

Intra-Articular Osteotomies of the Hip, Knee, and Ankle

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Realignment of the hip knee and ankle can be achieved by extra-articular osteotomy if there is no intra-articular deformity or incongruity. Intra-articular osteotomy of the femoral head, femoral condyles, tibial plateaus and tibial plafond can all be achieved technically and biologically and lead to a congruous joint. This is a new frontier for realignment surgery extending the indications for joint preservation surgery.

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Extra-articular osteotomies of the femur and tibia are used for realignment of the hip, knee, and ankle. The closer each osteotomy is to an adjacent joint, the greater the reorientation with angular correction. Extra-articular realignment and reorientation can redistribute forces on these major weight-bearing joints. The resultant pain reduction and decreased wear rate increase the longevity of these joints. Extra-articular osteotomies do not address problems of joint incongruity. Joint incongruity and associated instability, subluxation, and impingement lead to rapid degeneration of the hip, knee, and ankle.

Intra-articular osteotomies are not a common treatment consideration for the hip, knee, or ankle. Intra-articular osteotomy of the medial proximal tibia is perhaps the only such osteotomy that is well recognized^{1,2} intra-articular osteotomy of the distal femur, of the femoral head, or of the tibial plafond have not been previously described. The purpose of this paper is to describe the techniques of intra-articular osteotomies of the hip, knee, and ankle joints.

Knee

Intra-articular osteotomy of the knee can be divided into proximal tibia and distal femur. Each of these can be divided into medial and lateral. For the proximal tibia the technique used depends on the indication. Posttraumatic malunion of the proximal tibia is treated differently than developmental hypoplasia of the medial or lateral tibial plateaus.

Malunited Tibial Plateau

These are caused by tibial plateau fractures with incongruity of one plateau relative to the other (Figs. 1 and 2). On the medial side the plateau is most commonly tilted, whereas on the lateral side there is most commonly a segmental depression or diastasis with widening. On the medial side, the plateau may be osteotomized from a small medial incision and reoriented with an opening wedge correction. On the lateral side, the plateau can be narrowed by resection of the defect and or the depressed segment can be elevated and bone grafted.³

Blount's Disease

The medial plateau is tilted into varus and procurvatum (Fig. 3). A medial hemiplateau elevation with or without an extra-articular high tibial osteotomy is performed to realign the medial to the lateral plateau. Before surgery, there is mediolateral instability of the knee joint. The osteotomy is performed through a medial incision with image intensifier control. The pes anserinus is cut and the insertion of the superficial medial collateral ligament is elevated off the tibia distally to permit the tibia to be valgusized to the femur. Once the plateau is elevated, the knee is immediately stable. The medial plateau should be elevated to a line drawn across the lateral plateau extended medially. I start by inserting a subchondral guide wire parallel to the lateral plateau. When the medial plateau is sufficiently elevated in both the frontal and sagittal planes, the guidewire can be advanced under and parallel to the medial plateau. A bone graft is used to fill the medial opening wedge osteotomy. I prefer to fix the elevated fragment with three 7.0-mm cannulated screws from the lateral side. If there is an associated extra-articular malalignment, torsion, or leg length difference a proximal tibial osteotomy is performed to carry out these corrections in addition to the plateau elevation. If the osteotomy is performed before skeletal maturity,

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Figure 1 (A) Anteroposterior (AP) and lateral radiographs of malunited Schatzker 3 tibial plateau fracture. Note the widening of the tibia on the AP view. (B) Computed tomography scan cuts showing wedge-shaped defect of lateral plateau. (C) The defect was resected and the plateau closed like a book hinging on the posterior cortex. This was fixed with 3 lateral screws. (D) Final appearance after removal of the screws. The width of the tibia has been restored to normal.

a decision has to be made to spare or close the physis. In girls younger than age 8 and boys younger than 10 it is worth trying to save the proximal tibial physis. In these cases the hemiplateau elevation is performed in the epiphysis and the bony bridge across the physis is resected if it is proven to exist (Fig. 3). After this age, there is not enough growth remaining to justify a hemi-epiphyseal approach and instead the osteotomy may cross the physis and the remaining open lateral physis is physiodesed.⁴

Degenerative Medial Plateau Osteoarthritis with Medial Plateau Depression and Lateral Knee Subluxation

There is bone and cartilage loss of the medial hemiplateau with lateral collateral laxity and lateral subluxation of the tibia on the femur with varus stress (Fig. 4). Valgus stress radiographs demonstrate reduction of the tibia on the femur with a medial opening wedge joint space. Medial hemiplateau elevation is used to fill this space and stabilize the knee. I use the same strategy as for Blount's disease with elevation of the medial plateau through a small medial incision. I fix the plateau with screws from the lateral side and a bone graft medially. To unload the arthrosis of the medial compartment, an extra-articular osteotomy is performed to shift the load laterally.^{5,6}

Lateral Plateau Depression Attributable to chondroectodermal Dysplasia

Chondroectodermal dysplasia (Ellis von Crevald Syndrome) is associated with a severe valgus knee with hypoplasia of the lateral tibial plateau and undergrowth of the proximal fibula (Fig. 5). The latter may cause pressure on the lateral compartment, which may lead to epiphyseal growth disturbance. Extra-articular osteotomy leads to joint and physal malorientation. Intra-articular osteotomy depends on whether the physis is open or closed. Unlike Blount's disease for the medial plateau, there is no mediolateral instability with this condition. Therefore, all the lateral soft tissues crossing the knee need to be released to allow the knee to be varusized and to wedge open the lateral knee compartment. These lateral structures include the Ilio-tibial band, the lateral collateral ligament, the biceps tendon, the lateral head of gastrocnemius and the peroneal nerve.

Through a lateral incision, I lengthen the Ilio-tibial band and the biceps in a z fashion. The head of the fibula is osteotomized and reflected proximally with the lateral collateral ligament. The peroneal nerve is decompressed and mobilized to free it from the fibula. The lateral head of gastrocnemius is released from the femur. The knee joint can now be wedged open on the lateral side. It is only limited by the capsule. If the physis is open, an intraepiphyseal osteotomy is performed and a bone graft inserted. The osteotomy should extend posteriorly beneath the elevated head of the gastrocnemius. The capsule should not be cut because it provides the circulation to the articular portion of the plateau after the osteotomy. If the physis is closed the same osteotomy can be performed more distally. The osteotomy is either hinged at the tibial spines or a separate antero-posterior osteotomy can be performed at the medial edge of the step

