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Displaced Hip Fractures in Children and Adolescents

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The results of ten acute, displaced proximal femoral fractures in patients 14 years and under are reported. These high-risk fractures were managed with urgent open reduction and pin or screw fixation with supplemental spica casting. The exception to this protocol was in two Delbet's type IV (intertrochanteric) fractures which were managed by closed reduction and spica casting. There was a case of partial avascular necrosis of the femoral head in a type I transepiphyseal fracture. At a minimum followup of 2 years the patients were asymptomatic with no significant limitation of hip motion.

Hip fractures in children are relatively uncommon and either result from high-velocity trauma or from minor trauma in pathologic bone. Because of the proximal femoral physis and the vulnerability of the terminal branch of the medial femoral circumflex which supplies the proximal femoral epiphysis these fractures are prone to complications. These can include aseptic necrosis of the femoral head or intertrochanteric region, growth arrest, and coxa vara. Complications of this nature can have a profound effect on the developing hip and lead to a lifetime of disability.

Delbet (3) classified these fractures according to level (Fig. 1). Because of significantly different risks of complications with each fracture type, results should be reported according to this classification.

Boitzy (1) has reported excellent results with these fractures with an aggressive management protocol of open reduction, capsulotomy, and internal fixation with compression. We instituted this protocol in our hospital system in 1975 and are reporting the results in our first ten patients.

MATERIALS AND METHODS

We retrospectively reviewed all cases of proximal femoral fractures in patients under the age 15 years managed at Children's Orthopedic Hospital in Seattle, or at Harborview Medical Center, Seattle's regional trauma center, from 1969 through 1981. We identified 17 fractures during this time period. Seven fractures occurred with minor trauma in pathologic bone and are not included in this review (Table I). Charts and X-rays were reviewed and followup exams and interviews were conducted at a minimum of 2 years post fracture. The authors managed or assisted in the management of five of the ten patients with proximal femoral fractures from significant trauma.

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RESULTS

Using Delbet's classification, there were three type IV fractures, four type III, two type II, and one type I fracture (Fig. 1). These fractures occurred with high-velocity trauma (Table II) and all were significantly displaced. All of the patients injured as passengers in motor vehicle accidents were unrestrained. Three of the four car versus pedestrian accidents involved children on bicycles.

Four of the ten patients had multiple fractures in other extremities. Two patients sustained head injuries (one open skull fracture and one closed head injury) and one of these developed findings consistent with a large renal contusion as well.

Nine of 10 patients were taken to the operating room within 12 hours of the injury and the other patient reached the operating room 22 hours postinjury because

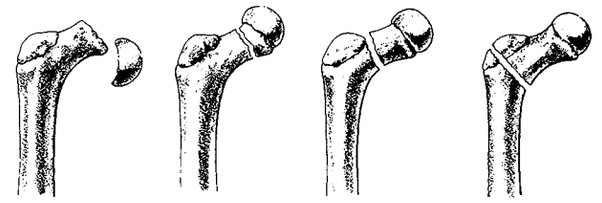

FIG. 1. Classification of pediatric hip fractures.

TABLE I
Etiology of pathologic proximal femoral fractures

Osteopenia
Unicameral bone cyst
Lymphangiomatosis
Following plate removal after derotational osteotomy
Following attempted arthrodesis
Osteomyelitis
Fibrous dysplasia

TABLE II
Fracture management

	Patient	Age (yrs)	Sex	Fx type	Mechanism	Treatment	Duration of Casting	Complications	Followup
1.	J.J.	14	M	I	MVA	Closed reduction failed—open reduction pin fixation	6 weeks	Type 2 AVN	2 yrs: full ROM, minimal collapse radiographically
2.	J.W.	5½	M	II	Fall 10′	Closed reduction* screw fixation	8 weeks	—	3 yrs: full ROM
3.	T.R.	8	M	II	MVA	Closed reduction failed-open reduction screw fixation	16 weeks	—	3½ yrs: 15° IR
4.	R.H.	13	M	III	Car vs. ped.	Closed reduction* screw fixation	8 weeks†	—	4 yrs: full ROM
5.	C.P.	10½	M	III	Car vs. ped.	Closed reduction* screw fixation	8 weeks	—	5 yrs: full ROM
6.	C.F.	11½	M	III	Car vs. ped.	Closed reduction* pin fixation	10 weeks	—	2 yrs: full ROM
7.	E.B.	13	M	III	Fall 15′	Closed reduction* pin fixation	8 weeks	—	4 yrs: full ROM
8.	D.K.	3½	F	IV	Car vs. ped.	Closed reduction* pin fixation	6 weeks	10° varus deformity after pin removal at 4 weeks	2 yrs: full ROM
9.	P.C.	2	M	IV	MVA	Closed reduction	6 weeks	—	—
10.	K.H.	1	M	IV	Fall 3′	Closed reduction	4 weeks	—	2 yrs: full ROM

* Anterior capsulotomy.
† Had 3 weeks of skeletal traction for a contralateral femoral shaft fracture before casting.

of initial evaluation at another facility and prolonged transit. Details regarding the management of the fractures are listed in Table II.

