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PICTORIAL ESSAY

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# Frequently missed fractures in children (value of comparative views)

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**Abstract** Fractures in infants and children are different to those seen in adults. Many are very subtle and difficult to detect with certainty. Furthermore, variations in bone contour and epiphyseal plate configuration are endless and at first may suggest pathology. Comparative views are therefore invaluable and are emphasized throughout this communication, which deals with: (1) plastic bending fractures, (2) hairline fractures, (3) impaction fractures, (4) subtle epiphyseal–metaphyseal Salter–Harris fractures, and (5) subtle angle buckle fractures. Helpful points to assist one in detecting these fractures are presented.

**Keywords** Children · Fractures · Subtle

## Introduction

Many fractures in infants and young children are extremely subtle and often difficult to detect with certainty. Furthermore, variations in bone contour and epiphyseal plate configuration as children grow from infants to adolescents are endless, and at times a normal finding may, at first, suggest pathology. It is to this end that the comparative view will be emphasized throughout this communication. As far as the fractures are concerned they are addressed as follows: (1) plastic bending fractures, (2) hairline fractures, (3) impaction fractures, (4) epiphyseal–metaphyseal Salter–Harris fractures, and (5) subtle angled buckle fractures.

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Comparative views are not obtained by all, and the pros and cons of obtaining them have been addressed in a previous communication [1]. However, many if not most fractures present with little or no clinically obvious deformity of the extremity, only swelling and pain. In these cases the underlying fracture(s) usually are very subtle, and it has been our experience that comparative views aid one in prospectively suggesting the correct diagnosis. Clearly, there never will be total agreement as to whether one should obtain comparative views in all, or all potentially subtle cases, but in our experience this practice has proven to be very worthwhile. It terminates any interpretative ambiguity (common) very quickly and leads to definitive diagnoses.

## Plastic bending fractures

These fractures result from an axial load on a long bone. Most commonly they occur in the forearm [2, 3], involving both the radius and ulna (Fig. 1). They are easily missed without comparative views and are especially easy to miss when they involve the clavicle (Fig. 2). In our experience the clavicle is the second most common site for plastic bending fractures [4]. In all cases comparative views are invaluable because normal bones vary considerably in their contour, and in some individuals they may appear bent but still be normal. Plastic bending fractures also can occur in the fibula, but are much less common in other bones.

## Hairline fractures

There are four locations where subtle hairline fractures commonly occur in infants and children; (1) the small bones of the hands and feet, (2) the tibial diaphysis, (3) the proximal tibial metaphysis, and (4) the proximal ulna. Fractures occurring through the tibial diaphysis are the originally described toddler's fracture by Dunbar

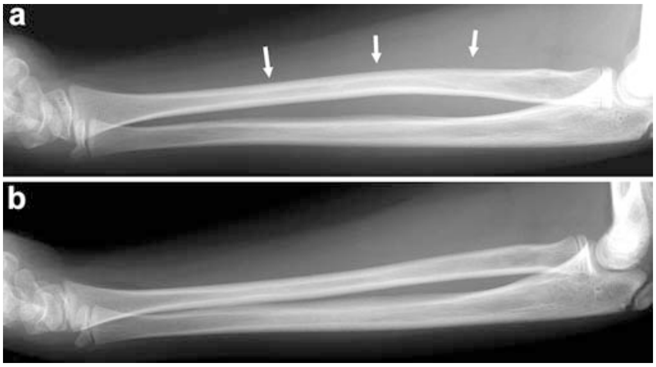


**Fig. 1a, b** Plastic fracture, forearm. **a** Note the upward bend of the radius (*arrows*). **b** Normal side for comparison. Note the straight configuration of the radius

[5], designated the type I toddler's fracture. This is a spiral fracture of the tibial diaphysis (Fig. 3a) resulting from torque forces applied to the tibia and often is very elusive (Fig. 3b, c). Clinically, the problem often is believed to be in the ankle and thus ankle radiographs are obtained. Fortunately, very often the fracture is visible on the oblique view of the ankle, as it extends into the distal tibia.

A more recently described toddler's fracture (toddler's type II) is an impaction-induced fracture of the upper tibia [6]. Hyperextension forces on the lower extremity (knee) are the induction factor, and a constellation of findings associated with this fracture are diagrammatically depicted in Fig. 4. The findings consist of a transverse, usually hairline fracture through the upper tibia, an associated buckle fracture (often lateral), irregularity and increased concavity of the notch for the tibial tubercle, and anterior tilting of the plate of the upper tibia (Fig. 5a–c). In some cases one's attention might be drawn more to the increased concavity and distortion of the normally concave notch for the tibial tubercle (Fig. 5d–f). This fracture is common and one needs to be aware of all its associated findings to accomplish its diagnosis.

