Chapter 6
The shoulder, humerus, elbow and radius

Scapulohumeral (shoulder) joint and humerus

RADIOGRAPHIC TECHNIQUE

Equipment

The scapulohumeral joint may be radiographed with the horse standing if a high-output x-ray machine is available. Better-quality radiographs are generally obtained with the horse under general anaesthesia in lateral recumbency. With the horse anaesthetized, positioning is easier and longer exposure times can be used without risk of movement, so a lower output x-ray machine may be used. The radiation hazard to personnel is also reduced. Digital systems, or rare earth screens and appropriate film, are essential due to the high exposures required to penetrate the large muscle mass in this area. A grid is recommended to reduce the effects of scattered radiation, and lead should be placed behind the cassette to limit back scatter. There is less soft tissue to penetrate cranially; therefore it may be necessary to repeat a view with different exposure factors in order to assess both the cranioproximal aspect of the humerus and the more caudally situated scapulohumeral joint properly. Alternatively an aluminium wedge filter can be used to modify the exposure. For mediolateral radiographs obtained with the horse standing, the cassette should be mounted in a holder and not hand held. Both mediolateral and oblique views are required for a complete assessment of the scapulohumeral joint, and in selected cases arthrography yields valuable additional information.

Positioning

Mediolateral view

STANDING

The forelimb to be examined is positioned next to the cassette and the limb is protracted as much as the horse will comfortably allow, to avoid superimposition of the left and right shoulder joints (Figure 6.1). If possible the shoulder joint is superimposed over the trachea, to give the best images. Some horses resist protraction of the limb and this may result in movement blur and partial superimposition of the left and right shoulder joints. Sedation may be helpful, but the horse may relax and lower its neck so that a

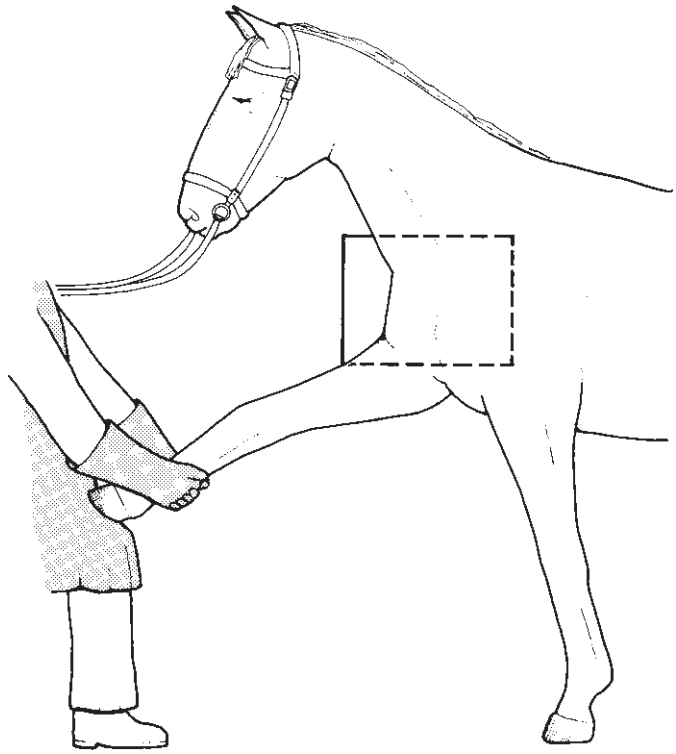


Figure 6.1 Positioning of the horse and cassette to obtain a mediolateral radiographic view of the scapulohumeral joint.

larger proportion of the distal scapula is superimposed over the cervical and thoracic vertebrae. Raising the head and neck can help to minimize this. The use of an analgesic such as butorphanol facilitates the examination of horses suffering severe pain.