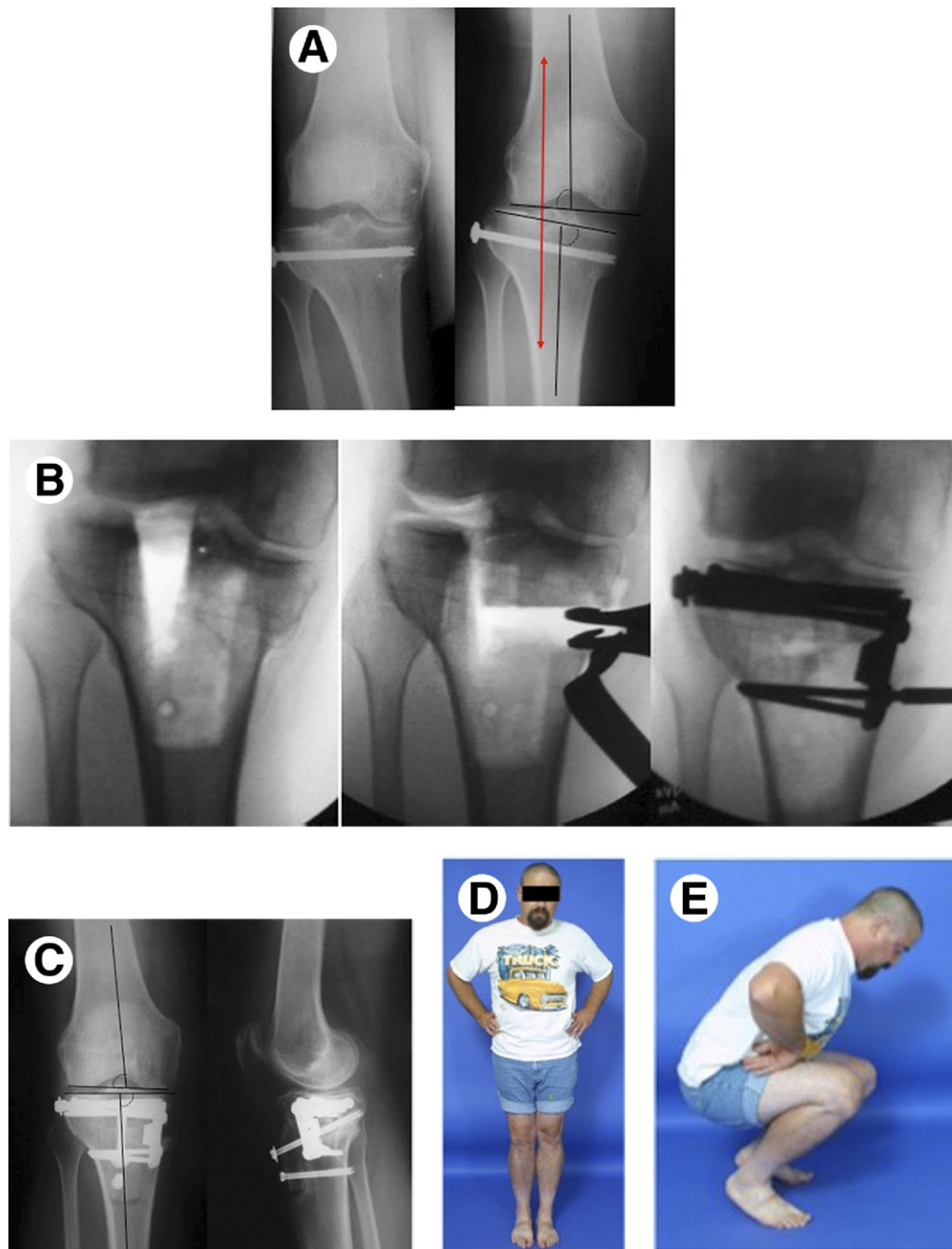


Figure 2 (A) Malunited Schatzker 5 tibial plateau fracture with depression of medial plateau, widening of lateral plateau, and varus-valgus instability. There is lateral mechanical axis deviation. (B) The lateral bone defect was closing wedge resected. The medial plateau was osteotomized and opening wedge elevated. The wedge of bone from the lateral side was inserted on the medial side to support the plateau elevation. To visualize both medial and lateral plateaus, the tibial tuberosity was osteotomized and reflected proximally with the patellar tendon. (C) Final AP and lateral of knee after the osteotomies of the tibia and femur healed. The alignment is normal. (D) Clinical picture showing the knee fully extended and aligned. (E) Clinical picture showing the knee fully flexed in the squatting position. (Color version of figure is available online.)

depression of the lateral plateau. A bone graft is used to support the plateau. Screws or a plate can be used. The fibula can be resected and used as a bone graft. One advantage of this is to allow the anterior and lateral plateau muscles to retract distally and medially thus allowing the peroneal nerve to move more medial. This takes all tension off the peroneal nerve after the acute varusization of the tibia on the femur. If in addition to the

intra-articular tibial deformity the lateral distal femoral angle is abnormal ($<85^\circ$) the distal femur also needs to be varusized.⁴

Neonatal Sepsis-Related Femoral Condylar Deformities

Neonatal sepsis leads to damage to the distal femoral epiphyseal growth as well as to physseal growth of the distal femur (Figs. 6

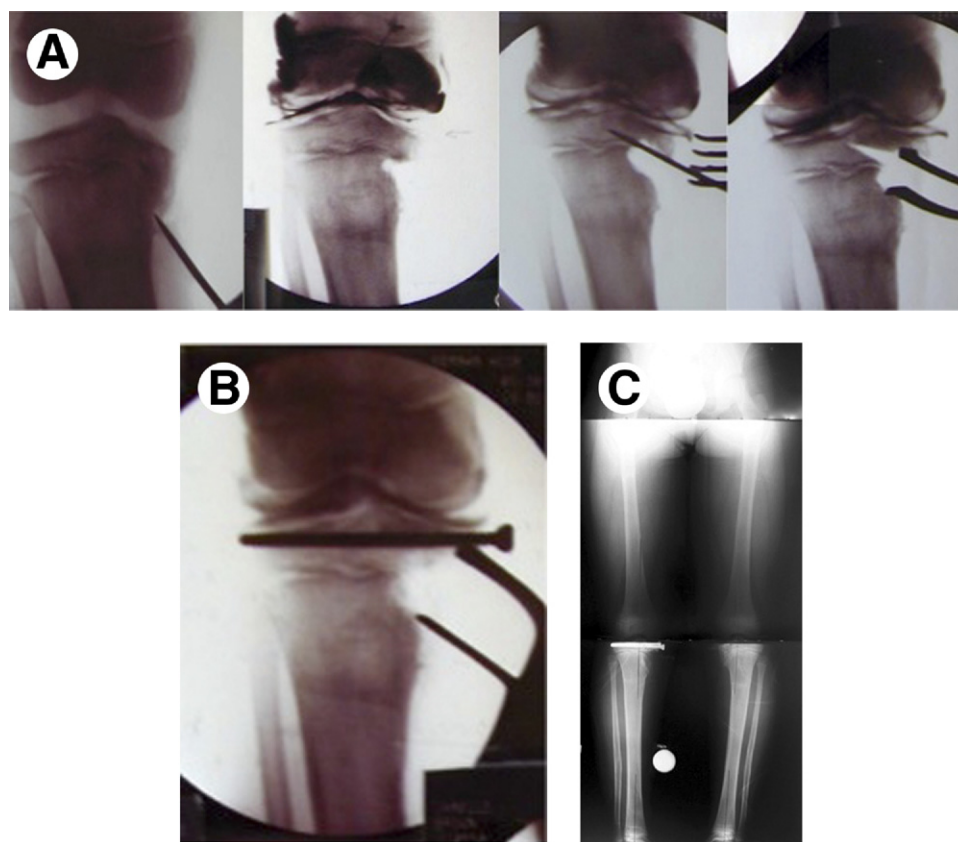


Figure 3 (A) Blount's disease in an 8-year-old girl. The growth arrest of the medial side is resected. A medial epiphyseal osteotomy is performed and the medial plateau was elevated. (B) The bone defect is supported by the use of screws to fix the plateaus and bone cement. (C) The cement was removed but the alignment stayed unchanged. The bony bridge did not recur. (Color version of figure is available online.)

