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CHAPTER 24

Unique Concerns and Contact Injuries

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INTRODUCTION

Little League baseball serves as an excellent avenue for acquisition of athletic skills and socialization for the preadolescent and adolescent youngster. The team sport emphasis provides the young athlete with the basis for comradery, work, sharing, and contributing. Individually, the Little League athlete learns the skills involved in throwing, fielding, batting, game preparation, and the importance of dedication, hard work, and training in sport. During the maturation process, a change in play is evident when the young athlete throws harder, runs faster, and hits further. During this growth phase, the athlete is at increased risk for injury (1). The emphasis should be on prevention. Communication from the medical team and coaches has improved. The *Play it Safe* publication is a good start (2).

PSYCHOLOGIC CONSIDERATIONS

The cry "Play it for Fun" should be the goal and motto of the Little League participant. Promoting cooperation among the athletes creates a more constructive base than do feelings of winning at all cost (3). Emphasis should be directed toward acquisition of skills, having fun, meeting new friends, and socialization with peers, parents, and coaches. Oftentimes, the pressures that the young athletes put on themselves have a negative effect. Pressures to pitch the best game, hit the longest ball, catch the fly ball may intensify and be detrimental to the health and happiness of the young athlete. The young individual internalizes the pressures from teammates, parents, and coaches, and envisions a mistake on the field as a major disappointment completely out of proportion. These stresses can cause behavioral changes, easy fatigability, attention deficits, and even physical illness.

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Eric Erickson has described ages of 6 through 11 years as the latency period. It is followed by identity periods of ages 12 to 21 (4).

The basis of a healthy ego is the ability to master skills both in the classroom and on the athletic field. If the young baseball athlete perceives that he or she has failed to acquire certain skills or please his peers, parents, or coaches, that healthy ego will not develop. A sense of failure and inferiority results. As the athlete matures and seeks independence from family, the importance of achieving goals, being accepted by peers, and obtaining stability become even more important (4). Pease and Anderson reported that parents had the greatest influence on the young athlete early in his or her development. They also stated that a child's values in regard to winning were already set by age 10 to 12 (5).

The influence of the Little League coach is particularly important in the development of a psychologically sound individual. Sinclair and Veely identified new personality techniques used by a coach as the most important factors that influence the athlete's perception of himself in sport and society (6). Immediate positive feedback by coaches creates gains in self-confidence.

The fear of injury also must be considered, especially at this young age. There are two perspectives of psychology of athletic injury. First, a psychologic predisposition to injury may exist. On the other hand, if an athlete has a debilitating injury, psychophysiologic responses may occur that prevent full recovery and prevent participation in sports ever again (7).

The different stages of reaction to injury have been debated. Kübler-Ross (8) likened the injured athlete to the reaction occurring in a dying patient. Stages of denial, anger, bargaining, depression, and acceptance were described. Smith et al. (9) did not find denial but described the occurrence of global mood disturbances. Even at this early stage of development, the Little League athlete usually has seen injuries occur in his family, peers, parents, or coaches. It is important not to underestimate the impact that even a minor injury might have on the young athlete. Underlying fears concerning injuries should be dealt with professionally. If an injury does occur, open communication coordinated by the physicians with the athlete, parents, and coaches must address all concerns.

UNIQUENESS OF IMMATURE SKELETON

Appreciation of upper extremity injuries unique to the immature athlete is the goal of this section. Unlike the adult, in the skeletally immature athlete, the sport of baseball can create injury to the epiphysis, apophysis, articular cartilage, or, as in the adult, the musculotendinous unit. These injuries in youth are a consequence of physeal growth patterns, increased physiologic capsular and ligamentous laxity, and excessive biomechanical forces mediated through immature physeal plates and articular cartilages. In children, fracture patterns differ from adults, due to open epiphyseal plates, bone plasticity, joint hyperelasticity, and articular cartilage softness (10). The physis is susceptible to tensile compression through the zones of hypertrophy and calcification. In the adult, similar traumatic forces are more likely to cause a pure ligamentous injury. The immature articular cartilage is more soft than mature joint surfaces, thus increasing the risk of compression-type injuries. In the skeletally immature, because of relative hyperelasticity and less muscular development that is inherent in this age group, excessive joint translation is common. During each throwing motion, the forces generated depend on the individual's unique joint anatomy, strength, maturity, and biomechanics.