Five patients had an anterior capsulotomy performed via the Watson-Jones interval for evacuation of intracapsular hematoma after the open reduction was completed. Threaded Steinmann or Hagie pins were used for fixation in four cases and AO malleolar or 6.5-mm cancellous screws were used in four cases. The decision regarding which implant to use was according to surgeon preference but all implants were left short of the epiphyseal plate with the exception of the type I fracture (Case 1). Blood loss did not exceed 150 cc for any case and there were no transfusions required. All patients were placed immediately into double hip plaster spica casts with the exception of Case 4 who was treated with skeletal traction for 3 weeks until casting for a contralateral femoral shaft fracture.

The implants were removed at an average of 4.5 months (range, 4 weeks–9 months) postoperatively in seven of the eight cases during a brief inpatient stay. None of these procedures was complicated by significant (>100 cc) blood loss, operative time greater than 1 hour, or with significant morbidity.

At a mean followup of 3½ years (range, 2–5 years) all patients were free of symptoms referable to the fractured hip. One patient, Case 9, had left the area but reportedly has a full range of motion and is asymptomatic at 2 years' followup. Of the remaining patients the maximum leg shortening was 1 cm.

COMPLICATIONS

Complications included one case of Ratliff grade 2 (partial head) avascular necrosis of the femoral head in the only type I fracture in the series. This case also may have gone on to early epiphyseal closure but because of the advanced age (14 years) this was not a clinically significant phenomenon. At a limited followup of 2 years the avascular necrosis had not yet resulted in significant collapse and the patient was symptom free. There were no wound infections in the series and no significant cast complications. One patient with a type IV fracture, Case 8, developed a mild varus deformity of the proximal femur when her pins were removed at 4 weeks. There were no nonunions or other cases of premature epiphyseal closure of coxa vara.

DISCUSSION

Although uncommon, fractures of the proximal femur in children have a high incidence of complications because of the unique osseous and vascular anatomy of the femoral head and neck region in the growing child. The lateral epiphyseal artery to the proximal femoral epiphysis is vulnerable because of its end-artery status. Nonpathologic fractures in the mid (type II) and low (type III) fractures are the result of high-velocity trauma and

the artery can either be torn or kinked over fracture fragments. Furthermore, intracapsular tamponade can occlude intact vessels within the capsule by a pressure gradient phenomenon. This has been documented in a laboratory animal model (8). The upper femoral epiphysis provides 13% of the overall femoral length such that injury to the physis by a fracture (type I) or by operative fixation can cause either a leg length discrepancy or varus deformity. This is especially critical in the younger child. These intrinsic problems make the treatment of these fractures a challenge to orthopedists.

Classification of these fractures by Delbet as reported by Colonna (3) has provided a real stepping stone in the management of these fractures. This has afforded a means whereby individuals can compare the results of treatment by evaluating complication rates which vary at each fracture level. Furthermore, the recognition of degrees of severity of avascular necrosis of the proximal fragment by Ratliff (6) has provided a reliable means of grading the severity of these complications.

In the literature the percentage of good results has been found to be inversely proportional to the degree of displacement of the fracture (1, 4–6). All fractures in this series were significantly displaced and were therefore at high risk of the complications of avascular necrosis, premature closure of the physis, and coxa vara.

As has been the experience in other series, our case of transepiphyseal (type I) fracture was associated with avascular necrosis. The femoral epiphysis was completely dislocated from the acetabulum and no doubt the blood supply to the upper femoral epiphysis was completely disrupted at the time of injury. Our case was managed with open reduction and threaded Steinmann pin fixation across the physis and spica casting for 6 weeks. The pins were removed at 4 months and type 2 avascular necrosis resulted as well as premature closure of the proximal femoral epiphysis. This was not significant because of the advanced age (14 years) of the patient. At a limited followup of 2 years some collapse was evident but the patient did not have functionally limiting symptoms. He was thereafter lost to followup. For type I fractures we feel that a gentle attempt at closed reduction under fluoroscopic control is indicated if the physis is not completely displaced. If this fails or if the displacement is complete then an urgent open reduction of the posterior dislocation using a posterior approach and pin or screw fixation across the physis is indicated. The prognosis is poor for these fractures but with this management the degree of eventual deformity of the upper femur may be limited. This is greatly dependent, however, on the age of the patient at the time of the fracture.