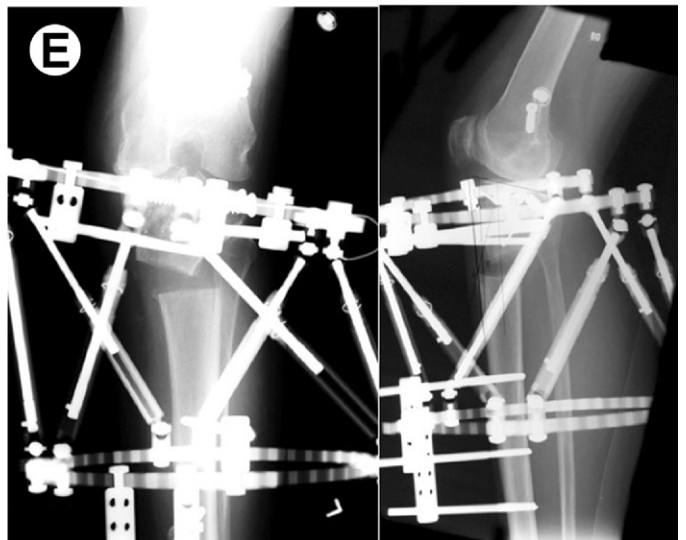
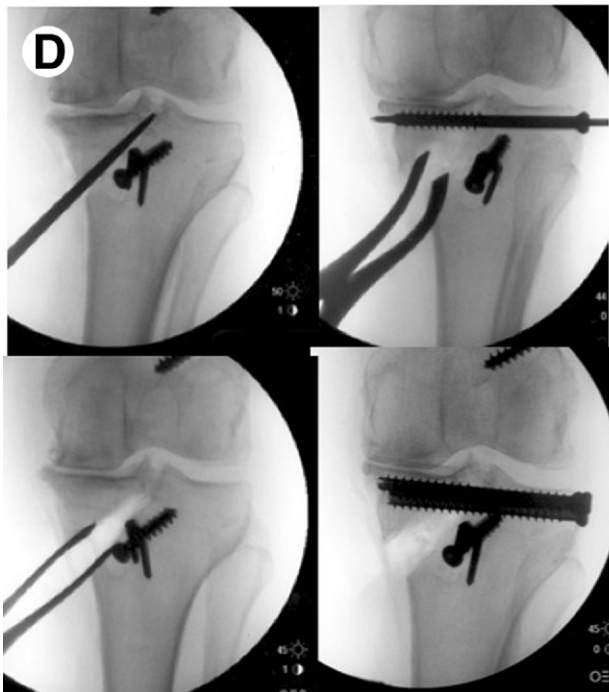
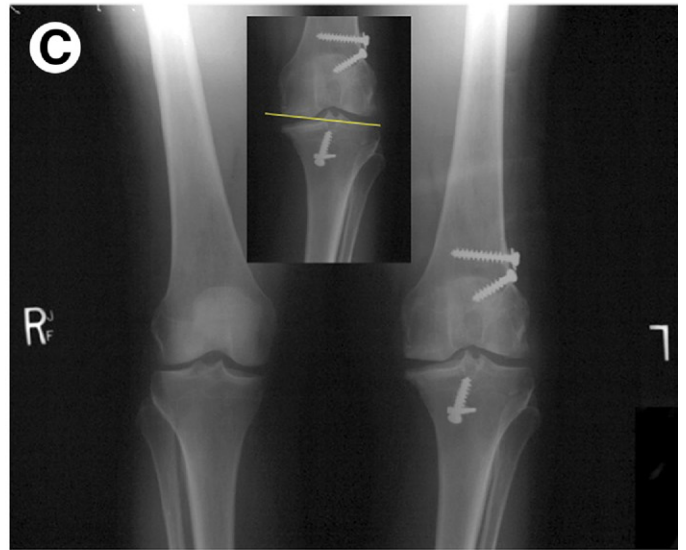
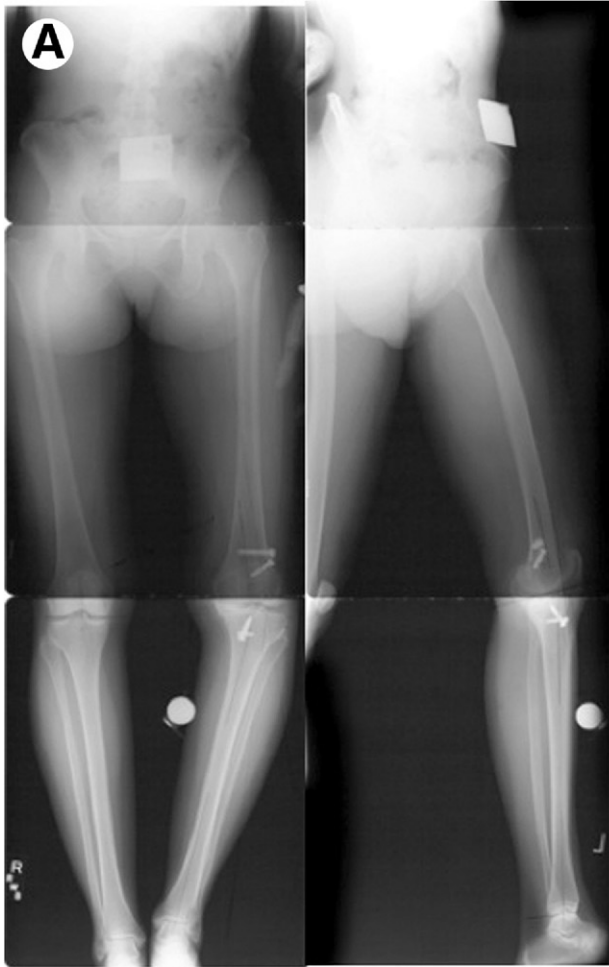
and 7). The most common lesion is a central growth arrest leading to a fishtail deformity of the distal femur. The femoral condyles grow towards each other obliterating the intercondylar notch. The distal femur becomes narrower than the opposing articular surface of the tibia and in some cases one femoral condyle comes to rest on the tibial spines. External rotatory instability of the tibia on the femur results leading to subluxation and dislocation of the patella on the femur as the patellar tendon moves laterally with the externally rotated tibia. If the damage is predominantly of one femoral condyle, it may become hypoplastic and a step deformity develops between the 2 condyles. This results in frontal plane knee instability. Intra-articular osteotomy is used to level the condyles to each other or for fishtail deformity to widen the condyles apart creating a notch and even creating a groove for articulation with the patella. The rotatory instability of the tibia and the dislocated patella are addressed as previously described by Paley in the superknee procedure.⁷

A midline anterior incision is used and medial and lateral flaps are created. If the patella is dislocated then the modified Langenskiöld procedure as described by Paley is used.⁸ If not, then a parapatellar approach is used to expose the femoral condyles anteriorly. It is very important not to strip the medial or lateral soft tissues off the femur to preserve the vascularity of the condyles. A transverse osteotomy is made either on the medial or lateral side depending on which condyle is being moved.

