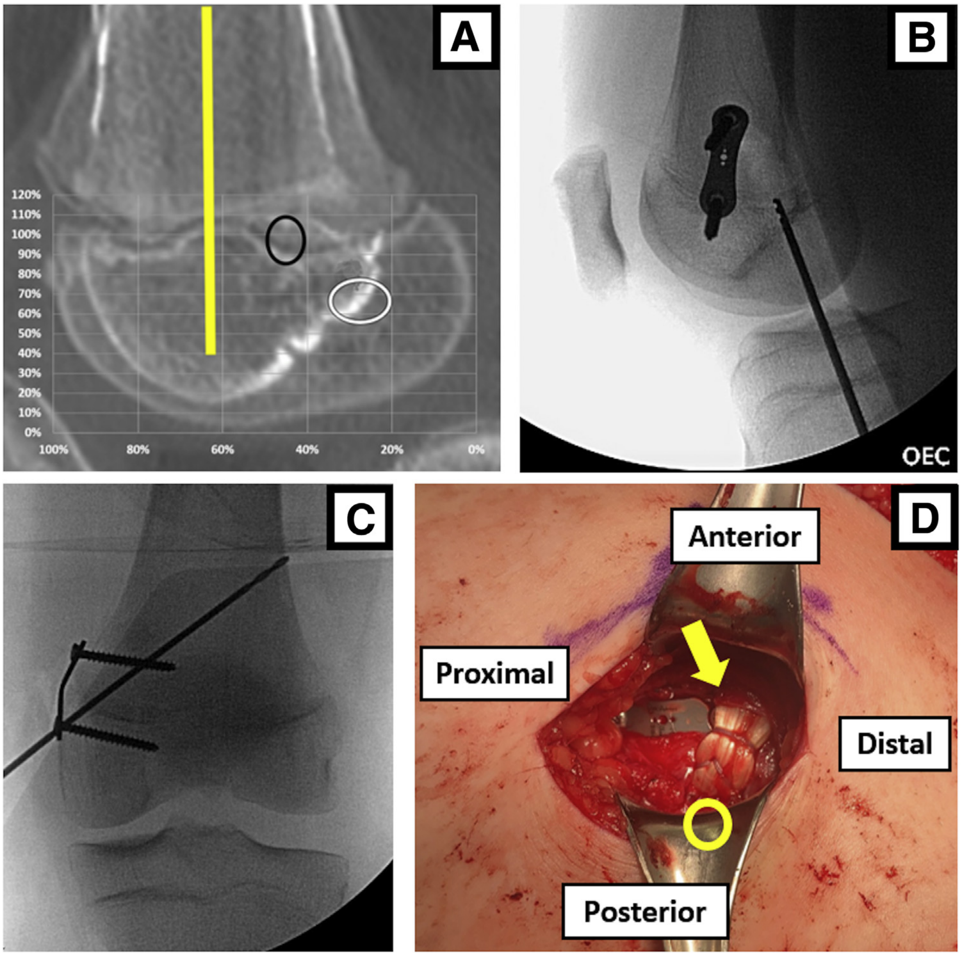

Fig 7. Proximity of the native medial patellofemoral ligament (MPFL) origin to an implant-mediated guided growth plate. Superimposed sagittal view of the distal femur (A) showing ideal placement of guided growth plate (A, yellow line), along with native MPFL femoral origin in skeletally immature cadaveric specimens (black circle, age 7 to 11; white circle, age 2 to 6). An optimally placed guided growth implant remains anterior to an anatomic MPFL femoral tunnel, but the graft frequently overlies the distal aspect of the plate. Case example showing lateral (B) and anteroposterior (C) fluoroscopic view of anatomic MPFL femoral tunnel and its proximity to a guided growth plate, which is typically at the level of the distal screw (in the proximal-distal direction) and directly posterior. After graft fixation (D), the MPFL graft overlies the distal guided growth plate screw (yellow arrow) as it courses toward the femoral tunnel (yellow circle). (Panel A adapted with permission from: Shea KG, Martinson WD, Cannamela PC, et al. Variation in the medial patellofemoral ligament origin in the skeletally immature knee: An anatomic study. *Am J Sports Med* 2018;46:363-369.)

remaining growth can be harnessed via implant-mediated guided growth to correct deformity, thus decreasing morbidity associated with osteotomy (such as large incisions, bony manipulation, potential for nonunion, and longer rehabilitation).[23,48] The use of guided growth in the setting of patellar instability is an emerging technique that although promising, has been very sparsely reported on in the literature.[49]

Three previous retrospective studies have assessed the use of guided growth for patellar instability. Kearney and Mosca[50] reported in 2015 on a series of 26 knees treated with isolated hemiepiphysiodesis for genu valgum—associated patellar instability. They found that substantial deformity correction and symptomatic improvement could be achieved.[50] At a mean follow-up of 30.9 months, a mean deformity correction of 6.8° was achieved, and 69% of patients achieved complete symptom resolution (no further instability events), whereas 31% achieved symptom reduction. In 2019, Tan et al.[51] reported a similar retrospective series of 20 knees undergoing isolated hemiepiphysiodesis for genu valgum—associated patellar instability at 1-year follow-up and found 80% of patients achieved symptom resolution, with a mean tibiofemoral angle correction of 3.4°. Four patients (20%) developed recurrent instability and required distal femoral osteotomy, and the authors noted that the patients who developed recurrence tended to be older, achieved