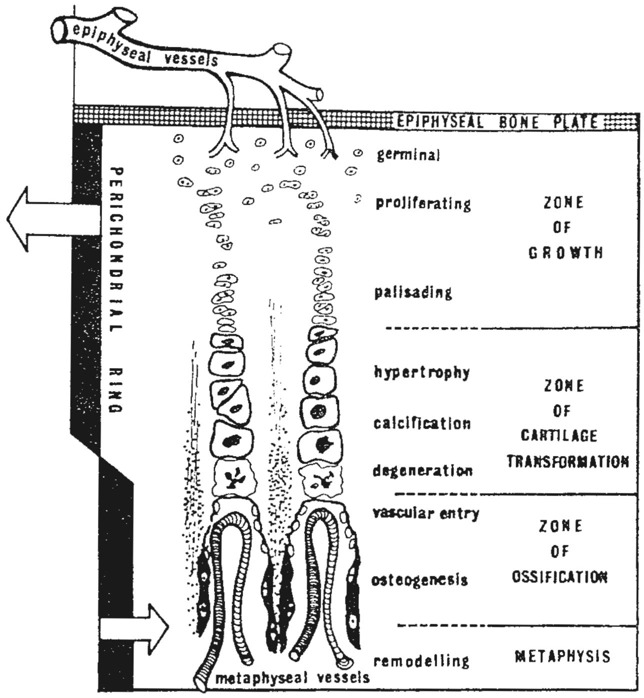


FIG. 1. The arterial blood supply to the immature physis is from the epiphyseal vessels entering into the germinal layer in the zone of growth and the metaphyseal vessels entering into the zone of ossification. The zones are: zone of growth, which includes germinal proliferating palisading cell columns; zone of cartilage transformation, including hypertrophy, calcification, degeneration columns; zone of ossification, which is vascular entry and osteogenesis and the metaphysis where remodeling occurs. Fracture patterns occur through the zone of hypertrophy and calcification cell columns. Reprinted with permission from Siffert R S, Gilbert M D. Anatomy and physiology of the growth plate. In: Rarg M, ed. *The growth plate and its disorders.* Baltimore: Williams & Wilkins, 1969.

EPIPHYSEAL PLATE ANATOMY AND FRACTURE PATTERNS

The epiphyseal plate receives blood supply through epiphyseal and metaphyseal vessels (11) (Fig. 1). The epiphyseal artery supplying the epiphyseal ossification center and subchondral plate is shown above. The metaphyseal loop of vessels and periosteum are seen below. Dale and Harris (11,12) describe two fundamental types of epiphyses. One is surrounded by cartilage, and another with soft tissue attachments. The epiphyses with soft tissue attachment, if separated with a soft tissue hinge, the epiphyseal circulation remains intact, and no significant growth rest occurs. Epiphyses that are totally surrounded with cartilage, such as the proximal femur and proximal radius, depend solely on communication from these vessels. Avascular necrosis of the physeal plate and epiphysis do occur in the epiphyses surrounded by cartilage.

Microscopic fracture lines occur between the calcified and uncalcified layers of the growth plate (11–13). The different zones of the epiphyseal plate are (a) the zone of growth (germinal, proliferating, and palisading), (b) the zone of cartilage transformation (hypertrophy, calcification, and degeneration), and (c) the zone of ossification (vascular entry and osteogenesis). Undulating fractures tend to occur through cell columns in the zone of cartilage transformation. The germinal cells remain with the epiphysis and the calcified layer remains with the metaphysis (11). The classification of growth plate injury by Salter-Harris has been well accepted (11,13) (Fig. 2). Depicted schematically, Salter I fracture transects the epiphyseal plate. Radiographs are negative unless stress views are obtained. Radiographs during healing may show callus and increased radiolucency across the physeal plate. Type II patterns extend from the physeal plate to the metaphysis, opposite the site of fracture initiation. This metaphyseal fragment (Thurston Holland sign), produced where the periosteum remains continuous, acts as an intact bridge and is an advantage in reduction. Type III injuries are more unusual and may require operative intervention. The fracture direction is from the physeal plate to the epiphysis and hence into the joint. Type IV fracture direction

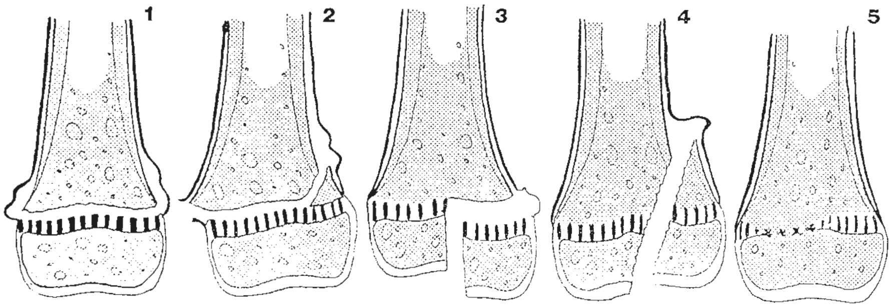


FIG. 2. Salter-Harris classification of fracture patterns of the epiphyseal plate is shown by diagram. A Salter I fracture extends directly across the epiphyseal plate. In a Salter II pattern, the periosteum is disrupted on the epiphyseal side through plate and into metaphysis where periosteum is still intact. This metaphyseal piece attached to the periosteum is named a Thurston Holland fragment. Type III involves the plate and epiphysis and is intra-articular. Type IV fracture pattern involves the epiphysis, plate, and metaphysis. Type V is a crush injury to the epiphyseal plate and is likely to result in growth alterations. Reprinted with permission from Salter RB, Harris WR. Injuries involving the epiphyseal growth. An experimental study. *J Bone Joint Surg* 1963;45A:587.

is vertical, splitting the epiphysis, the plate, the physeal, and metaphysis. The most common type III fracture is the distal humeral lateral condyle fracture. Recognition of this type fracture is quite important. Open reduction and internal fixation are often necessary. Type V injuries involve a crushing force applied to the epiphysis and then the physeal plate. Type V injuries, although unusual, commonly result in growth arrest if the physeal damage is complete. Radiographic follow-up is suggested until skeletal maturity. Counseling the patient and the family on potential angular deformity, growth arrest, and nonunion should be initiated at the time of the diagnosis of the injury.