There are 2 options: shorten the long condyle or lengthen the short condyle. This step can be combined with tilting of the condyle. The decision to shorten or lengthen a condyle depends on the frontal plane stability of the knee joint. Varus-valgus stress radiographs will show joint space between the femur and tibia medially or laterally. To eliminate this instability, the short condyle of the femur can be advanced into the space.

Hemicondylar Osteotomy Technique

A transverse osteotomy is made on the side to be lengthened or shortened. The osteotomy should only go half way across the femur to coincide with a longitudinal osteotomy through the notch. The transverse osteotomy should not be too close to the joint to allow sufficient bone for fixation. It is important not to fracture the side that will not be reoriented. In some cases a supracondylar osteotomy can be performed to reorient the knee joint extraarticularly after the hemicondylar osteotomy is moved and fixed. Often, the condyles grow together posteriorly, eliminating the intercondylar notch together with the patellar groove becoming convex instead of concave. This can be corrected by widening the posterior aspect of the condyles with a laminar spreader, hinging the bone on the anterior cortex. This creates a concave patellar groove on the anterior femur and is combined with a realignment procedure for the patella. Reorientation can also be performed in the sagittal plane by rotating the condyle



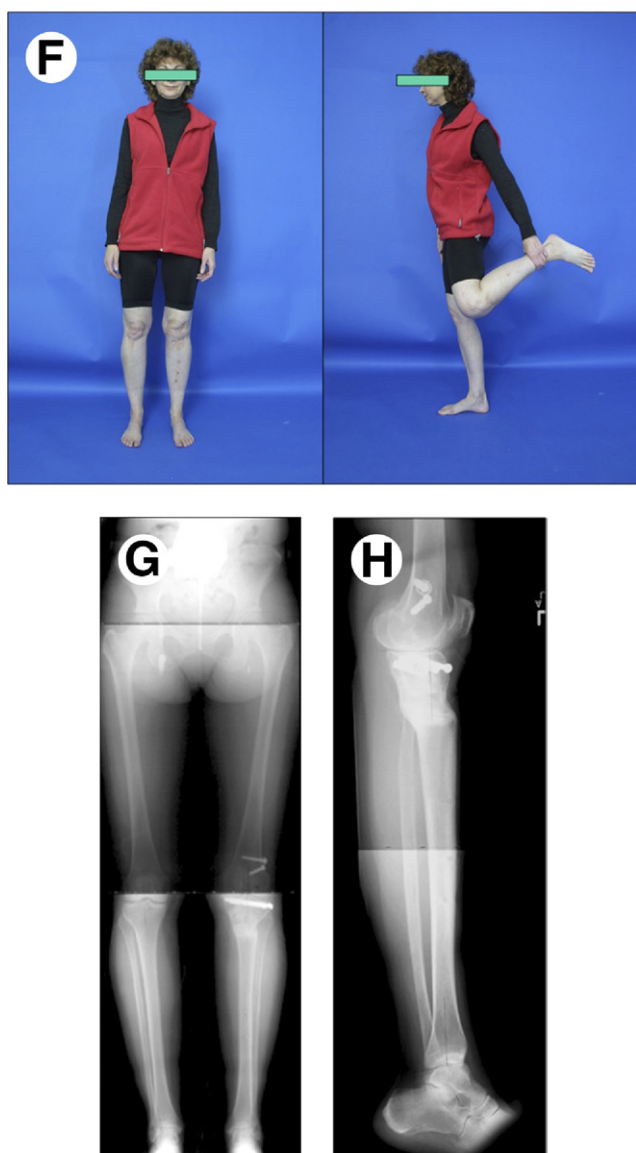


Fig. 4 (Continued) (F) Clinical photos demonstrating the frontal plane alignment and the range of motion at 2 years follow-up. Her result remains the same after 10 years follow-up. (G) Final erect legs radiograph showing excellent alignment with overcorrection into valgus. (H) Final lateral radiograph.

around the knee center of rotation. To achieve this type of correction, first correct the width, length, and frontal plane orientation of the femoral condyle, after which a guide pin can be inserted across the center of rotation of the knee joint. The con-

dyle can then be rotated around this guide pin. Once the final reduction of the condyle is achieved, a partially threaded cannulated screw is used to fix the proximal end of the condyle and generate compression across the longitudinal osteotomy proximally. A fully threaded cannulated screw is used to keep the condyles apart distally. Three or 4 cannulated screws are enough to stabilize the condyles. I usually avoid using a side plate because of the risk of devascularization of the condyles.

Intra-Articular Osteotomy of the Femoral Head

There are 3 types of intra-articular osteotomies of the femoral head: (1) subcapital; (2) excisional (cheilectomy)⁹⁻¹¹; and (3) intracapital (Fig. 8). Subcapital osteotomy is used to reduce the deformity resulting from slipped capital femoral epiphysis. Excisional and intracapital are used to reshape a nonspherical femoral head. The Ganz safe surgical dislocation approach is used for all 3 types of intra-articular osteotomies of the hip.¹²

Subcapital

The technique for this was developed by Slongo and Ganz^{13,14} after identifying, isolating and protecting the vascular pedicle of the femoral head I perform a subcapital osteotomy of the femoral head in the skeletally mature patient. I resect a triangular section of the femoral neck posteriorly where the neck has remodeled to the posteriorly located femoral head. The remaining femoral head is wedge shaped like the blade of an axe. The femoral head is relocated onto the axe blade shaped neck leaving a defect anteriorly. The triangular bone that was resected is grafted anteriorly and fixed to the femoral head and neck with screws. As long as the vascular pedicle is protected and is not stripped from the femoral head or stretched or kinked as it traverses between the piriformis fossa across the neck to the femoral head then avascular necrosis will not occur. This is a technically very challenging procedure, much more difficult than that described recently for reduction of the acute slipped capital epiphysis.^{13,15}

Excisional Versus Intracapital

The concept of excisional osteotomy previously known as cheilectomy has been made safer with the Ganz safe surgical dislocation technique. The concept of intracapital osteotomy of the femoral head is a new original concept of Slongo and Ganz and has not been previously published. The description below is the methodology I have used modified from the

Figure 4 (A) Standing AP and lateral long radiographs showing medial compartment osteoarthritis with marked genu varum. There is also lack of full knee extension. Hardware remains from a previous anterior cruciate ligament reconstruction. (B) AP varus stress x-ray of both knees. There is bone on bone arthritis on the medial side. The tibia is laterally subluxed on the femur. (C) AP valgus stress x-ray of both knees. The lateral compartment is well preserved. The tibia is reduced on the femur. A line drawn across the lateral plateau is not parallel to a line drawn across the medial plateau (insert). (D) A medial hemiplateau osteotomy was performed through a small medial incision. It was fixed by screws from the lateral side. (E) A second osteotomy was performed to overcorrect the alignment into valgus using the Taylor Spatial Frame external fixator. The second osteotomy is extra-articular and below the tuberosity. The correction is angulation and translation because the center of rotation of angulation is at the joint line. On the lateral view the bone was displaced anteriorly and extended to compensate for the anterior cruciate ligament deficiency.

