TABLE E-1 Data on the Patients

Case #	Age (Yrs)	Sex	Side	Distal Femoral Deformity (Etiology)	Other Related Conditions	# Months F/U	Preop Knee Pain	Knee Pain at Most Recent F/U	Change in Ambulatory Ability from Preop. to Most Recent F/U	# Weeks to Healing
1*	54	F	R	Valgus (Idiopathic)	Tibial plateau fracture; Tibial valgus	45	9	0	Markedly improved	18
2*	16	M	R	Valgus (Fracture malunion)	Tibial valgus	37	8	0	Markedly improved	6
3	32	F	L	Valgus (Idiopathic)		24	9	2	Markedly improved	16
4	16	M	L	Valgus (Partial physeal arrest)		32	4	0	Moderately improved	14
5	19	M	L	Valgus (Osteochondromatosis)		41	0	0	Slightly improved	8
6	13	F	L	Valgus (Idiopathic)		42	6	0	Unchanged	6
7	24	F	R	Varus (Congenital hypoplastic femur)	Ankylosed arthritic hip; Multiapical oblique plane femoral deformity	39	0	0	Unchanged	39
8	15	F	L	Varus (Idiopathic)		17^	0	0	Unchanged	10
9*	15	M	L	Varus (Blount disease)	Tibial varus; Obesity	6^	4	0	Markedly improved	14
10	72	F	R	Varus (Poliomyelitis)	Quadriceps strength = 0/5; Foreshortening of the lower extremity (55 mm)	37	0	0	Unchanged	9
11	38	M	L	Varus (Fracture malunion)		47	10	1	Markedly improved	9
12*	15	M	L	Varus (Blount disease)	Tibial varus;	36	5	0	Markedly improved	9
13*	18	M	L	Varus (Blount disease)	Tibial varus; Obesity	18^	7	0	Moderately improved	7
14*	17	M	R	Varus (Blount disease)	Tibial varus; Obesity	37	8	0	Moderately improved	10

F/U = follow-up
L = left
R = right
ROM = range of motion
mm = millimeters
* = indicates a simultaneous Ilizarov procedure to correct an ipsilateral tibial deformity
^ = lost to follow-up

TABLE E-2 Radiographic Data on the Patients

Case #	Deformity Description	Preop			Follow-Up		
		mLDFA (degrees)	MPTA (degrees)	MAD (mm)	mLDFA (degrees)	MPTA (degrees)	MAD (mm)
1*	Femoral valgus; Tibial valgus	80	93	90 lateral	90	88	14 medial
2*	Femoral valgus; Tibial valgus	83	94	66 lateral	90	88	0
3	Femoral valgus	83	90	58 lateral	88	90	3 medial
4	Femoral valgus	76	87	46 lateral	88	85	0
5	Femoral valgus	77	88	40 lateral	89	85	6 medial
6	Femoral valgus	81	90	31 lateral	89	90	6 medial
7	Femoral varus (multiapical oblique plane deformity)	95	90	12 medial	89	90	0
8	Femoral varus	95	88	26 medial	93	86	23 medial
9*	Femoral varus; Tibial varus	92	80	46 medial	88	88	10 lateral
10	Femoral varus	100	88	48 medial	91	85	0
11	Femoral varus	100	87	64 medial	88	86	10 medial
12*	Femoral varus; Tibial varus	100	64	103 medial	86	96	48 lateral
13*	Femoral varus; Tibial varus	102	70	120 medial	87	92	26 lateral
14*	Femoral varus; Tibial varus	103	73	120 medial	89	84	25 medial

mLDFA = mechanical lateral distal femoral angel (normal range = 85° to 90°)
MPTA = medial proximal tibial angle (normal range = 85° to 90°)
MAD = Mechanical axis deviation
* = indicates a simultaneous Ilizarov procedure to correct an ipsilateral tibial deformity

Surgical Technique in Detail

A monolateral Hex-Fix external fixator (Smith and Nephew, Memphis, Tennessee) was used in twelve cases. Two parallel 6-mm half-pins were inserted from lateral to medial in the anterior cortex of the distal part of the femur. Placement in the anterior cortex avoided the medullary canal, facilitating insertion of the intramedullary nail. Two more 6-mm half-pins were inserted proximal to the anticipated location of the proximal intramedullary nail tip. The Hex-Fix frame was loosely assembled with the bar anterior to the plane of the half-pins. Inserting the bar posterior to the half-pins would have obstructed later insertion of the intramedullary nail's locking screws from the more desirable lateral aspect.