EPIPHYSEAL FRACTURE INCIDENCES

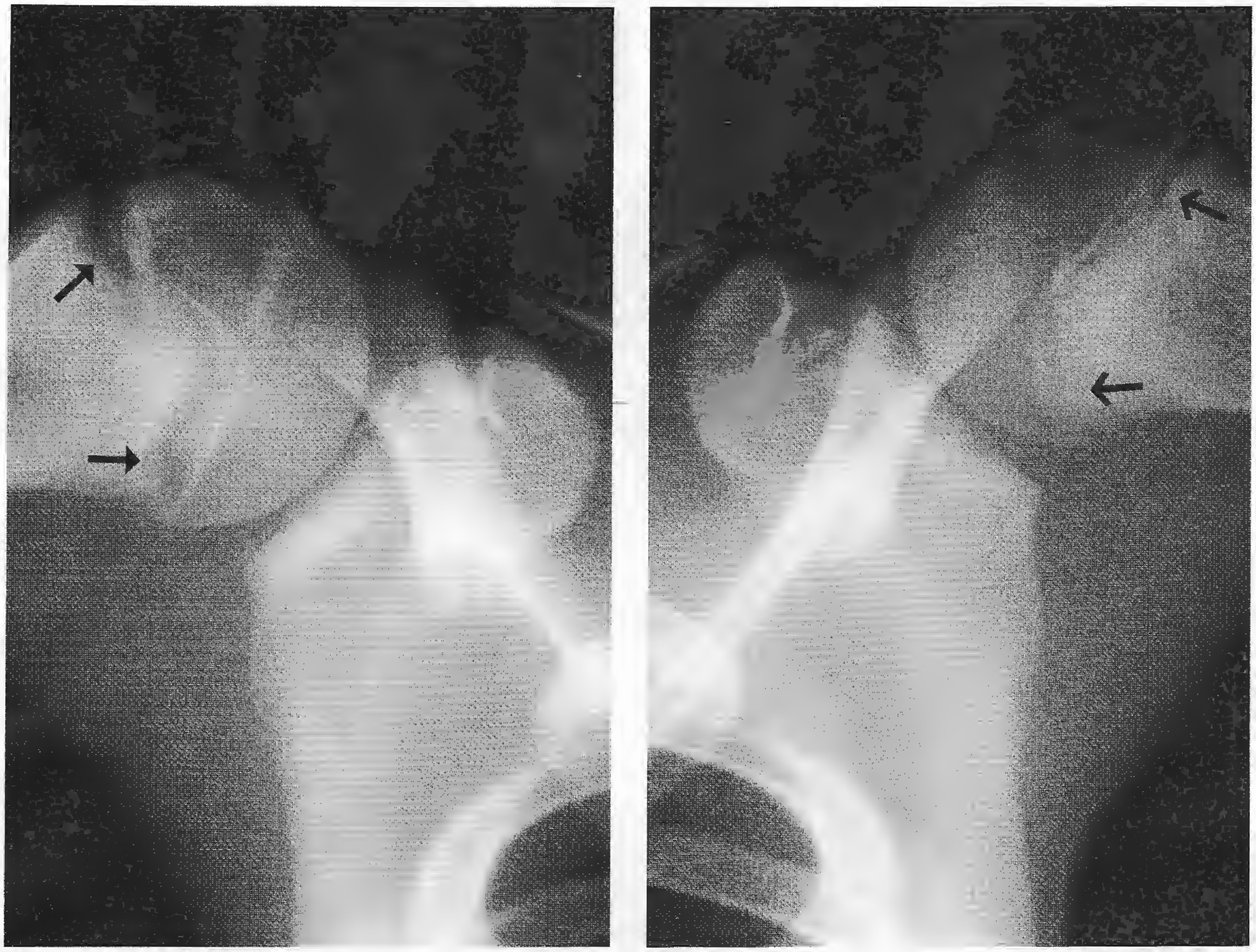
Several large series by Ogden, Peterson, and Neer (14–16) document the distribution of epiphyseal fractures (Table 1). The absolute number and percentages of injuries involving the upper extremity are tabulated. The distal radius epiphyseal fracture is the most common site, followed by the distal humerus. The order and range of upper extremity fractures as reported were the distal radius 43% to 62%, the distal humerus 10% to 24%, the phalanges 12% to 19%, and the proximal humerus 4% to 11%.

STRESS FRACTURES

Stress fractures are more common in adults and in the lower extremity. However, stress fractures do occur in the upper extremity in the skeletally immature. The Little League pitcher does not sit down if there is discomfort when throwing because the athlete is attempting to please coaches, parents, and peers. The pitcher continues to pitch. Reviews of stress reactions and fractures that occur in young athletes indicate the specific reasons for more fractures are increased intensity of training and a younger age for beginning competition (17–21). Increased athletic stresses on growing bones may result in soft tissue and bony injury if repetitively abusive (10,11,22–25). Stanitski et al. (26) reported 14 patients

TABLE 1. *Upper extremity epiphyseal fractures*

	Ogden		Peterson		Neer	
	Number	%	Number	%	Number	%
Distal Radius	197	43.1%	98	48.5%	1096	61.5%
Distal Humerus	108	23.6%	20	9.9%	332	18.6%
Distal Ulna	13	2.8%	12	5.9%	136	7.6%
Proximal Radius	12	2.6%	1	0.5%	124	7.0%
Proximal Humerus	41	9.0%	22	10.9%	72	4.0%
Phalanges (Fingers)	55	12.0%	39	19.3%		
Metacarpals	9	2.0%	10	5.0%		
Proximal Ulna	9	2.0%			21	1.2%
Proximal Clavicle	8	1.7%				
Distal Clavicle	5	1.1%				
Total	457	100.0%	232	100.0%	1781	100.0%



A B

FIG. 3. This right-hand dominant baseball athlete had been having pain in his right shoulder for 2 months. **(A)** Radiographs of Stryker and notch shoulder view reveal increased radiolucency and widening across the proximal humeral epiphyseal plate (*solid arrows*). **(B)** The normal side Stryker view demonstrates well the difference in appearance of the proximal humeral epiphyseal plate. Comparison views are helpful to determine any difference in appearance, radiolucency and separation of the undulating proximal humeral epiphyseal plate.

with 16 stress fractures, one of which was the humerus. Yngve (27) reported on 113 stress fractures in children <14 years old. Orava et al. (28) also reported stress fractures in children.