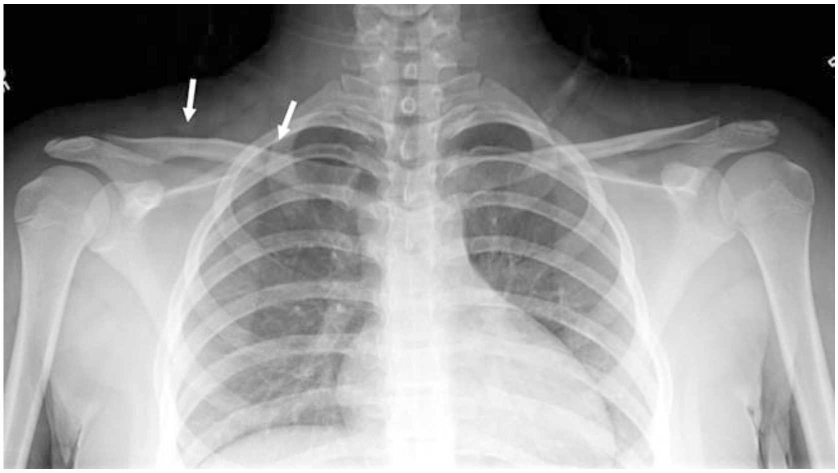

**Fig. 2** Plastic clavicle fracture. Note the upward bend (*arrows*) of the right clavicle. Normal clavicles are very symmetric and thus any difference in configuration should be treated with suspicion

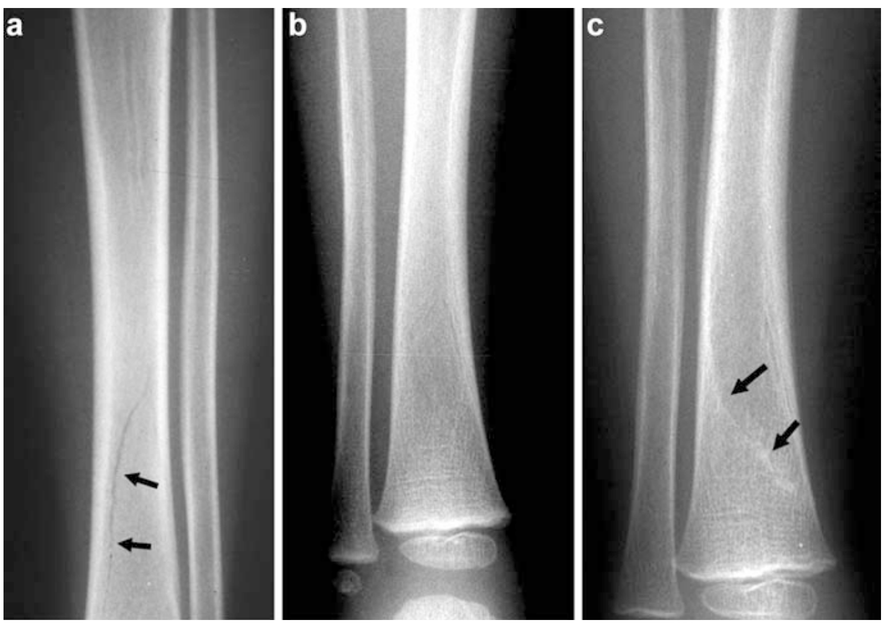


**Fig. 3a–c** Toddler's fracture, type I. **a** Classic spiral fracture (*arrows*). **b** In this patient it is difficult to visualize a fracture. **c** Later on, with healing, a line of sclerosis (*arrows*) is seen

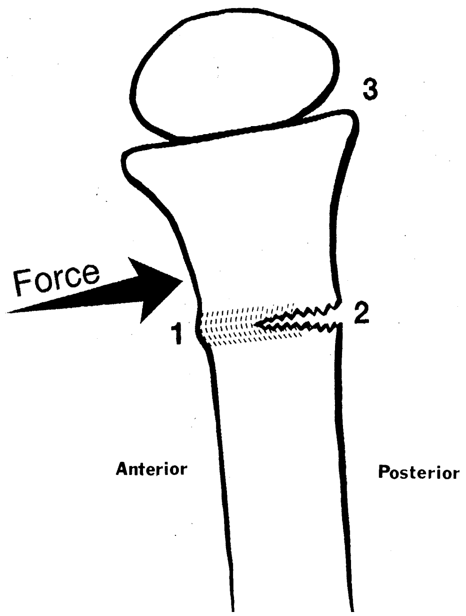


**Fig. 4** Toddler's fracture, type II. In this hyperextension-induced injury there is a buckle fracture noted anteriorly (*1*), a fracture visible posteriorly (*2*), and anterior tilting of the epiphyseal plate (*3*). From [6]