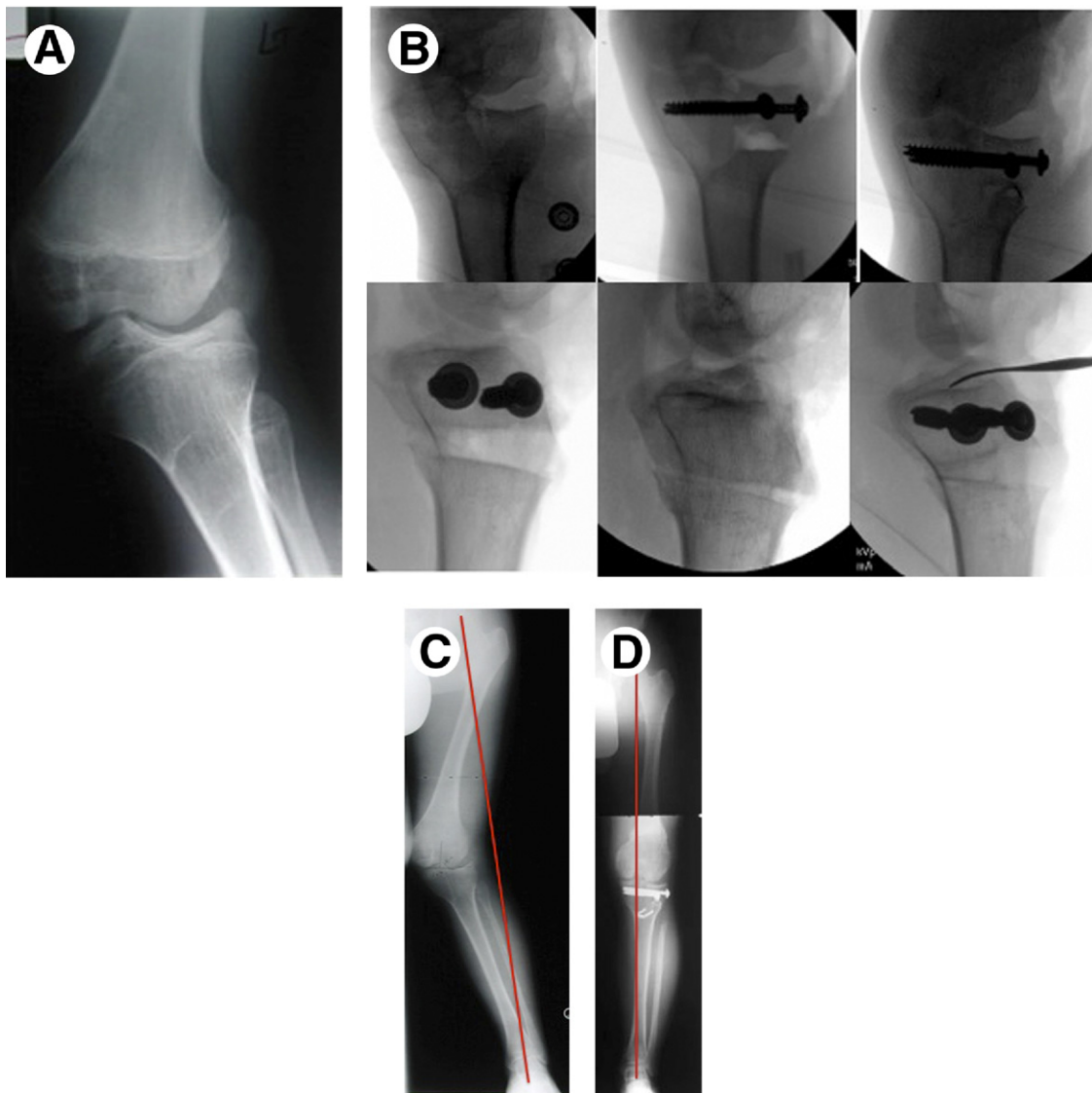


Figure 5 (A) AP knee radiograph in a 16-year-old boy with chondroectodermal dysplasia. Note the depressed stepoff of the lateral plateau. The patella is also dislocated. (B) Intraoperative serial radiographs of the process of surgical elevation of the lateral plateau and bone grafting with the excised fibular head. (C) Preoperative long standing radiograph of the left lower limb. (D) Postoperative long standing radiograph showing full correction of the alignment following lateral hemi-plateau elevation and varus osteotomy of the distal femur. The patella has been reduced into joint. (Color version of figure is available online.)

original techniques of Slongo and Ganz. When the femoral head is elliptic or saddle-shaped, femoroacetabular impingement and limitation of motion result. Pain and restriction of motion followed by labral pathology and degeneration of the joint cartilage are the natural history of the misshapen femoral head. In younger patients the acetabulum may remodel to the aspherical femoral head creating a secondary deformity.

Preoperative 3D reconstruction computed tomography scans are useful to attempt to assess the morphology of the deformed femoral head. The goal of surgery is to return the femoral head to a spherical shape and to excise the most damaged portion of the femoral head. The etiology of the aspherical femoral head is from Perthes, avascular necrosis or dysplasia resulting in a collapsed coxa magna shaped femoral head. Because the femoral head is much larger than the ace-

tabulum, the cartilage under the rim of the acetabulum experiences high pressures from impingement motion of the hip in abduction and flexion. Therefore, the most damaged cartilage is usually the part articulated with the rim of the acetabulum. The cartilage outside of the acetabulum is usually well preserved because it does not experience weight-bearing forces. The bone under this lateral cartilage may be very osteoporotic both from disuse and from peripheral revascularization of the avascular bone.

The decision of which type of osteotomy to perform depends on the findings and measurements made in surgery. When the peripheral cartilage is well preserved and the rim cartilage is damaged, an intracapsular osteotomy should be used to advance the lateral cartilage of the femoral head medially while excising the damaged cartilage of the central portion of the femoral head.