Normal development of soft tissue bone formation and growth is dependent on the judicious application of repetitive tensile, compressive, and rotatory forces (29). There are few reports that regard the effect of exercise on the skeletally immature (30–34). Wolff's Law states that bone will structurally remodel in order to resist the stresses placed upon it (35). Stanitski (26) was of the opinion that abnormal muscle forces acting across bones led to stress fractures. The demands of baseball and the highly concentrated eccentric and concentric muscle forces increase the direct load on the joints of the upper extremity, epiphyseal plates, and muscles. Linear fractures may result. The absorption of these forces (tension, compression, shear, and torsion) by fatigued muscle is quantitatively less; therefore, increased stress is produced across the bone that may result in failure (36). The majority of stress fractures involve the lower extremity, specifically the tibia. Upper extremity stress fractures indeed do occur. Ulnar diaphyseal stress fractures have been reported in tennis athletes (37,38). Stress fractures involving the epiphyseal plate also occur (13). In Little League athletes who perform other activities, such as strength training, the possibility of sustaining a distal radius epiphyseal stress fracture also should be considered. If distal radial growth arrest occurs, pain and limited wrist motion may result, as described in young gymnasts by Roy et al. (39).

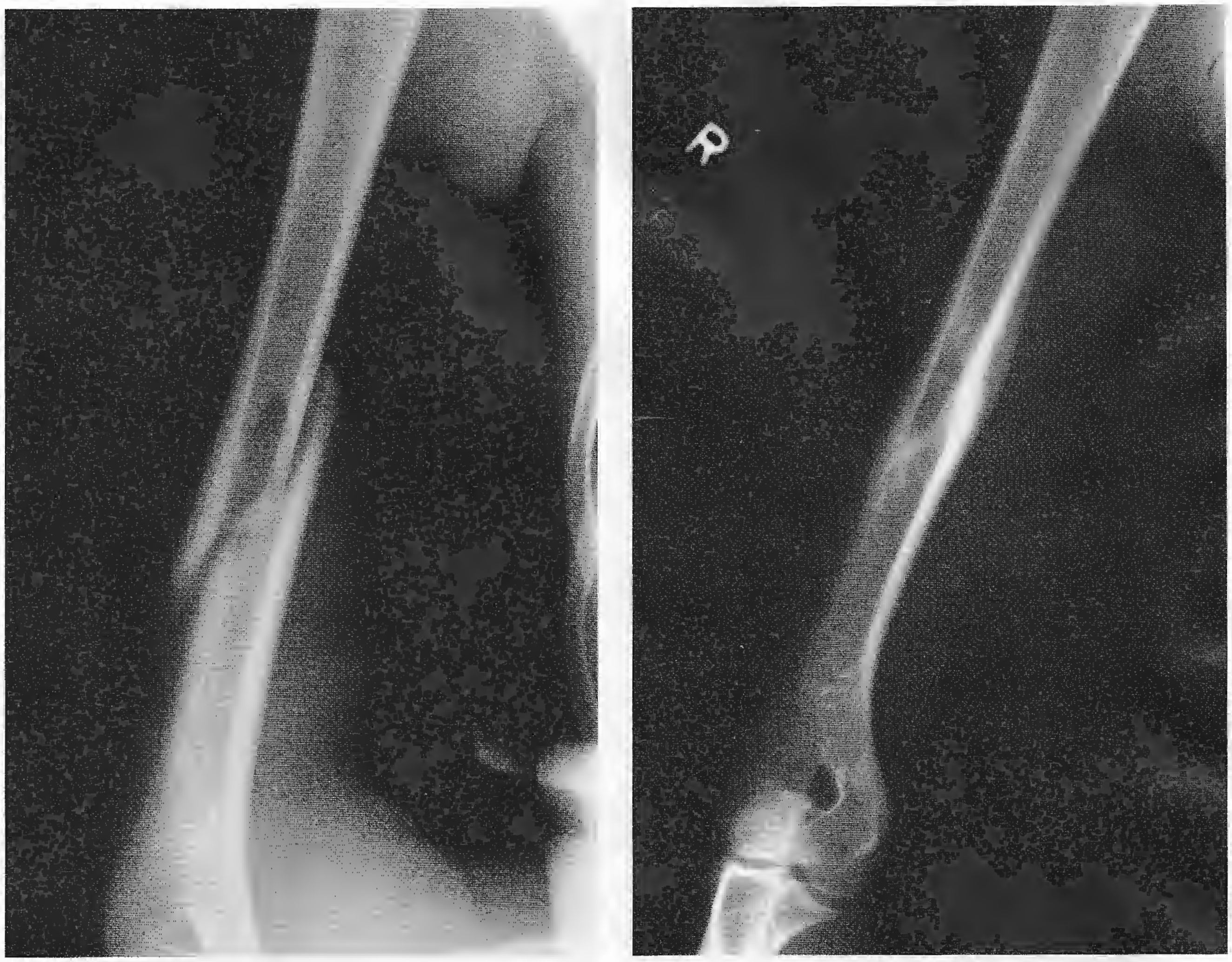


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FIG. 4. This outfielder felt a snap in his right arm as he threw the ball to home plate. He had no previous problems with his arm. The snap occurred at the end of the game. Radiographs revealed a spiral, diaphyseal humeral fracture. This was treated in a hanging arm cast. (**A**) Follow-up radiographs at 6 weeks revealed callus formation on the AP (**B**) and the lateral view (**C**). At 3 months, the fracture is completely healed (**D**). *Continued on next page.*

Treatment of stress fractures of the upper extremity is directed toward relative rest, changing factors of the sport that contribute to the injury, and strengthening of all of the surrounding muscles. Evaluation biomechanically of the throwing and pitching motions reduced load intensity, and improved biomechanics must occur in order to prevent recurrent fractures.