LATERAL RECUMBENCY

The anaesthetized horse is placed in lateral recumbency, lying on the limb to be radiographed. This limb is protracted, the contralateral forelimb is retracted and the neck is extended. It may be helpful to restrain the forelimbs using ropes. The position of the endotracheal tube is adjusted so that its distal end is not superimposed over the scapulohumeral joint. The examination is performed most easily if the horse is lying on a cassette tunnel, to avoid having to lift the horse in order to place the cassette beneath it. With appropriate sedation a foal may be restrained in lateral recumbency without the need for general anaesthesia.

CENTRING THE X-RAY BEAM

The x-ray beam is centred approximately 10 cm cranial to the distal aspect of the scapular spine of the limb contralateral to that being radiographed. This is approximately equivalent to centring at the level of the greater tubercle of the humerus of the protracted limb. It is helpful to mark the point at which the beam is centred (e.g. with sticky tape) so that appropriate corrections can be made for subsequent exposures.

If the scapulohumeral joint is positioned distal to the trachea, up to one-third of the distal scapula can be seen without superimposition of the cervical and thoracic vertebrae and the ribs. Evaluation of the proximal two-thirds

of the scapula is difficult because of the superimposed bones and the flatness of the scapula. If either rim of the glenoid cavity of the scapula or the proximal articular surface of the humerus are superimposed over the proximal or distal borders of the trachea, the summation of opacities makes interpretation difficult and additional radiographs may be required. It is sometimes helpful to position the scapulohumeral joint over the trachea. Although this can be achieved in the standing horse, it is most easily done if the horse is anaesthetized.

The distal two-thirds of the humerus is examined using a similar technique, but centring further distally. This examination is usually only indicated when a fracture is suspected and associated pain often makes adequate protraction of the limb very difficult. High exposure factors may therefore be required in order to obtain adequate penetration of the large muscle mass.

Cranial 45° medial-caudolateral oblique view

This view is most easily obtained with the horse standing. The forelimb to be examined is usually protracted and the cassette is held caudal to the shoulder muscle mass in order to position it sufficiently far medially. This inevitably results in some magnification. A grid is unnecessary, which allows lower exposure factors. The x-ray beam is centred at the level of the greater tubercle of the humerus. Alternatively a caudolateral-craniomedial oblique view may be obtained, but this usually results in greater magnification.

These views help to clarify some intra-articular lesions, especially those in the sagittal plane. They also permit identification of some fractures not visible in a mediolateral projection and help to determine the direction of a luxation of the humerus.

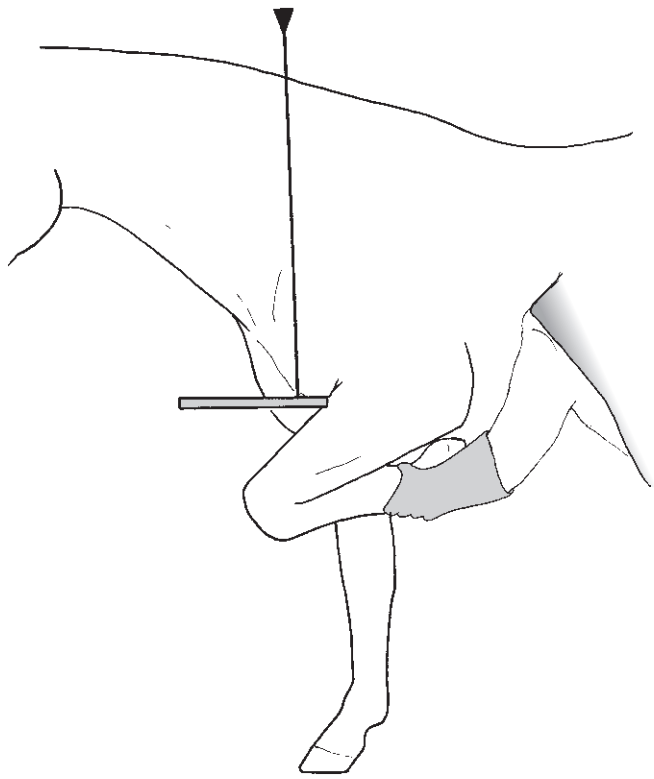


Figure 6.2 Positioning to obtain a cranioproximal-craniodistal oblique view of the proximal aspect of the humerus. The limb is held with the carpus flexed maximally. The imaging plate is held horizontally distal to the shoulder. The horse's head and neck are turned away from the limb to be examined. The x-ray beam is directed ventrally.