Table 2. Representative Case Example (Fig 8)

History	• 14-year-old healthy boy, with right knee patellar instability and a history of bilateral "knock knees." • 3 previous right patellar dislocations, which all spontaneously reduced.
Physical examination	• Mild tenderness to medial patellar facet. • 3+ quadrants of lateral subluxation with firm endpoint. • Mild apprehension in full extension. • Full range of motion, normal neurovascular examination.
Radiographic evaluation	• Dedicated right knee radiographs and standing alignment films: significant genu valgum with mechanical axis deviation of 52 mm lateral to the center of the knee, with deformity predominantly from the femoral side. • LDFA 72° MPTA 92°. • Left hand PA radiograph: bone age 14 years.
Surgical procedure	• Implant-mediated guided growth given his significant valgus deformity. ○ Bilateral guided growth given symmetrical genu valgum. • Concurrent ipsilateral medial retinacular plication. • Plan for staged MPFL reconstruction at the time of implant removal, if needed (if he had continued patellofemoral instability despite coronal plane angular correction, as coronal plane malalignment was considered to be the main driver of his patellofemoral instability). • Arthroscopy was not performed, as there were no history, examination, or magnetic resonance imaging findings concerning for loose body or chondral injury.
Postoperative course	• Follow-up at 2 weeks, 6 weeks, 3 months, 6 months, 8 months, and 10 months. • No further instability events at most recent follow-up (10 months). • 2+ quadrants of lateral patellar subluxation with firm endpoint by 6 weeks postoperative. • Return to full sports activity by 8 months. • Complete radiographic correction of coronal plane mechanical axis at 10 months postoperative. • If no further correction occurs over 3 months, plate removal is optional. If correction continues, plate removal is recommended to prevent overcorrection.

LDFA, lateral distal femoral angle; MPFL, medial patellofemoral ligament; MPTA, medial proximal tibia angle; PA, posteroanterior.

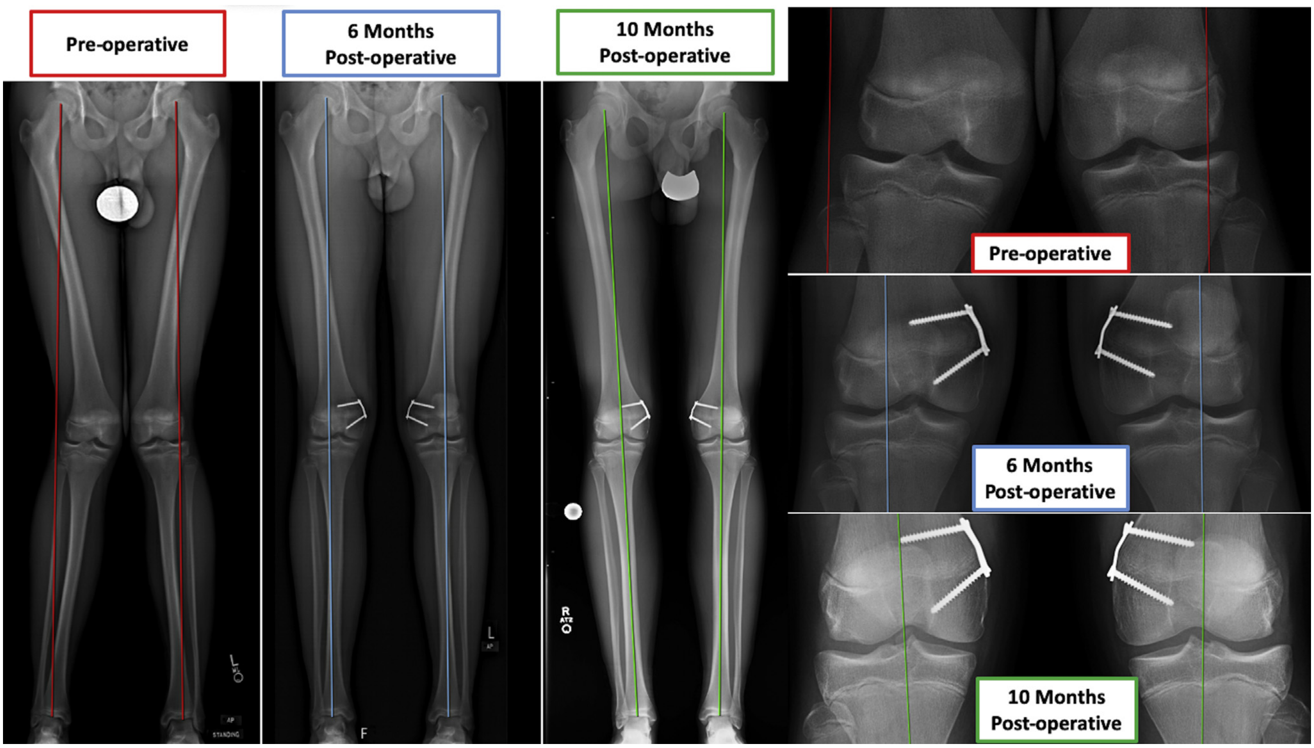

Fig 8. Case example of coronal plane angular deformity correction using guided growth with tension band plating in the setting of patellofemoral instability. Preoperative films show severe bilateral genu valgum with lateral mechanical axis deviation in the setting of recurrent right patellar instability. Interval correction is seen on 6-month postoperative standing alignment films, and by 10 months postoperative, complete correction was achieved. Vertical lines in all panels represent the mechanical axis. The patient had no further patellofemoral instability events, and had returned to full sports activity by 8 months postoperative.