A proximal physeal humeral Salter I fracture or "Little Leaguer's shoulder" has been described by Cahill et al. (40). It was Dotter who originally described Little Leaguer's shoulder in 1953 (41).

For about 2 months, a right-hand dominant pitcher had pain in his shoulder after throwing. On physical examination, he had weakness of the rotator cuff, but the most significant finding was diffuse pain in the proximal humerus without increased laxity when compared to the opposite shoulder. Radiographs of AP (Fig. 3A) and axillary lateral views (Fig. 3B) reveal increased lucency across the undulating, proximal humeral epiphyseal plate consistent with a stress fracture of a Salter I injury. Stryker and axillary radiographs of the opposite side reveal a normal growth plate without increased lucency or widening of the physis.

Gore et al. (42) presented a case of a spiral fracture of the humerus in one amateur athlete that undoubtedly was caused by a particularly violent throw. The shoulder muscle-force, absorbing ability failed, and a diaphyseal humeral fracture resulted (36). Similarly, an outfielder felt a snap in his throwing arm as he threw the ball to

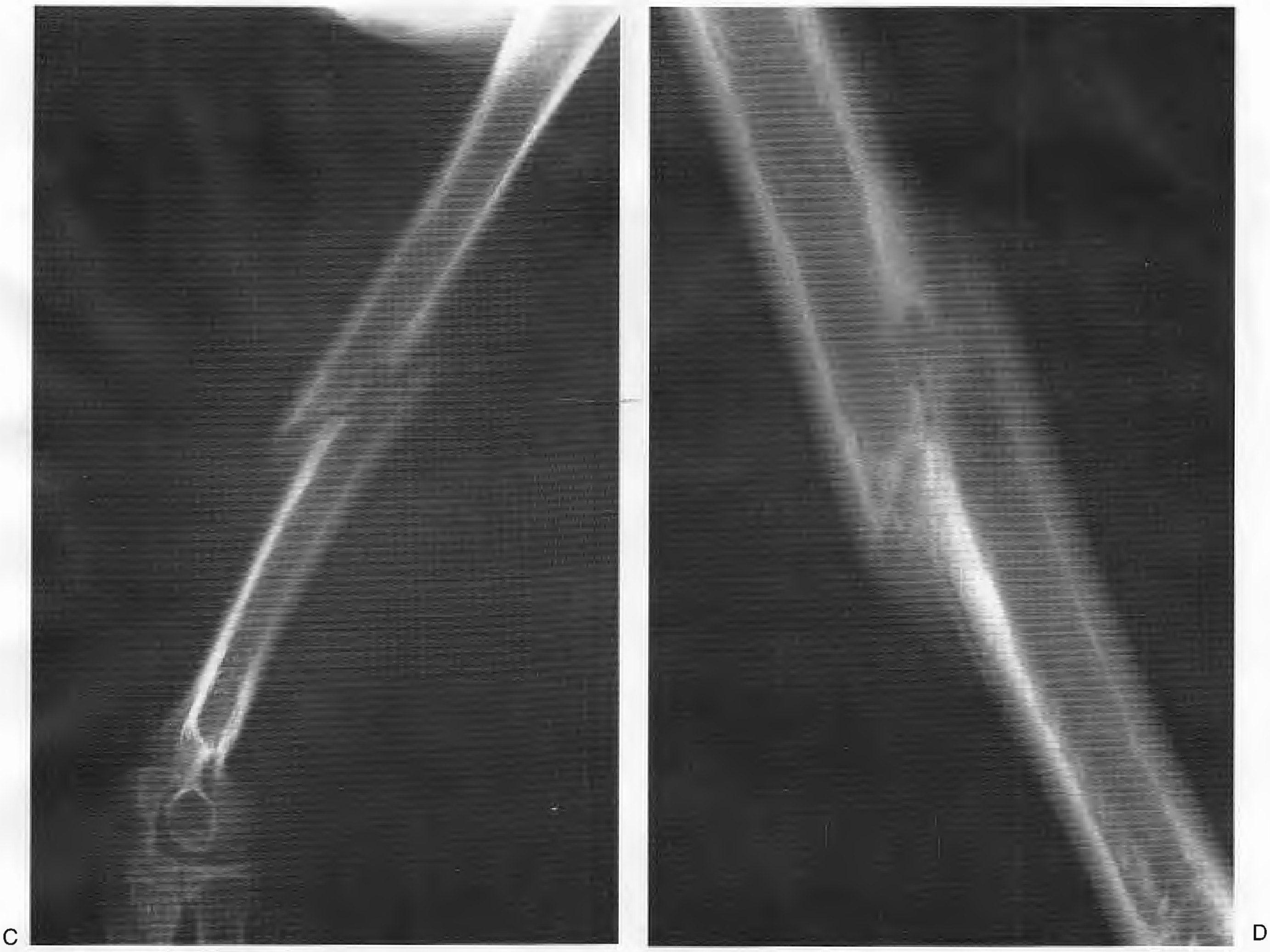

FIG. 4. *(Continued).*

home (Fig. 4A). He sustained a midshaft humeral fracture. There appears to be no predisposing factors. Radiographs, following reduction in a hanging fiberglass cast, reveal a humeral shaft fracture (Fig. 4B). He was casted for 6 weeks and then was found to be clinically and radiographically healing. Callus formation is shown on the AP and lateral views. Complete radiographic consolidation and clinical union occurred at three months, as noted on the AP (Fig. 4C) and lateral views (Fig. 4D).