Figure 6.3 Mediolateral view and diagram of a shoulder of a 12-day-old foal. The cranial centre of ossification of the glenoid cavity of the scapula and the lesser tubercle of the humerus are incompletely ossified. The curvature of the glenoid cavity of the scapula is more shallow and the ventral angle is more rounded compared with an adult shoulder.

Cranioproximal-craniodistal oblique 'skyline' view of the proximal aspect of the humerus

This view can be obtained either in the standing horse or with the horse under general anaesthesia. The limb is held with the carpus and elbow flexed (Figure 6.2), with the x-ray cassette positioned horizontally distal to the humeral tubercles. The horse's head and neck are turned away from the limb to be examined. The x-ray machine is positioned proximal to the shoulder and the x-ray beam is directed ventrally, centred on the humeral tubercles. This view helps to identify fractures of the greater, or less commonly lesser, tubercles of the humerus, that may be difficult to identify in other projections.

Caudolateral-craniomedial oblique view

This view is obtained with the horse standing. The x-ray machine is positioned against the thorax, on the ipsilateral side of the shoulder to be examined. A horizontal x-ray beam is used, angled at approximately 40° lateral to the sagittal midline (i.e., caudal 40° lateral-craniomedial oblique view). The x-ray cassette is positioned cranial to the shoulder, perpendicular

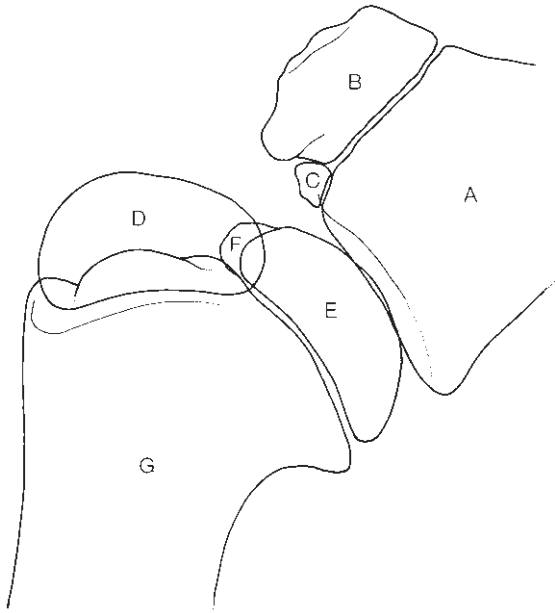


Figure 6.3 *Cont'd* A = body of scapula, B = ossification centre for the supraglenoid tubercle and coracoid process, C = ossification centre for the cranial part of the glenoid of the scapula, D = ossification centre for the greater tubercle of the humerus, E = ossification centre for the humeral head and lesser tubercle, F = incompletely ossified lesser tubercle, G = diaphysis of humerus.

to the x-ray beam. This view may highlight a fracture of the cranial part of the greater tubercle of the humerus.

Arthrography

Arthrography can be performed with the horse standing or in lateral recumbency under general anaesthesia. In the latter position the technique is more complicated because, after injecting the contrast medium with the limb to be examined uppermost, the horse must then be turned over for radiography. A small volume (7–10 ml) of a 60% mixture of sodium and meglumine amidotrizoate (Urografin 60%, Schering AG) is recommended. Dilution of the contrast agent with a balanced polyionic electrolyte solution may help definition of the articular cartilage. The technique can be used to highlight articular cartilage defects and subtle bone lesions and to identify dissecting cartilage flaps in cases of osteochondrosis.