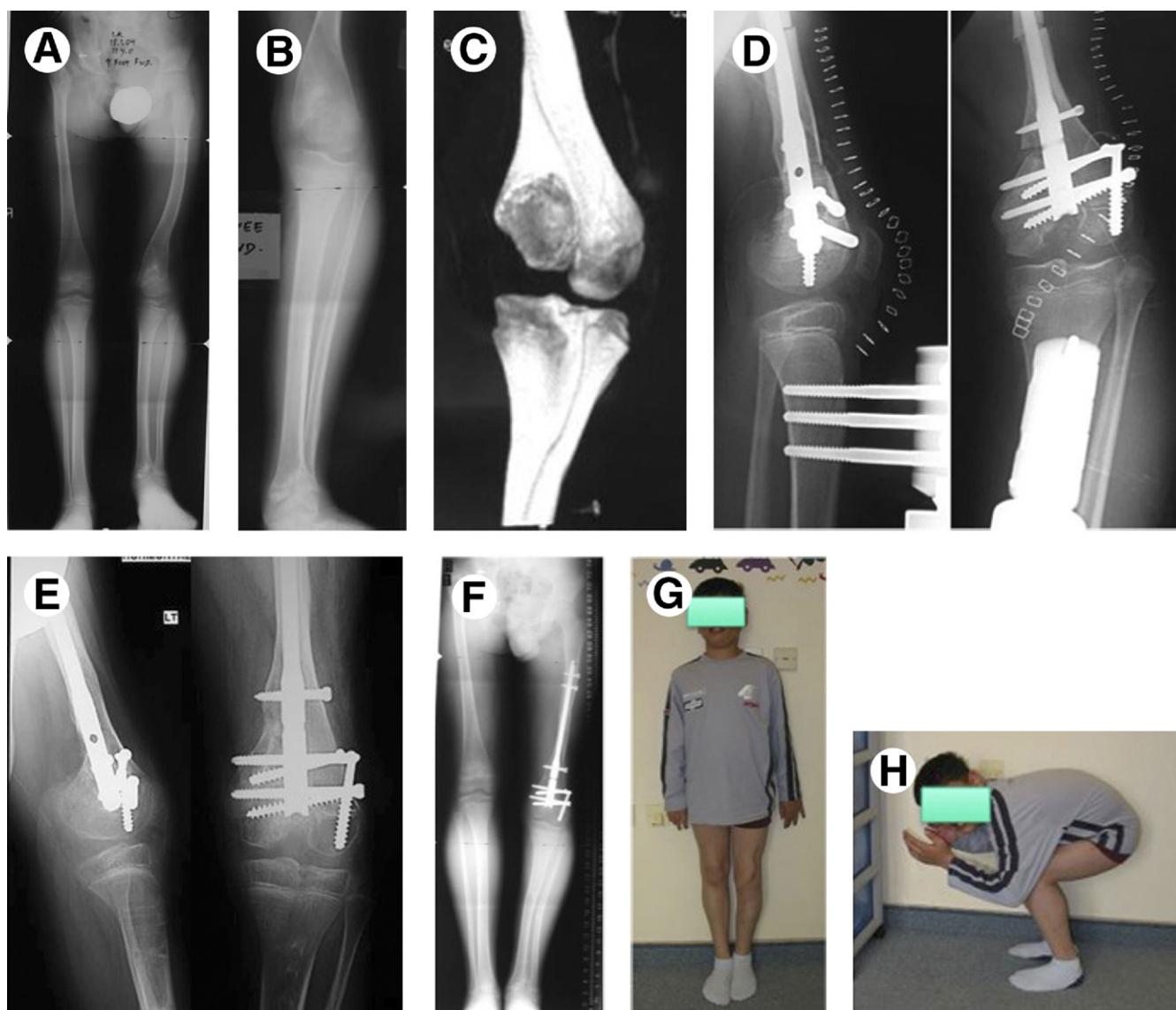


Figure 6 (A) Long radiograph 10-year-old boy with sequelae of neonatal sepsis, including dislocation of the patella. The femur has internal torsion and the tibia is externally rotated at the knee. (B) AP of the knee to include the tibia. The medial condyle of the femur is hypoplastic and has a step deformity to the knee. The femur condyles display a fishtail deformity attributable to central growth arrest. (C) 3D reconstruction of the knee showing the hypoplastic medial condyle. The intercondylar notch is very narrow because of the central growth arrest. (D) The femur was treated open with repositioning the patella into joint as well as widening the condyles and leveling the medial condyle relative to the lateral. It is fixed with an intramedullary nail and a hemi-epiphysiodesis screw for the lateral. The tibia was osteotomized and derotated. (E) Final radiograph after union. The condyles are the same level. (F) Final alignment on long radiograph. (G and H) Clinical photo showing alignment and knee range of motion. (Color version of figure is available online.)

When the peripheral cartilage is damaged but the central cartilage is well preserved then the lateral segment should be excised. In both of these methods the vascular pedicle of the femoral head should be mobilized by the safe surgical dislocation technique of Ganz. Careful excision of the stable trochanter combined with anterior to posterior peeling of the pedicle off the femoral neck for excisional osteotomies and off the middle segment for intracapsular osteotomies is the critical step in the procedure for preservation of the blood supply to the preserved sections of the femoral head.

The decision on where to perform the femoral head intra-articular reduction osteotomy is determined on the basis of measurements made in surgery. The lateral osteotomy is made to include part of the femoral neck with its perforating vessels. The osteotomy should be made from front to back. The most posterior part of the osteotomy should be made with an osteotome and the bone cracked and peeled back to avoid injury to the vessels crossing medially. The lateral and medial cuts should be measured for their lengths to ensure that they match. The curvature of the medial femoral head is



Figure 7 (A) Fishtail deformity of the distal femur in a 12-year-old girl with sequelae of neonatal sepsis. The width of the femoral condyles is narrower than the tibial plateaus. (B) Standing preoperative radiograph showing the leg length difference. (C) Operative sequence showing split of the condyles with distal displacement of the lateral condyle. Fixation with partially threaded lag screws proximally and fully threaded screws distally. A medial and lateral column screw were inserted. (D) Final radiograph after reconstruction of knee joint, removal of hardware and lengthening of the femur.

measured with a spherical template. The size of the acetabulum is also measured with a ball-shaped template (from a total hip replacement instrumentation set). The femoral head is reduced to ensure it is spherical such that the lateral portion fitted to the medial portion form a sphere and fit into the acetabulum. Fixation is achieved with headless screws. Because the femoral neck is weakened by this osteotomy a prophylactic screw is inserted up the neck for protection.

Intra-Articular Osteotomy of the Ankle

Osteotomy of the plafond of the distal tibia has not been previously reported to my knowledge. I have used it for one specific type of deformity that results from multiple etiologies

that all lead to proximal migration of the distal fibula. When the fibula migrates proximally in the growing child the talus migrates laterally, following the fibula. This shifts the load on the ankle more laterally. The ground reaction force vector at the level of the ankle is already lateral to the center of the plafond and therefore when the talus moves laterally the valgus moment arm on the ankle greatly increases.¹⁶ This promotes valgus of the plafond. The talus loses contact with the medial malleolus and with the medial plafond putting increased pressure on the lateral epiphysis. The plafond develops a V-shape. The lateral plafond parallels the lateral valgus tilt of the talus while the medial plafond remains perpendicular to the diaphysis of the tibia. If left untreated, the valgus lateral translation deformity will lead to wear of the joint cartilage and arthritis, pain and loss of ankle motion.