Table 3. Pearls and Pitfalls

Pearls	Pitfalls
Preoperative workup for patellar instability should include full length hip-to-ankle alignment films for deformity evaluation, magnetic resonance imaging to assess intraarticular pathology and axial alignment, and bone age radiograph.	Failing to recognize coronal or axial plane malalignment as a contributor to patellofemoral instability.
Careful dissection to preserve deep structures including medial collateral ligament, periosteum, and perichondral ring of Lacroix.	Using electrocautery too close to physis can cause permanent iatrogenic physeal injury.
Contoured plate, placed along anatomic axis of femur.	Avoid introduction of sagittal plane malalignment and/or iatrogenic joint penetration via errant placement of plate.
Cannulated drilling, but application of solid (noncannulated) screws.	Avoid use of cannulated screws to prevent screw fracture and implant failure, especially in overweight patients.
Fully cycle the knee after tightening screws and retighten screws after soft tissue freed.	Failure to free entrapped soft tissues from beneath plate can result in postoperative stiffness.

smaller deformity corrections, and had greater magnitude deformity prior to surgery. In a separate 2019 retrospective series, Parikh et al.[52] showed that in 8 knees undergoing hemiepiphysiodesis with concurrent MPFL reconstruction, symptom resolution was seen in 7 of 8 patients, with mean deformity correction of 9.4°. The one patient who developed recurrence was a 7-year-old boy with Down syndrome, who was found to have MPFL graft pullout and required revision reconstruction; subsequently he had no further instability. It must be noted, however, that although these studies all report positive results, they are all small noncomparative retrospective studies with nonstandardized follow-up protocols and no use of standardized clinical outcome scores.

Table 4. Advantages and Disadvantages

Advantages	Disadvantages
Small incision, especially compared with distal femoral osteotomy.	Requires sufficient remaining skeletal growth.
Small implants, no risk of delayed union or nonunion as with osteotomy.	Gradual correction, requires time.
Minimal bony disruption (compared with osteotomy).	Oftentimes necessitates removal of hardware to prevent overcorrection.
MPFL reconstruction can be performed through same exposure.	Potential for rebound deformity after plate removal if substantial growth remaining.

MPFL, medial patellofemoral ligament.

Further research is required to fully understand the long-term outcomes of guided growth in the setting of patellar instability. Notable pearls and pitfalls, as well as advantages and disadvantages of this technique are highlighted in Tables 3 and 4, respectively. High-quality evidence will help us identify shortcomings of this procedure as we aim to improve our surgical indications, techniques, and outcomes. Several important aspects of the application of guided growth to patellar instability must be characterized. First of all, it is known that the location of a properly placed guided growth implant is in close proximity to important medial-sided knee structures, such as the MPFL, medial collateral ligament, and joint capsule. It is known that in up to 50% of cases, during placement of medial tension band plate, there is partial dissection or perforation of the MPFL.[53] Further investigations into the possible iatrogenic effects on nearby anatomic structures are warranted. Additionally, rebound phenomenon, or partial recurrence of the corrected deformity,[54] has been documented to occur in up to 79% of patients after temporary hemiepiphysiodesis,[55] although symptom recurrence in patients who undergo the procedure for patellofemoral instability seems to be much lower in the limited studies in the literature. Animal studies have suggested that rebound growth occurs several weeks after removal of the guided growth implant,[56] but no studies have been done in humans. There is currently no consensus on whether overcorrection should be routinely performed to account for rebound growth. Finally, genu valgum can commonly present bilaterally, and it is known that approximately 10% of patients with pediatric patellar instability will develop contralateral instability.[26] Given that valgus alignment is a risk factor for patellar instability, the use of contralateral guided growth may reduce the risk of future contralateral patellar dislocation. However, there are currently no studies in the literature that address this question.

Coronal plane deformity plays a role in the pathogenesis of various intraarticular knee pathologies beyond patellofemoral instability, such as anterior cruciate ligament rupture, discoid meniscus, and osteochondritis dissecans. With advanced diagnostic imaging capability, enhanced clinical understanding, and earlier organized competitive sports participation among the pediatric population, the incidence of pediatric intraarticular knee pathologies is rising. As knowledge of the application of guided growth in patellar instability increases, the indications, surgical techniques, and outcomes will continue to evolve. If further high-quality evidence can continue to shed positive light on this emerging technique, it may become increasingly used for other intraarticular knee conditions as well (Video 1).

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