RADIOGRAPHIC ANATOMY, NORMAL VARIATIONS AND INCIDENTAL FINDINGS

Birth to 3 years old

Scapula

The scapula has four centres of ossification: the scapular cartilage, the body of the scapula, the cranial part of the glenoid cavity of the scapula and the supraglenoid tubercle (Figure 6.3). The latter two may be incompletely ossified at birth and have a fuzzy, irregular outline. The cranial part of the glenoid cavity of the scapula fuses with the body by 5 months after birth. The physis of the supraglenoid tubercle closes by 12–24 months after birth.

Figure 6.4(a) Mediolateral view and diagram of a normal adult scapulohumeral joint (compare with Figure 6.6). See text regarding Figure 6.4(a) on page 280.

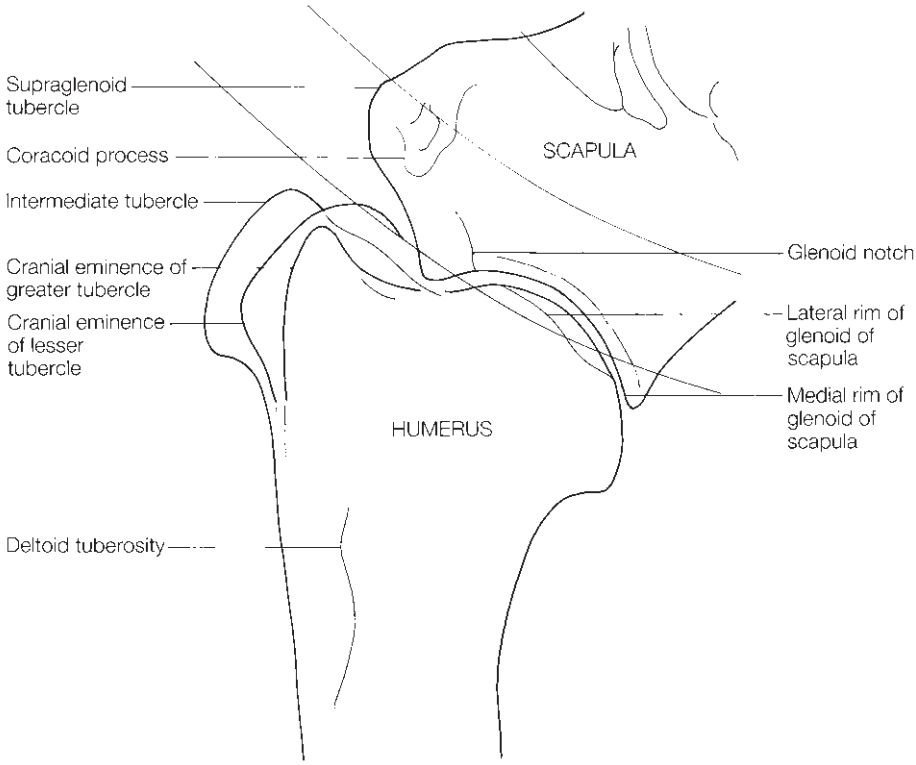


Figure 6.4(a) *Cont'd*

Figure 6.4(b) Coned down mediolateral view of a normal scapulohumeral joint, superimposed over the trachea. Note the congruity of the articulation between the scapula and the humerus and the sharply pointed ventral angle of the scapula (white arrow). The lucent line (black arrows) traversing the humeral head is normal, an edge effect created by the overlying lateral rim of the glenoid cavity of the scapula.

Humerus

The proximal humerus ossifies from three centres: the diaphysis, the humeral head and the greater tubercle. The lesser tubercle develops from the same ossification centre as the humeral head. It is usually incompletely ossified at birth and has a fuzzy outline and a granular opacity. The centres of ossification of the proximal humeral epiphysis merge by 3–4 months of age and gradually assume a more adult shape; the proximal humeral physis closes by 24–36 months.