Hairline fractures through the proximal ulna can be both transverse and longitudinal [7]. Transverse fractures result from direct blows to the posterior aspect of the proximal ulna with the elbow flexed (Fig. 6a). Longitudinal fractures result from a twisting, shredding force applied to the ulna when the forearm is hyperextended. In these cases the ulna is locked on to the trochlear notch of the humerus, and with any degree of rotation a shredding force is applied to the ulna and longitudinal or slightly spiral hairline fractures result (Fig. 6b).

## Impaction fractures

To some extent, the type II toddler's fracture addressed above is a form of impaction fracture. However, there are two other sites where impaction fractures are easily missed: the scaphoid bone of the wrist and the cuboid bone of the ankle. In the hyperextended wrist injury, with axial loading forces applied to the scaphoid bone, buckling impaction rather than classical transverse fractures occur [8]. In these cases the scaphoid bone is shortened, and in addition to the buckling may show a


**Fig. 5a–f** Toddler's fracture, type II. **a** AP view demonstrates a transverse hairline fracture with an associated lateral buckle fracture (*arrow*). **b** Lateral view demonstrates a posterior fracture (*posterior arrow*) and an anterior buckle fracture (*anterior arrow*). **c** Later with healing, sclerosis is seen (*arrow*). **d** In this patient the most striking finding is increased concavity and irregularity of the notch for the tibial tubercle (*arrows*). **e** Normal side for comparison. Note the shallow notch for the tibial tubercle (*arrows*) and lack of soft tissue swelling. **f** Healing demonstrates sclerosis (*arrows*) through the fracture zone


**Fig. 6a, b** Hairline fractures of the ulna. **a** Note the vertical, subtle hairline fracture (*arrow*) through the proximal ulna. **b** Longitudinal fracture (*arrows*) in the proximal ulna

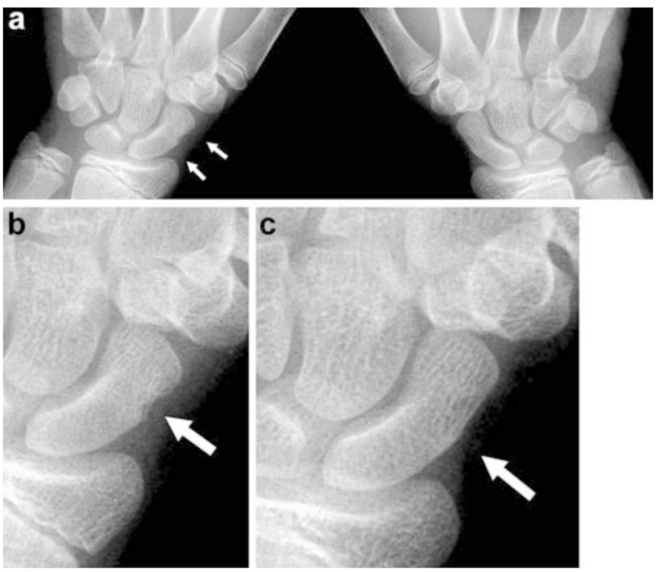


**Fig. 7a–c** Scaphoid compression fracture—subtle findings. **a** Note that the scaphoid bone on the right is shorter (*arrows*) than the one on the left. In addition there is a vague area of sclerosis through its distal third. Soft tissue swelling also is present. **b** Magnified view demonstrates the same findings with a little more emphasis on the transverse line of sclerosis (*arrow*). **c** Magnified view of the normal side demonstrates the normal scaphoid bone (*arrow*) which is longer and lacks any transverse sclerosis

line of sclerosis representing the buckled trabeculae along the fracture line (Figs. 7, 8). The navicular fat pad also will be obliterated and is a useful finding that should cause one to look more closely at the scaphoid bone.

The scaphoid bone is prone to a wide variety of normal contour configurations, and thus in some cases a normal bone will appear impacted. It is for this reason that we strongly suggest the use of comparative views. In virtually all normal individuals the scaphoid bone looks exactly the same on both sides. Therefore, when AP, oblique, and lateral views are obtained, and the two extremities are positioned exactly the same on the same study, any difference seen in the contour or density of a scaphoid bone should raise strong suspicion of the presence of a scaphoid bone fracture (Fig. 8).