In type II and III fractures Ratliff (6) reported an incidence of 42% avascular necrosis and a 9% incidence of premature closure of the physis. In this large series of 70 fractures, 45 were displaced. In a similar series of 75 fractures (in which 40 were displaced) Lam (5) reported an incidence of 17% avascular necrosis, 32% incidence of coxa vara, and a 20% incidence of premature epiphyseal closure. This series was primarily the result of managing these fractures with closed reduction and casting. More recently Canale and Bourland (2) reported a 43% incidence of avascular necrosis, 21% incidence of coxa vara, and 61% incidence of premature epiphyseal closure. This was a series of 61 fractures (79% were displaced) managed with closed reduction and Knowles pin fixation. The authors attributed the higher incidence of premature closure of the epiphysis to crossing the growth plate with the implants. The lower incidence of coxa vara was felt to be due to the secure internal fixation. The significant incidence of avascular necrosis was thought to be secondary to the high degree of initial fracture displacement and injury to the vascular supply to the femoral head. The results of this complication tended to be poor in older children.

In our smaller series of six displaced type II and III fractures we had excellent functional and radiographic results with emergency open reduction, internal fixation with threaded pins or screws, and anterior capsulotomy (five cases) for evacuation of intracapsular hematoma. These results are similar to those achieved by Boitzy in a larger series of 15 patients.

In a small series of patients with a protocol that includes several steps it is difficult to identify the key factors. We believe that reduction as soon as clearance for other injuries can be obtained is the critical part of the treatment. In most instances the vessels to the proximal epiphysis are probably kinked rather than torn and therefore reduction becomes the key. Earlier we utilized fixation with AO malleolar or 6.5-mm cancellous screws (depending on the size of the patient) for rigid fixation. More recently we have been using 4.5-mm AO cortical screws short of the epiphysis overdrilled in the proximal fragment for the lag effect and have been pleased with compression of the fracture site. Compression may need aid in faster recanalization of the venous channels of the cancellous bone. We believe that anterior capsulotomy should always be done for evacuation of potential intracapsular hematoma which could occlude the vessels from an internal pressure gradient. These preliminary results of no nonunions, coxa vara, premature closure of the physis, or avascular necrosis in six patients tend to support the continued use of this protocol but a larger series and longer followup are necessary. Our experience with a similar protocol has produced excellent results in 25 patients treated during the same time period (7).

We agree with Canale and Bourland (2) that type IV fractures should be initially treated with closed reduction and casting and that when this fails internal fixation should be performed to secure the reduction. The implants should be left in until there is complete assurance of fracture healing. Because of the more distal location (extracapsular) of this fracture the prognosis is much more favorable if coxa vara can be avoided.