Skeletally mature horse

Mediolateral view

There is little variation in the normal radiographic anatomy of the scapulohumeral joint except as a result of positioning. The medial rim of the glenoid cavity of the scapula is projected proximal to the lateral rim and is smoothly curved (Figure 6.4a, pages 278 and 279). Its caudal edge, the ventral angle of the scapula, is sharply pointed. The lateral rim of the glenoid cavity of

Figure 6.5 Mediolateral view of a normal adult scapulohumeral joint. There is an irregularly shaped radiolucent area (arrow) in the subchondral bone of the middle of the glenoid cavity of the scapula (see text on page 283).

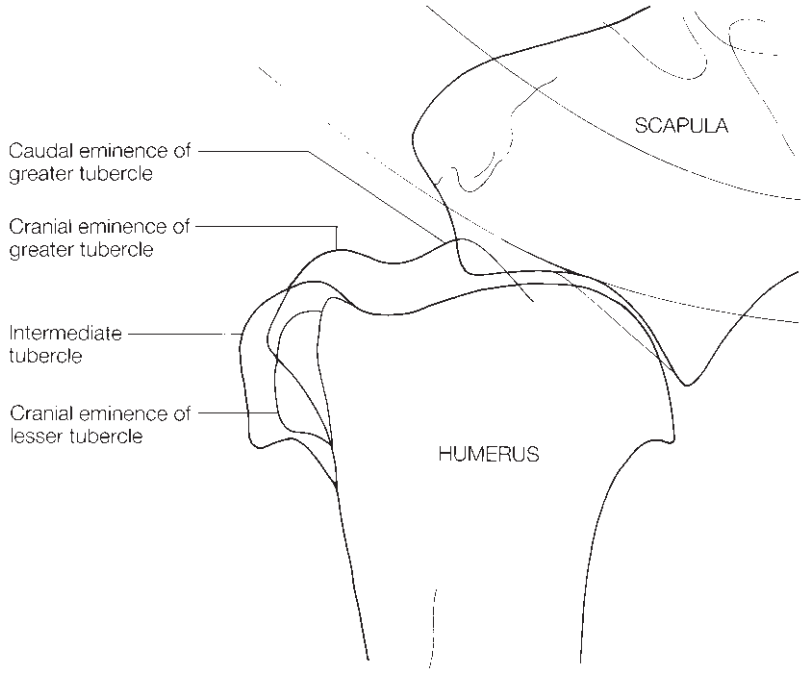


Figure 6.6 Mediolateral view and diagram of a normal adult scapulohumeral joint (compare with Figure 6.4a). Due to slight differences in position of the proximal humerus, the greater tubercle appears more prominent. Note also the slightly more rounded ventral angle of the scapula compared with Figure 6.4(b). The caudal aspect of the joint is slightly underexposed.

Figure 6.7 Cranial 45° medial-caudolateral oblique view and diagram of a normal adult scapulohumeral joint.