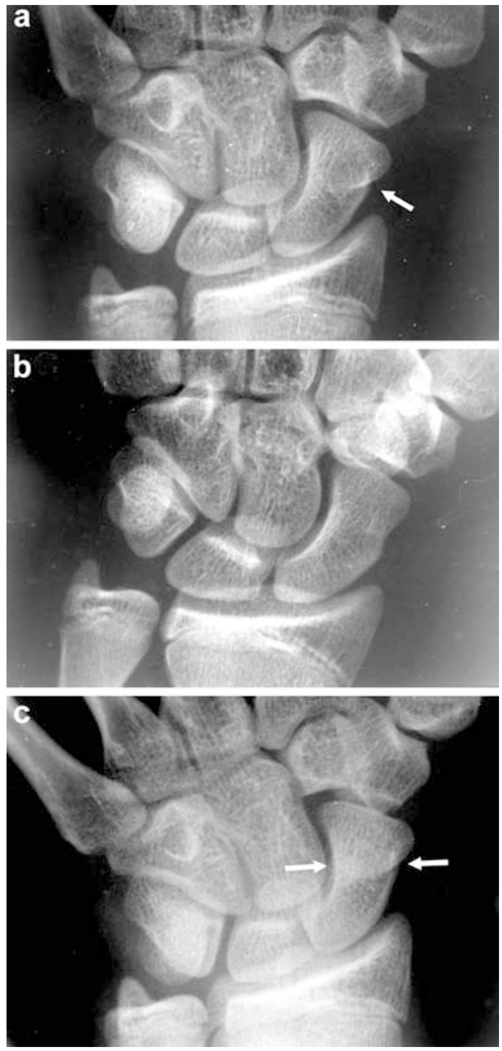


**Fig. 8a–c** Scaphoid compression fracture with healing. **a** Note the cortical buckle fracture (*arrow*) and slight transverse sclerosis in the scaphoid bone. **b** Normal side for comparison. The bone is longer and the cortex smoother. There is no buckle. **c** Later image of the injured wrist demonstrates sclerosis (*arrows*), consistent with healing

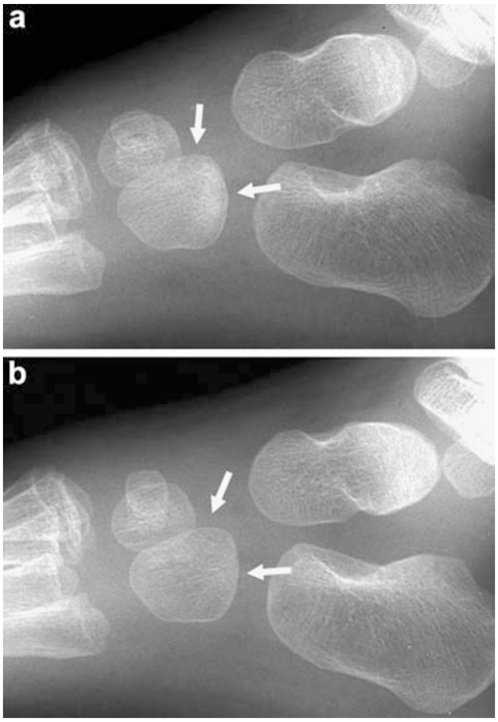

Fig. 9a, b Impaction fracture; cuboid bone. **a** Note sclerosis through the cuboid bone (*arrows*) on the involved side. **b** On the normal side no sclerosis is present (*arrows*)

The impaction fracture of the cuboid bone results from landing on the hyperflexed forefoot, in the vertical position. Because this mechanism frequently is at play when children fall or jump from the top of a bunk-bed, the fracture is referred to as a bunk-bed fracture. If initial impaction is pronounced, one will see sclerosis of the cuboid bone along the fracture zone, but more usually the fracture is detected a little later when healing produces sclerosis within the cuboid bone (Fig. 9).

## Epiphyseal–metaphyseal Salter–Harris injuries

For the most part Salter–Harris injuries which are easily missed include Salter–Harris type I and type II fractures. In all of theses cases subtle widening of the epiphyseal plate will provide the first clue to the presence of the fracture, a finding which may not be obvious unless comparative views are obtained (Fig. 10a, b). These fractures occur throughout all joints but are most common in the wrist and ankle. Salter–Harris epiphyseal fractures can also occur when the epiphyseal plate is closing in adolescents, where the findings can be very subtle (Fig. 10c, d).