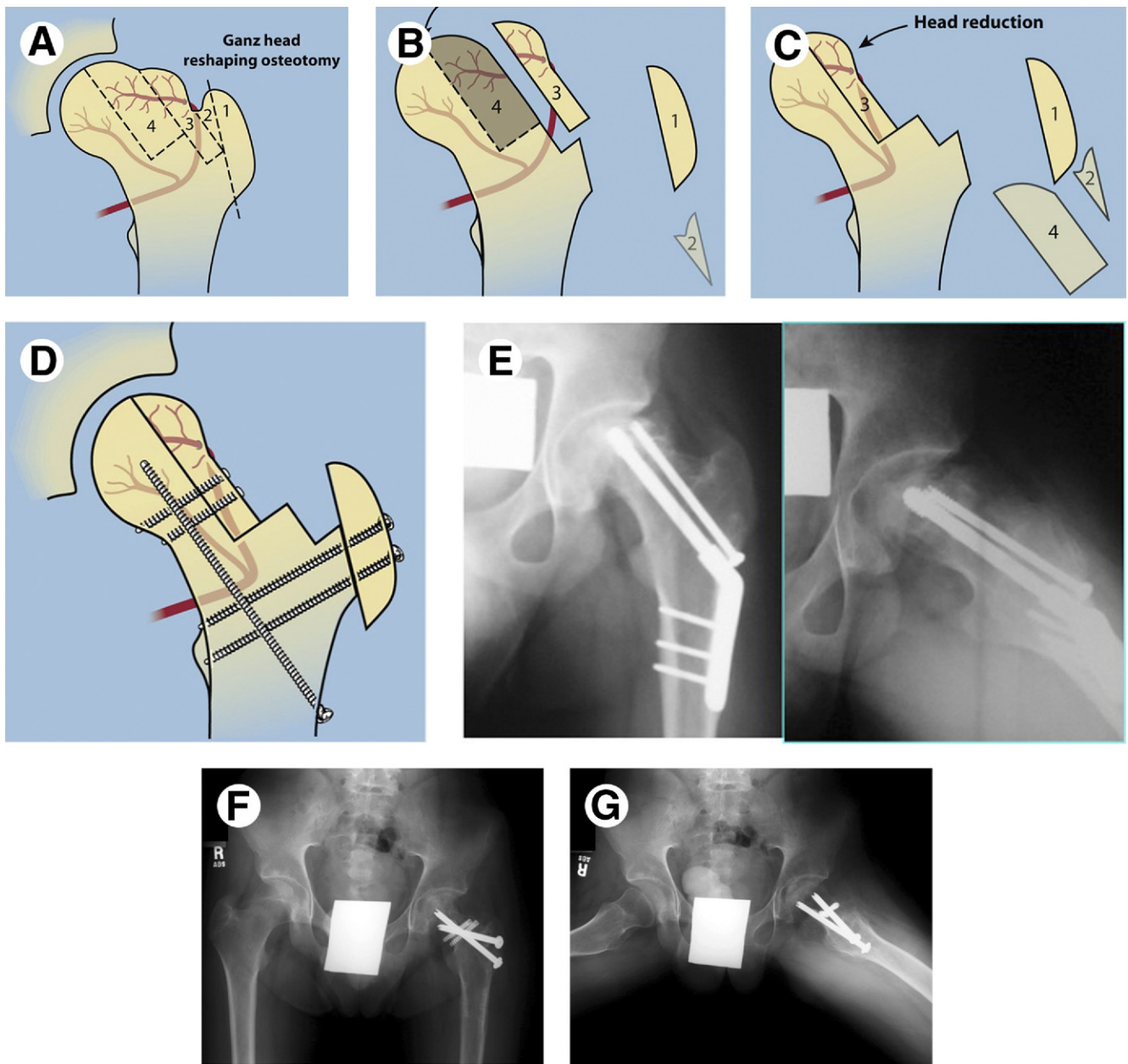


Figure 8 (A) Ganz head reshaping osteotomy cuts for elliptic or saddle-shaped femoral heads. (B) The greater trochanter is osteotomized to safely dislocate the hip. In addition the bone from the stable trochanter is resected and the vessels to the femoral head mobilized. The lateral osteotomy is performed and it is mobilized on its vascular pedicle. The central bone is resected through a medial osteotomy. (C) The lateral segment is reduced to the medial stable femoral head. (D) The femoral head is fixed with headless screws and the trochanter is fixed with headed screws. Finally, a prophylactic screw is inserted up the femoral neck. (E) AP and lateral radiographs of a 15-year-old boy with avascular necrosis following a femoral neck fracture. There is significant collapse of the femoral head with flattening and extrusion. (F) Four years after femoral head reduction osteotomy the femoral head is fully contained. (G) Four-year postoperative frog lateral radiograph of hips shows a normal shape and size to the femoral head on the lateral. This is because the reduction is only medial-lateral.

Varus supramalleolar osteotomy will not correct the intra-articular deformity of the joint nor restore the fibula to its correct level.

The osteotomy is performed through an anterior incision exposing the anterior tibia and fibula (Fig 9). An arthrotomy of the anterior ankle joint is performed to visualize the V-shaped plafond and the vacant space medial to the medial

talar border. Because the fibular shortening is the original cause of this deformity, it is essential to restore the tibiofibular relations to anatomic. The amount of shortening of the fibula is measured radiographically. A pentagon-shaped segment of bone of the distal tibia is resected. Distally, a chevron osteotomy is made with one limb of the chevron parallel to the lateral plafond and one limb parallel to the medial pla-