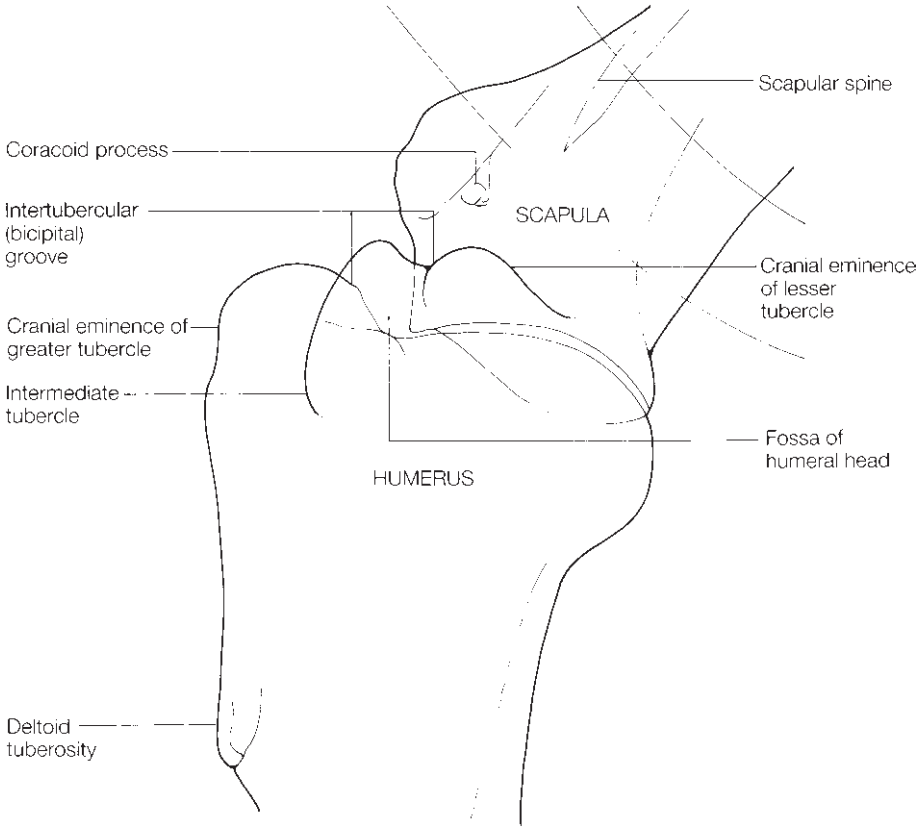


Figure 6.7 *Cont'd*

the scapula is seen as a relatively less opaque area immediately distal to the medial rim and may make the latter appear poorly defined. It may be superimposed over the humeral head, resulting in a relatively lucent area in the cranial part of the humeral head which should not be mistaken for a lucent lesion in the subchondral bone of the humeral head (Figure 6.4b, page 279). The lateral rim of the glenoid cavity forms the proximal border of this lucency.

There is a clearly demarcated band of opaque, sclerotic bone, of uniform width, around the caudal two-thirds of the glenoid cavity of the scapula. In approximately 5% of horses there is a small lucent zone (up to 0.5 cm diameter) in the middle of the glenoid cavity of the scapula within the opaque band (Figure 6.5, page 280). A faint vertical lucent line is sometimes seen at the junction of the cranial and middle thirds of the glenoid cavity. This represents the glenoid notch. Cranial to the glenoid notch the opaque band is usually narrower.

The outline of the humeral head is smoothly curved. The greater, lesser and intermediate tubercles may be slightly separated or superimposed upon each other depending on the positioning of the humerus (Figures 6.3 and 6.6).

There is reasonable congruity between the outlines of the glenoid cavity of the scapula and the humeral head, although in some horses the glenoid cavity of the scapula is more curved, resulting in apparent widening of the joint space in the middle of the joint.