## Angled buckle fractures

These fractures result from axial loading on a long bone with added varus, valgus, hyperextension, or hyperflexion forces [8]. As a result, the typical outward cortical bulging seen with classic buckle fractures is absent. Rather, the cortex is merely angled and at times difficult to differentiate from normal (Fig. 11). Comparative views are invaluable in these situations. Angled buckle fractures are a metaphyseal phenomenon and most commonly occur in the wrist, ankle, and elbow. In the wrist, the most commonly occurring angled buckle fracture occurs over the dorsal radial cortex and is best seen on lateral view (Fig. 12). Similar, commonly

**Fig. 10a–d** Salter-Harris type I fracture. **a** Note widening and increased lucency of the epiphyseal line through the distal tibia (*arrows*). It would be difficult to determine that this is abnormal from this single view. **b** Comparative view of the other side shows a normal epiphyseal line (*arrows*), and thus secures the diagnosis of a Salter-Harris type I injury on the other side. **c** In this adolescent with a shoulder injury note increased sclerosis along the closing epiphyseal plate (*arrows*). Under ordinary circumstances no attention would be paid to this finding. **d** Comparative view of the other side demonstrates the normal configuration of the closing epiphyseal plate

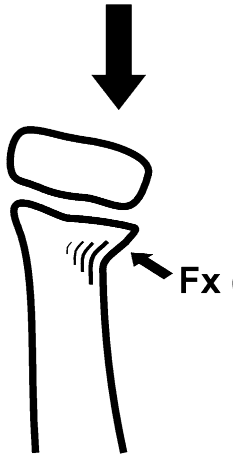


**Fig. 11** Angled buckled fracture. With these fractures the cortex is not outwardly buckled, but merely angled (*arrow*). From [9]

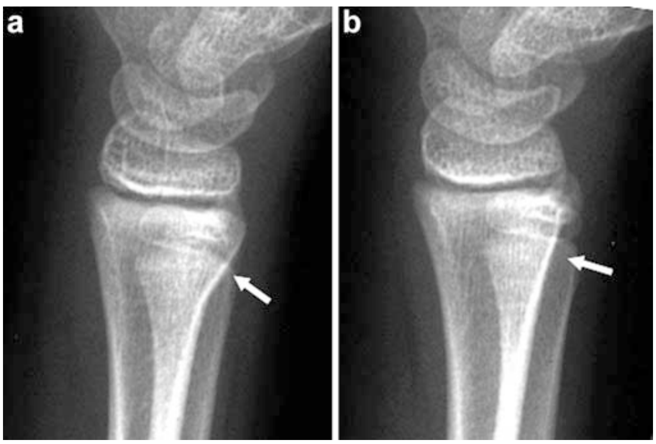


**Fig. 12a, b** Angled buckle fracture; distal radius. **a** Note the angled, cortical fracture (*arrow*) through the distal dorsal radial cortex. Under ordinary circumstances this probably would be considered normal. **b** Normal side for comparison. With comparison to the normal side where the cortex is not angled (*arrow*), the fact that an angled buckle fracture has occurred on the other side is more obvious

occurring angled buckle fractures occur through the proximal radius, distal tibia, and in the distal humerus [9].

The angled buckle fracture which occurs through the distal humerus can be detected on both AP and lateral views of the elbow [10]. Once again, however, the findings are subtle and for the most part are the minimal-most expression of the classic supracondylar fracture of the distal humerus. Often these fractures are more readily detected with the aid of the anterior humeral line [11] (Fig. 13), but in any case since the fat pads around the elbow will be displaced or obliterated, an underlying fracture should be suspected.

Angled buckle fractures also occur through the base of the first metatarsal, representing one of the two so-called "bunk-bed" fractures [12]. These fractures result


**Fig. 13a, b** Angled buckle fracture distal humerus. **a** Note slight angulation of the dorsal cortex of the distal humerus (*arrow*). This represents the minimal-most presentation of a supracondylar fracture. The anterior humeral line (*line*) intersects the capitellum through its anterior third. **b** Normal side for comparison. Note the smooth distal, normal dorsal humeral cortex (*arrow*). Also note that the anterior humeral line (*line*) intersects the capitellum through the posterior third

from landing on the forefoot and exerting axial loading forces on the metatarsals. The first metatarsal takes the brunt of this force. Because this is what happens when children jump from the top bunk of a bunk-bed, the fracture again has been termed a "bunk-bed" fracture. Angled buckle fractures also occur through the small bones of the hands and feet and appear just as they do at other sites.

## Conclusion

Many fractures in infants, young children, and even adolescents are subtle. Often there is difficulty in differentiating them from normal findings. To this end comparative views are invaluable. With comparative views one will be able to detect these subtle fractures with more certainty, no matter where they occur.

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