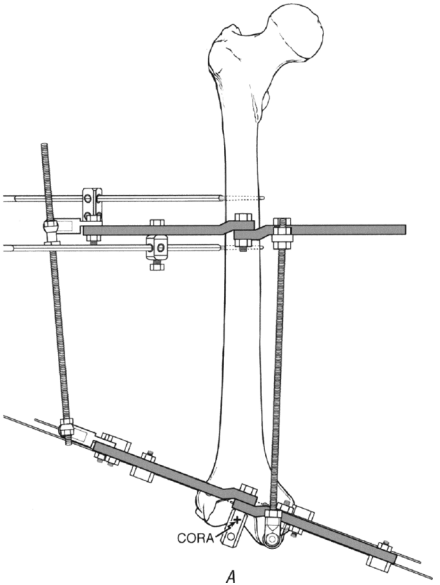
An Ilizarov external fixator (Smith and Nephew) was used in two cases (Fig. E-1). When the Ilizarov fixator was used, the distal 1.8-mm wires were placed in the anterolateral and anteromedial cortices in a crossing configuration to avoid the medullary canal. The proximal implants were 6-mm half-pins affixed to a proximal ring with use of the standard technique.

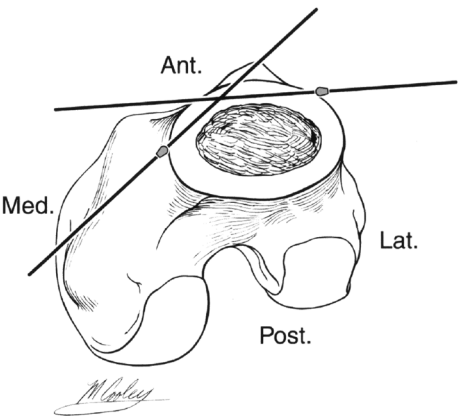
The level of the osteotomy was determined by preoperative planning, with creation of a distal fragment of sufficient size to allow insertion of at least two interlocking screws into the intramedullary nail. The osteotomy was a circular arc shape (concave distally), with the center of the dome at the level of the center of rotation of angulation. The location of the dome osteotomy was determined by building a temporary construct on the distal Hex-Fix pin clamp or Ilizarov ring and by loosely affixing an acrylic block with a series of holes (Smith and Nephew) to a temporary construct on the fixator. The most distal hole of the block was placed directly over the previously determined center of rotation of angulation with use of fluoroscopic guidance. Different radii of curvature for the osteotomy were tried by swiveling the semi-radiolucent block under fluoroscopy. The arc of the dome at the level of the osteotomy had to completely traverse the flared distal part of the femur and yet be as small as possible to avoid translating the fragments so far that the nail could not pass from one fragment to the other. The amount of translation that would occur at various radii of osteotomy cuts was estimated by placing a clear plastic goniometer on the preoperative anteroposterior radiograph with its hinge at the center of rotation of angulation, spreading the two arms of the goniometer to the angle being corrected, and measuring the distance between the centers of the two arms of the goniometer at various distances from the center of rotation of angulation.

After the level of the osteotomy was determined, a 3-cm transverse incision was made over the anterior midline of the distal part of the thigh. With use of Metzenbaum scissors, the quadriceps fascia and muscle fibers were spread longitudinally to the anterior femoral cortex. With use of the drill guide and the acrylic block, perforations were made in a curved pattern with a 3.8-mm drill bit, penetrating both the anterior and posterior cortices, with care taken to avoid suddenly plunging through the posterior cortex. To facilitate perforation of the lateral and medial cortices, a 1.8-mm Ilizarov wire was inserted through the guide, cortical placement was confirmed with fluoroscopy, and then the cortex was perforated with a 4.8-mm cannulated drill bit over the wire. The wire and cannulated-drill technique was necessary because a regular drill bit will slip off the inclined medial and lateral cortices of the distal part of the femur. The osteotomy was performed by connecting the holes with a 6.3-mm straight Hibbs osteotome. The handle of the osteotome was rotated with a 16-mm box wrench to complete the osteotomy. The box wrench was then used to rotate a 12.7-mm straight Hibbs osteotome to translate the fragments. Angulation was corrected by moving the leg laterally for correction of varus or medially for correction of valgus. The fixator was locked in place. A portable radiography machine was used to measure the lateral distal femoral angle before insertion of an intramedullary nail. The external fixator was adjusted until the lateral distal femoral angle had been corrected to normal and cross-table fluoroscopy confirmed no displacement in the sagittal plane. The incision was then closed in layers.