A stress reaction about the elbow also does occur. In 1965, Adams described injuries to the throwing arm and the term *Little Leaguer's elbow* was coined (43). Most of the complaints in the Little League pitcher are related to the development of medial tensile forces. However, a specific diagnosis should be based on the anatomic site involved and the findings of a fracture, strain, or inflammation. Other apophyseal injuries do occur in the upper extremity, specifically, olecranon apophysitis at the triceps insertion. Microtraumatic, tensile stress reaction may result in medial epicondylar hypertrophy or an avulsion fracture. Increased vascularity, stress reaction, or a displaced fracture may result. The lateral compression injury of osteochondritis dissecans has potentially significant joint-deforming complications. Early recognition is key. In the skeletally immature, lateral compartment compressive loads can result in joint irregularity, loose fragments, and permanent deformity. The modified hinge of the osseous elbow places a considerable stress on bone. Particular early attention must be given these shoulder and elbow bony reactions.

INJURIES FROM BATTING AND BASE RUNNING

Contact injuries are commonly seen in batting or base running. An athlete dived into a base striking a dorsiflexed left wrist. He complained of pain for several

FIG. 5. (**A**) An acute fracture of the navicular waist in a skeletally immature left wrist that occurred from diving into a base. (**B**) Eight weeks of immobilization resulted in fracture healing.

weeks. Radiographs reveal a nondisplaced navicular waist fracture (Fig. 5A).

Immobilization for 8 weeks resulted in clinical and radiographic healing (Fig. 5B).

A young baseball player was unsure of any specific injury, but complained of pain over the palmar, radial aspect of his right wrist when batting. Carpal tunnel radiographs demonstrated a nondisplaced pisiform fracture (Fig. 6).

Routine lateral radiographic views in ulnar radial deviation did not exhibit this pisiform fracture. This fracture healed uneventfully with cast immobilization for 4 weeks with return to baseball play in 3 months.

Another example of base-running injuries is depicted in this young player who complained of pain in his hand for 6 months following an injury sliding into base. He was unable to bat because of point tenderness over the hamate. A carpal tunnel view showed nonunion of the hamate (Fig. 7). He underwent excision of the nonunited fragment.

Correlation of clinical tenderness with routine radiographs is necessary in making an early and correct diagnosis. If volar wrist pain is present, a carpal tunnel view should be included.

LITTLE LEAGUE RULES

The official regulations and playing rules of Little League Baseball give detailed information, especially about pitching. The type of pitch is not specified. The two legal pitching positions are windup and set. If a player pitches less than four innings, 1 calendar day of rest is mandatory. If a player pitches four or more innings, 3 calendar days of rest must be observed. A player may pitch a maximum of six innings in a calendar week. Violation can result in protest of the game (44). Limiting the amount the athlete can pitch during a week is helpful (45). Nevertheless, the rules do not control the number of

FIG. 6. Routine radiographs in lateral views of ulnar radial deviation did not exhibit this pisiform fracture. With volar wrist pain of the ulnar aspect, a carpal tunnel view is necessary. A nondisplaced pisiform fracture is seen (*arrow*). This healed with cast immobilization uneventfully in 4 weeks with return to baseball play in 3 months.

FIG. 7. This patient complained of pain for 6 months over the volar aspect ulnar side of his wrist. He had pain when batting. Routine wrist radiographs were negative. However, a carpal tunnel view revealed nonunion of a hamate fracture. He underwent excision of the nonunion and returned to baseball in 2 months.

pitches allowed in practice or at play. There is a need for education of the coach, parent, and athlete in the areas of injury patterns, prevention, and correct training and throwing techniques. Too often parents or coaches challenge the athlete with an additional number of pitches, which may create overuse injuries. Young athletes need to be encouraged to report shoulder or elbow pain and soreness immediately. It is important to reassure them that play can be resumed once they are pain-free. It is wise to discourage excessive practice and throwing in the skeletally immature athlete.

CHRONIC PROBLEMS FROM LITTLE LEAGUE PLAY

During Little League play, repetitive microtraumatic injuries can lead to a variety of permanent joint problems. A former left-hand dominant Little League pitcher's complaints of elbow pain caused an end to his baseball career. The pitcher developed limited extension and supination range, which were the result of radial head overgrowth and anterior subluxation. Palpation revealed an enlarged, anteriorly positioned, and radial head incongruity that resulted in loss of supination (Fig. 8). Another former Little League pitcher had a painful, limited arc of motion of the elbow. Lateral radiographs (Fig. 9A) revealed osteophytes and loose bodies posteriorly. Arthroscopic removal of loose bodies (Fig. 9B) decreased complaints, but there was permanent loss of motion and persistent pain.

Individual cases like these are seen commonly in sports medicine centers. It is difficult to track the numbers of serious injuries that result from Little League play. Well-organized and documented epidemiologic studies are needed. Long-term problems that result from Little League participation are probably greater in number than the amount reported. The elbow of the immature skeleton when injured is most vulnerable to permanent sequelae.

FIG. 8. Palpation of the radial head with the arm in maximal supination reveals the anteriorly subluxed radial head. The examiner's fingers are on the radial head. There is loss of 60° of supination.

Early diagnosis and treatment of elbow injuries are needed in order to prevent permanent joint restrictions from articular surface incongruity, malunion, and abnormal growth.