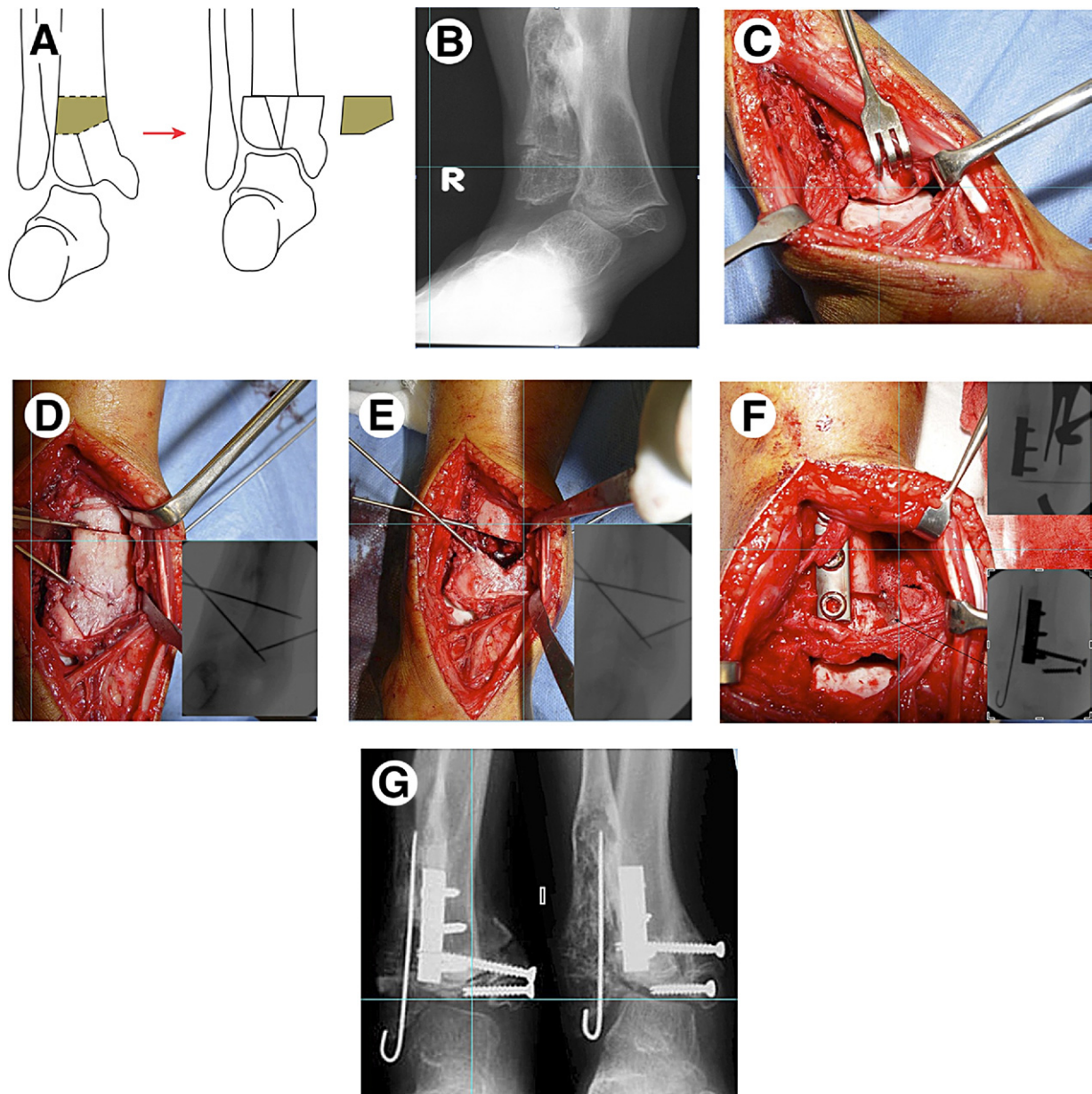


Figure 9 (A) Left: Valgus deformity of the ankle joint with lateral subluxation of the talus. The talus is resting against the fibula. The joint line is V shaped and there is space between the talus and the medial malleolus. Right: Pentagon osteotomy. The distal bone cuts parallel the V-shaped joint lines. The proximal osteotomy is perpendicular to the tibia. The distance between them is the desired shortening required to bring the talus to the correct level relative to the fibula. An opening wedge osteotomy is made at the level of the joint line to make the tibial plafond a horizontal line. The talus is reduced in the joint with no space between it and the medial malleolus. Shenton's line of the ankle is reduced on the lateral side. (B) Preoperative AP radiograph of the ankle mortis in a 6-year-old boy with Ollier's disease. The talus is laterally subluxated, the joint line is V-shaped, there is a space medially between the medial malleolus and the talus, the fibula is shortened. (C) Intraoperative photo: anterior approach to the ankle joint shows the V-shaped joint line and the medial vacant space. The talus sits laterally subluxated next to the fibula. (D) Intraoperative photo: the pentagon osteotomy is completed and outlined by k-wires. Intraoperative radiograph shows the k-wires in place before the osteotomy was made. (E) Intraoperative photo: the pentagon shaped bone segment has been removed. Intraoperative radiograph showing the same. (F) Intraoperative photo: intra-articular osteotomy performed at the apex of the V to flatten the joint line. The ankle joint is now congruous. The medial space is gone. A locking plate was used laterally. Upper right radiograph showing the opening wedge split into the joint held open with a laminar spreader. Because of the growth plate, cranioplast cement was placed across from the epiphysis to the metaphysis to prevent a physeal bridge. An epiphyseal and metaphyseal screw were inserted. Only the epiphyseal screw crosses the cement (lower right radiograph). (G) Radiograph of ankle shortly after surgery compared with 1 year later. Note the natural growth occurring from the distal tibial physis evidenced by the proximal migration of the metaphyseal screw relative to the epiphyseal screw. The joint remains well reduced and aligned. The relative fibular length has been restored as has the joint stability.

fond. The apex of the chevron corresponds to the apex of the V-shaped plafond. A second proximal osteotomy is made perpendicular to the tibial diaphysis at a distance equivalent to the fibular shortening from the lateral border of the chevron osteotomy. The medial and lateral cortices of the segment to be resected form the remaining 2 sides of this “pentagon” osteotomy. The distal segment, which includes the plafond, is separated from the fibula through the distal tibiofibular joint and allowed to shorten. Finally, a longitudinal osteotomy is made connecting the apex of the chevron osteotomy with the apex of the V-shaped plafond.

The osteotomy should not cross the articular surface. The chevron is wedged open hinging on the articular surface of the joint. At the osteotomy level the medial and lateral arms of the chevron osteotomy become collinear and are opposed to the transverse bony surface of the proximal tibial osteotomy. The only part of the osteotomy that remains “open” without bony contact is the open wedge longitudinal osteotomy. If the distal tibial physis is open then bone cement (preferably cranioplast to avoid thermal necrosis) is inserted into this open wedge to prevent bony bridge formation across the open distal tibial physis.

Clinical Results

There is a paucity of published information about intra-articular osteotomies, especially for congenital and developmental problems. I have yet to publish my clinical results for any of the aforementioned osteotomies. Therefore, to add credibility to the techniques being described I will report here a brief summary of my clinical results.

Proximal hemiplateau osteotomies for tibial plateau fracture malunions. In a series I reported at the Limb Lengthening and Reconstruction Society in Albuquerque, New Mexico, in July 2008 there were 9 intra-articular osteotomies performed to treat tibial plateau fracture malunions. Followup was between 28 and 108 months. The original fractures were classified according to Schatzker as Type 1, 1 case; type 2, 1 case; type 4, 2 cases; type 5, 2 cases; and type 6, 3 cases. All patients had alignment and knee stability restored to normal. No patients had pain in follow-up. Knee range of motion at follow-up was an average of 105° and not significantly different from preoperative range of motion.

Proximal medial hemiplateau osteotomies for medial tibial plateau arthritis for degenerative cases were performed combined with extra-articular high tibial valgus osteotomy in 10 cases. Follow-up was from 2 to 9 years. All were painful with frontal plane knee instability preoperatively. None had pain or instability at follow-up.

Proximal medial hemiplateau elevation for Blount’s disease was performed with and without subtuberosity extra-articular realignment osteotomy in 20 cases with 2-20 years’ follow-up. All remained with good stability and range of motion of the knee without degeneration of the knee. Most were painless in follow-up, whereas some had mild knee pain related to their overweight habitus.

Lateral hemiplateau elevation for chondroectodermal dysplasia was performed by use of the aforementioned technique

in 8 knees of 4 patients. All achieved normal knee alignment, stability, and range of motion. One knee developed a transient peroneal nerve palsy that fully recovered. Follow-up ranged between 1 and 15 years in this group. The distal femur was also varusized in 2 of these knees.

In a series of distal femoral intercondylar osteotomies performed for the treatment of sequelae of neonatal sepsis, I reported at the Limb Lengthening and Reconstruction Society in New York City, NY in July 2010, there were 7 patients who were followed between 2 and 9 years. The mean preoperative range of motion was 9° and mean postoperative range of motion was 68°. Knee stability was greatly improved in all cases. No patients reported pain at follow-up, which ranged from 2 to 10 years.

Femoral head intracapsular reduction osteotomy was performed by me in 20 patients over the past 5 years. Patient age ranged from 11 to 23 years. The etiology of deformation of the femoral head was Legg–Calvé–Perthes syndrome in 15, adolescent posttraumatic avascular necrosis in 3, and dysplasia in 2. Avascular necrosis occurred in one case. Follow-up after osteotomy was more than 1 year in all cases. There were 14 good or excellent results and 6 fair or poor results. The preliminary results of this technique appear to be very promising, especially considering that the only alternative for most of these patients was a hip fusion or hip replacement during adolescence. Ganz also reported similar results in 14 patients.^{17,18}

Pentagon osteotomy for V-shaped deformity of the ankle was performed in 5 patients with 1-4 year follow-up. All improved ankle range of motion, alignment, and stability. Pain was eliminated in all 5. The physis continued to grow in the 1 patient, where cement was used across the physis at age 6. The diagnosis of the original pathology was Ollier’s disease in one, a type of tibial hemimelia in one, neuropathic in one, unknown dysplasia in one, and congenital pseudarthrosis in one.

In conclusion, intra-articular osteotomy of the hip, knee, and ankle is technically feasible and can yield successful results for appropriate indications. It is a technically very demanding procedure and should only be undertaken by surgeons already proficient in extra-articular osteotomy surgery.

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