A statically locked retrograde intramedullary nail (Smith and Nephew) was then inserted after reaming. To achieve stability, we determined the appropriate nail length by measuring the preoperative radiographs and placed the nail tip in the distal part of the isthmus. Because a longer nail tends to displace the distal fragment to its original position, we used a nail that was long enough to barely reach the isthmus. Multilevel osteotomy required the use of a custom-made nail from the intercondylar notch to the proximal part of the diaphysis.

The fixator was removed, and the stability of the osteotomy was checked under fluoroscopy. If any movement was seen, bicortical Poller screws (Fig. E-2) were inserted percutaneously from anterior to posterior proximal and distal to the osteotomy site, under fluoroscopic guidance[28]. No motion of the nail or the osteotomy fragments was seen under fluoroscopy after Poller screw insertion.





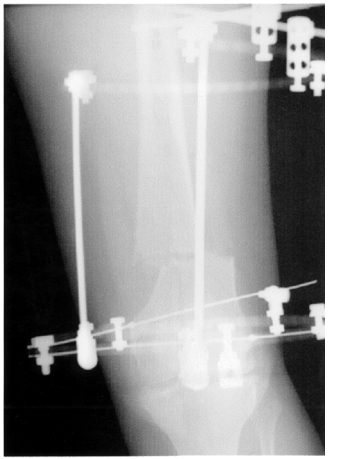


Fig. E-1

An Illizarov multiplanar fixator was used in two cases. *A:* The fixator is applied with the juxta-articular hinge at the level of the center of rotation of angulation (CORA). *B:* The Illizarov wires are inserted in the distal metaphysis, in the anteromedial and anterolateral cortices. *C:* Since the CORA is at the intercondylar notch and the osteotomy is performed at a site other than the CORA, a combination of angulation and translation is necessary for accurate correction.

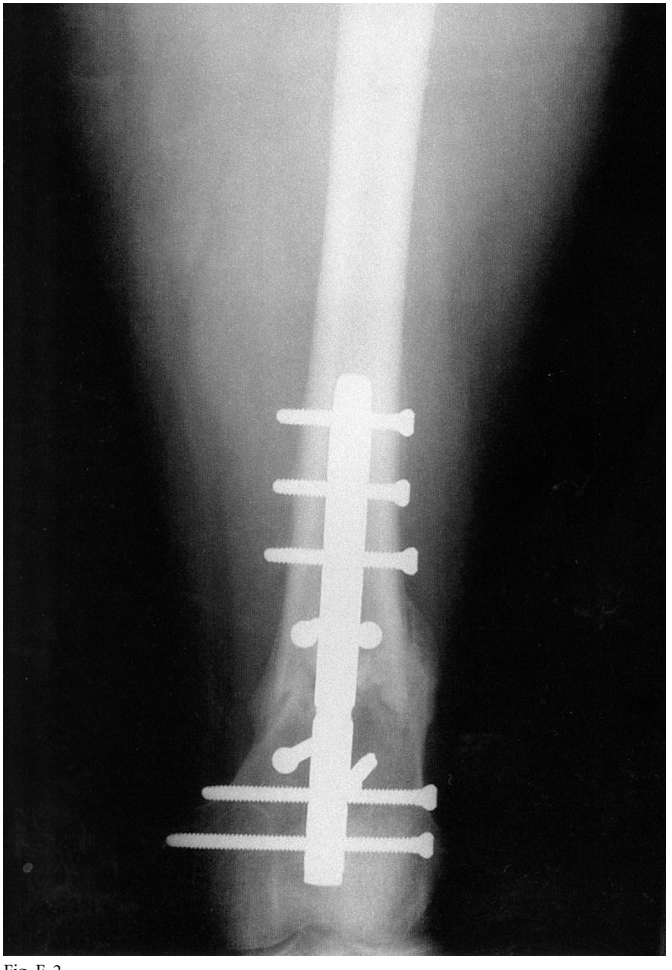


Fig. E-2

Poller (so-called Bumper) screws are added if motion is detected on fluoroscopy after insertion of the nail and locking screws.