LITTLE LEAGUE PITCHING RESEARCH

Most research on throwing has focused on the skeletally mature athlete. Few studies have focused on the Little League player, and additional studies are needed. The biomechanics of the throwing motion are a complex interaction of bony articulations, ligamentous and muscular stability, and individual style that involves the leg, trunk, shoulder, elbow, and hands. The shoulder, which is usually physiologically lax in youth, allows placement for acceleration and deceleration of the extremity during the throwing act. Distraction of the glenohumeral joint during acceleration necessitates a strong rotator cuff to stabilize the humeral head and to decelerate the arm. Tensile forces on the cuff in a physiologically lax joint create the potential for rotator cuff dysfunction.

When throwing, forces of the elbow result in compression laterally, and distraction medially. The specific stress applied depends both on technique and on the phase in the pitching motion. Differences in the transfer of forces from the trunk to shoulder and elbow are seen in the joint and reflect the muscularly underdeveloped Little Leaguer.

The phases of throwing are similar in the skeletally immature to the adult baseball athlete. The phases are the windup, cocking, early and late, acceleration, and follow-through (45–49). The motor activity of specific muscles in each phase has been described in Chapter 1. The

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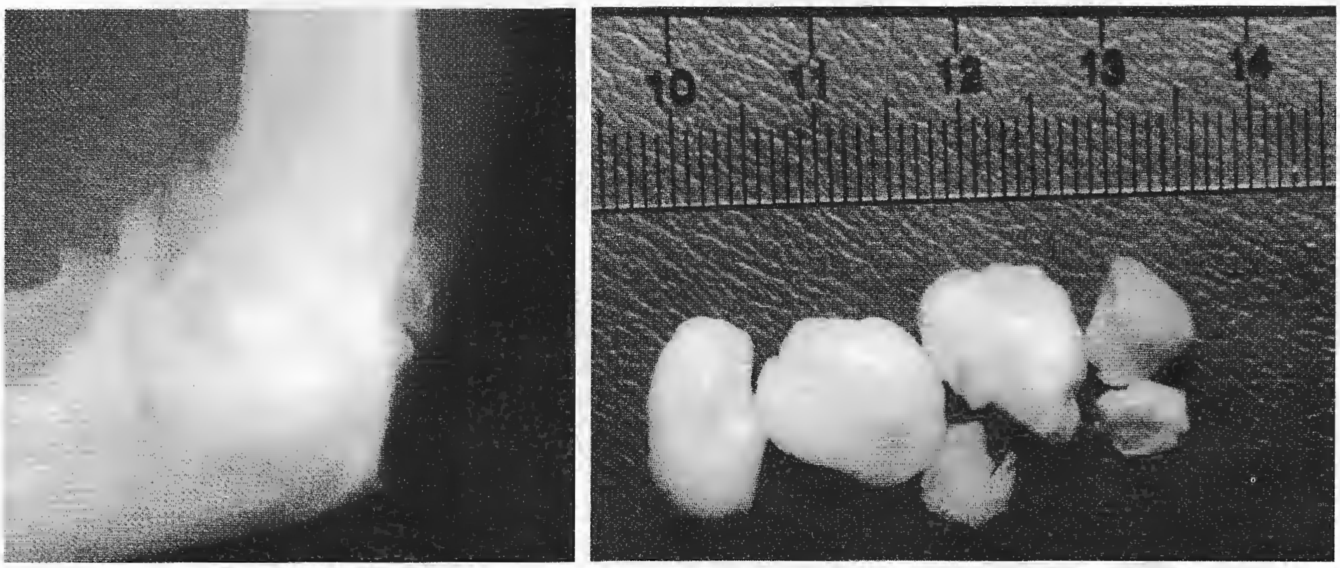
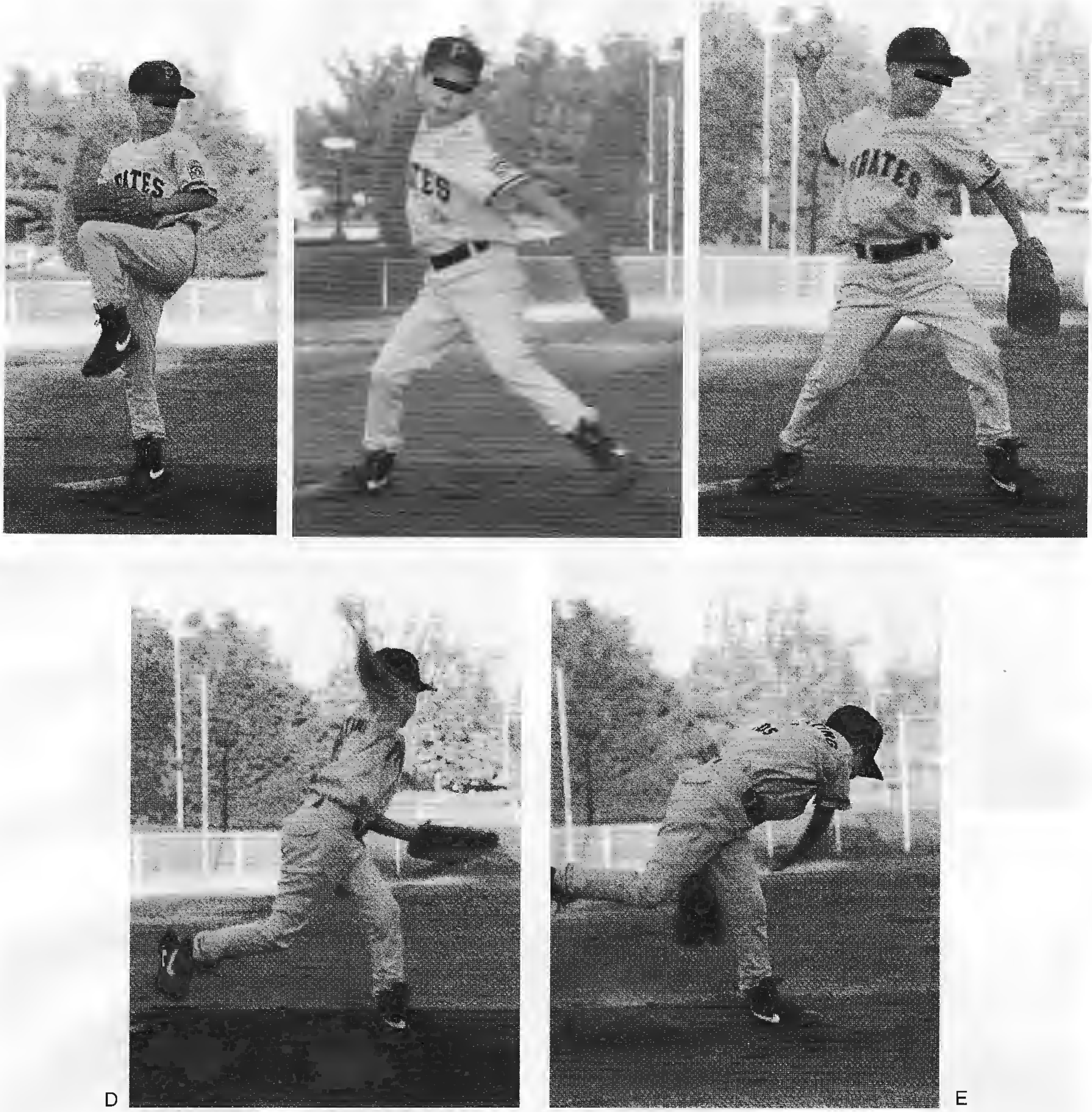