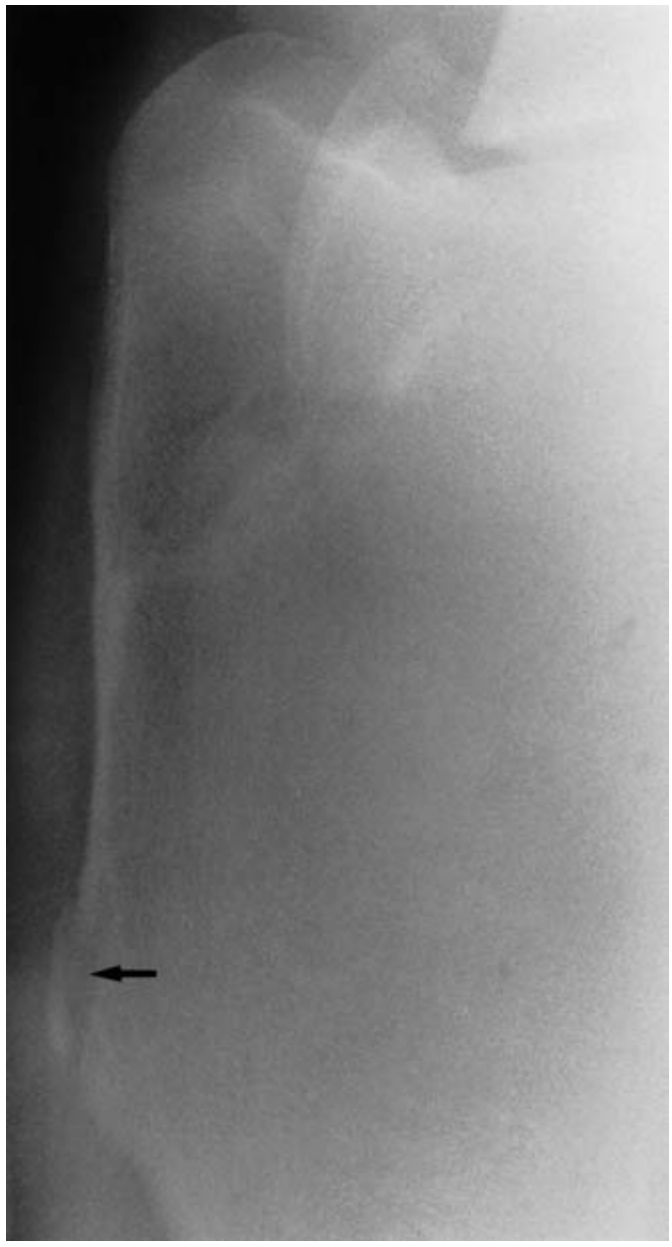


Figure 6.8 Craniomedial-caudolateral oblique view of a normal adult humerus. The 'lip' of the deltoid tuberosity is projected (arrow) and should not be confused with a chip fracture.

Cranial 45° medial-caudolateral oblique

In this projection the width of the scapulohumeral joint space is more variable than in the mediolateral view. The cranial eminence of the lesser tubercle, the intermediate tubercle and the intertubercular groove are highlighted and the deltoid tuberosity is outlined (Figure 6.7). The 'lip' of the deltoid tuberosity, which curves caudolaterally, may be projected in this view and should not be confused with a chip fracture (Figure 6.8).