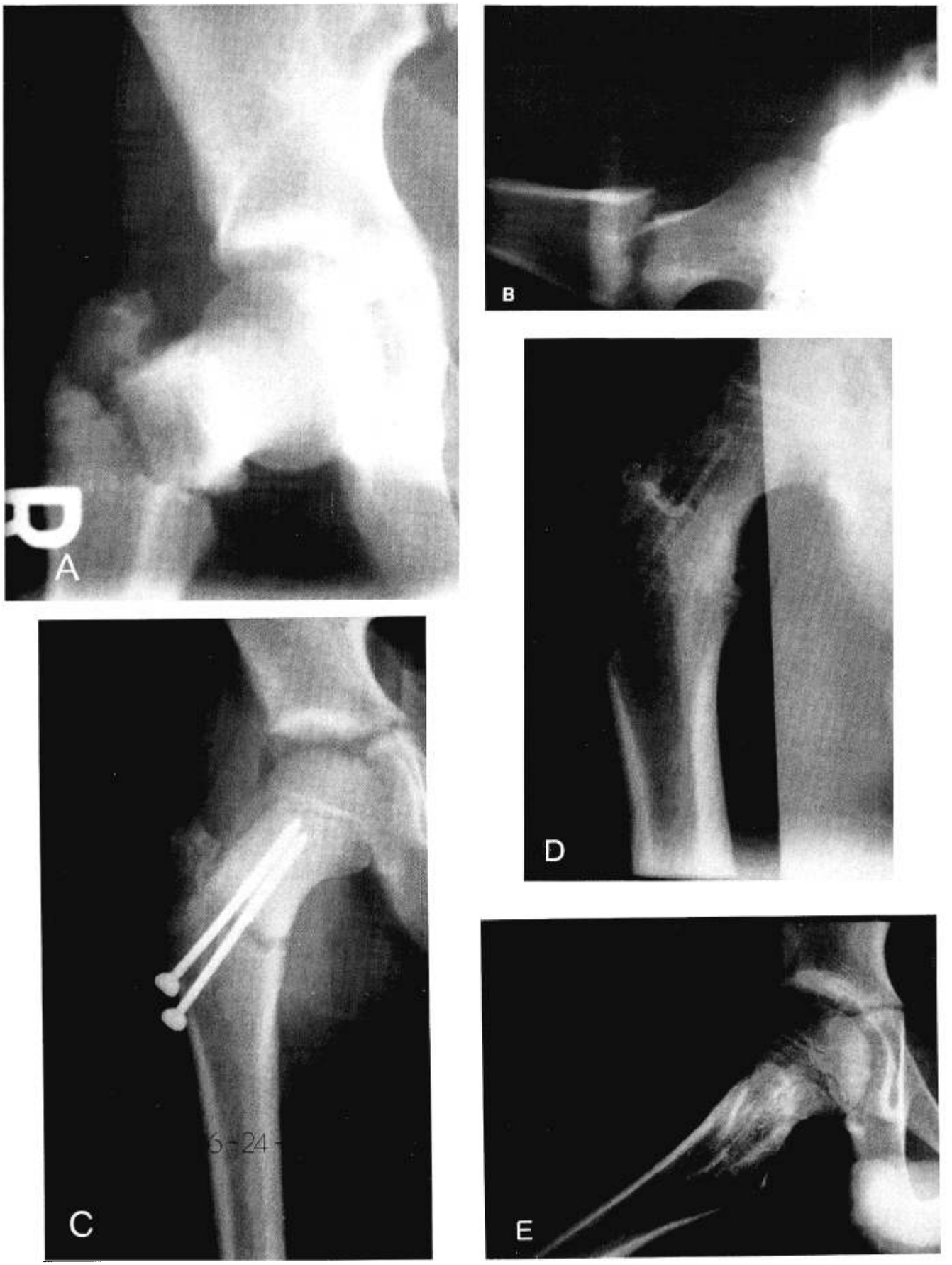

FIG. 2. Case 5: Displaced type III fracture in a 10½-year-old male (**A**, **B**). Fracture salvaged with emergency open reduction, capsulotomy and fixation with 2 AO malleolar screws (**C**). Followup X-rays at 18 months (**D**, **E**) show complete union of the fracture and no sign of avascular changes in the femoral head. Scanograms obtained 18 months postinjury (**D**) showed no evidence of proximal femoral epiphysis growth arrest.

REFERENCES

1. Boitzy, A.: Fractures of the proximal femur. *In* Weber, B. G., Brunner, C., Freular, F. (eds): *Treatment of Fractures in Children and Adolescents.* Berlin, Springer-Verlag, 1980, pp. 254–267.
2. Canale, S. T., Bourland, W. L.: Fracture of the neck and intertrochanteric region of the femur in children. *J. Bone Jt. Surg.*, **59-A:** 431–443, 1977.
3. Colonna, P. C.: Fractures of the neck of the femur in children. *Am. J. Surg.*, **6:** 793–797, 1929.
4. Ingram, A. J., Bachynski, B.: Fractures of the hip in children: Treatment and results. *J. Bone Jt. Surg.*, **35-A:** 867–886, 1953.
5. Lam, S. F.: Fractures of the neck of the femur in children. *J. Bone Jt. Surg.*, **53-A:** 1165–1179, 1971.
6. Ratliff, A. H. C.: Fractures of the neck of the femur in children. *J. Bone Jt. Surg.*, **44-B:** 528–542, 1962.
7. Swiontkowski, M. F., Winquist, R. A., Hansen, S. T.: Fractures of the femoral neck in patients between the ages of twelve and forty-nine years. *J. Bone Jt. Surg.*, **66-A:** 837–846, 1984.
8. Woodhouse, C. F.: Dynamic influences of vascular occlusion affecting the development of avascular necrosis of the femoral head. *Clin. Orthop.*, **32:** 119–129, 1964.