B

FIG. 9. (**A**) A lateral radiograph shows multiple loose bodies in the anteroposterior compartment. (**B**) Arthroscopic removal of numerous large loose fragments. The patient had improvement of his pain, but had continued loss of motion.



A–C

D

E

FIG. 10. The phases of throwing of windup, early cocking, late cocking, acceleration, and follow-through are depicted. Windup (**A**) begins as the pitcher is preparing and ends when the ball leaves the glove. Early cocking phase (**B**) begins when the ball leaves the glove and the shoulder goes into external rotation and ends when the forward foot makes ground contact. The late cocking phase (**C**) begins with forward foot ground contact and ends as the shoulder is maximally externally rotated and the forearm is parallel to the head. Maximal shoulder rotation is reached during late cocking. As the arm begins internally rotating, the acceleration phase begins and ends with ball release (**D**). Follow through begins after the ball has been released (**E**).

wind-up phase (Fig. 10A) begins when the pitcher prepares and ends when the ball leaves the glove. The cocking phase is divided into early and late by the position of the forward foot making ground contact. As the lead foot lands, the end of early cocking occurs. The shoulder is externally rotated, and the forearm is parallel to the head (Fig. 10B). During the late cocking phase, maximum shoulder rotation is reached (Fig. 10C). As the arm internally rotates, the acceleration phase begins and ends with ball release (Fig. 10D). Follow through follows ball release (Fig. 10E).

Children who pitch with a sidearm motion are three times more likely to develop arm and shoulder problems than those who throw with an overhand technique (25,50). Specific pitches, notably the curve ball, may also provide added stresses to the elbow with lateral compression, medial distraction, and posterior symptoms due to triceps muscle overuse in elbow extension. To throw a curve ball causes an immature elbow to change rapidly from acute flexion to forced extension or even extreme hyperextension, and from wrist pronation to supination. This stressful state is magnified by the contractive forces of the wrist and finger flexors as the forearm is maintained in supination (49,51). This violent flexor motion causes an excessive increase in muscular strain in the flexor-pronator muscle group that is manifested in increased tensile force at the medial epicondyle of the distal humerus (10). In contrast, throwing a fast ball creates less tension over the medial epicondyle because the flexor-pronator group is not firing as violently. In contrast, throwing the fast ball generates more compression force across the radiocapitellar joint with possible long-term implications on the articular and subchondral surfaces of the capitellum and radial head (49,51).

Comparison of forces in the shoulder and elbow were calculated when throwing a fast ball in 10 pitchers, both at the professional and the Little League level (50,52). The shoulder in professionals had a greater internal rotation moment, increased maximum internal rotation velocity, and greater shoulder compression forces than the youngsters. In the Little League pitcher, the elbow exhibited greater extension torque in the follow-through and a prolonged elbow valgus moment, which did not reduce during acceleration, as was the case in the professional pitchers (50). Over time, these force differences result in increased posterior and lateral compression and medial tensile forces on the Little League pitcher's elbow.

CONCLUSIONS

With a knowledge base of normal anatomy, normal variants, injury patterns, and abnormal radiographs, the sports medicine professional is better equipped to treat the young baseball athlete. Prevention is the key. By establishing an early, precise diagnosis with proper treatment, potential complications from the injury can be prevented. Care is indeed a team approach. Communication between and education of all people responsible for these young athletes is crucial. This endeavor includes coaches, parents, members of the medical teams, and the athletes. It is important to let youngsters be youngsters. "Play it safe," says the author. Kids do not have contracts and will not strike. Their goal is to please all, outperform their peers, and enjoy playing well. The medical team must protect these youngsters from preventable physical injury and psychologic harm by making correct diagnoses and instituting early treatment.

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