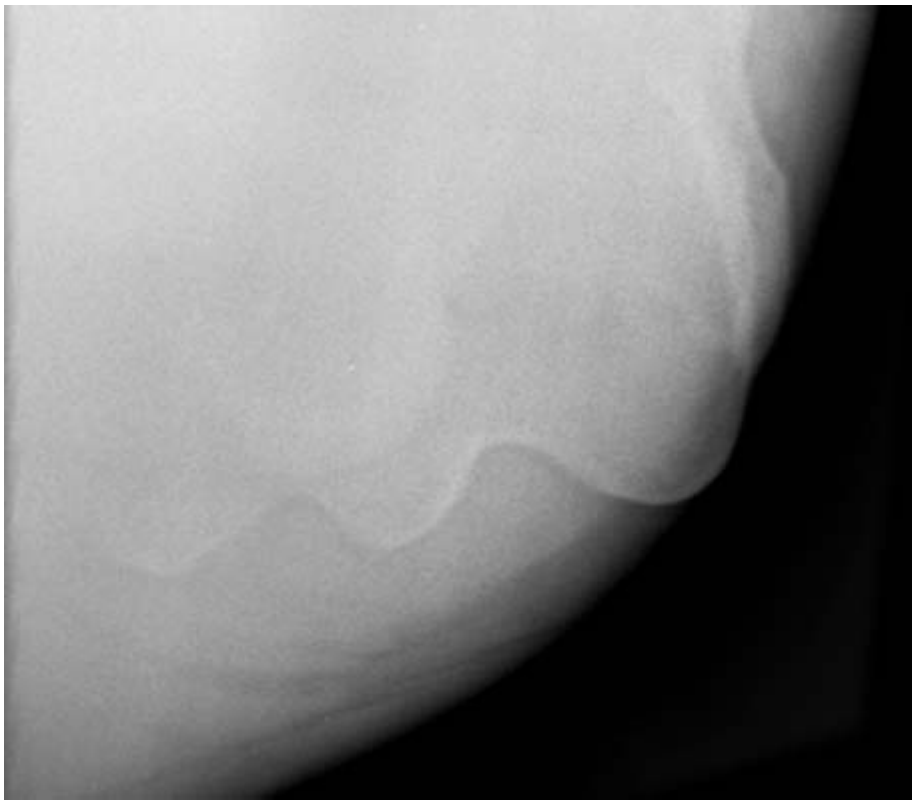


Figure 6.9 Cranioproximal-craniodistal oblique view of the humeral tubercles of a normal adult horse (medial is to the left).

Cranioproximal-craniodistal oblique view of the proximal aspect of the humerus

This view skylines the humeral tubercles, the medial (lesser), intermediate and lateral (greater), which should have a smooth contour (Figure 6.9).

Arthrography

A narrow band of contrast outlines the articular surfaces of the scapula and humerus (Figure 6.10). Some contrast may also be superimposed over the distal scapula and the humeral head. This outlines the proximal cul-de-sac of the scapulohumeral joint capsule and distal aspect of the joint capsule, respectively. In a small proportion of normal horses, arthrography will demonstrate communication between the scapulohumeral joint capsule and the intertubercular bursa.

SIGNIFICANT RADIOLOGICAL ABNORMALITIES

Osteochondrosis

Radiographic abnormalities associated with osteochondrosis are identified in the scapula, the humerus or both. The changes predominantly involve the caudal half of the joint and result in loss of congruity between the

Figure 6.10 Mediolateral arthrogram of a normal adult scapulohumeral joint.

subchondral bone adjacent to the articular surfaces of the scapula and humerus. In some cases there is only subtle variation in contour of the articular surfaces (Figure 6.11a). In other cases there are extensive, irregularly outlined lucent zones in the subchondral bone, which may be surrounded by some sclerosis (Figure 6.11b). There is often flattening of the subchondral bone of the humeral head and/or the glenoid cavity of the scapula (Figure 6.11c). The caudoventral angle of the scapula, which is usually sharply pointed, may be modelled so that it is more bulbous. The rim of the glenoid cavity of the scapula may have a blurred outline. Some of the modelling of the scapula and the humerus is due to secondary degenerative joint disease. Osteochondrosis may occur unilaterally or bilaterally, usually in horses less than 3 years of age. It causes a variable degree of

Figure 6.11(a) Mediolateral view of the scapulohumeral joint of a 3-year-old Thoroughbred with osteochondrosis. There is a slight depression in the humeral head (arrow).

lameness. Lameness may or may not be improved by intra-articular anaesthesia.

The majority of horses treated conservatively remain lame; surgical treatment has given encouraging results in immature horses.

In older horses focal osteochondral lesions in the distal aspect of the scapula and the proximal aspect of the humeral head have been associated with lameness. Lesions include focal sclerosis deep to the subchondral bone of the distal aspect of the scapula, small focal radiolucent zones in the distal aspect of the scapula and focal flattening of the humeral head. Arthroscopy invariably reveals associated cartilage defects. The aetiology of these lesions is uncertain; they may be the result of osteochondrosis or trauma. Surgical treatment is recommended.

Osseous cyst-like lesions

Poorly defined lucent zones of irregular shape in the subchondral bone of either the scapula or the humerus are a manifestation of osteochondrosis (Figure 6.11b), but distinct, large circular lucent areas (osseous cyst-like lesions) may be a different clinical condition (or conditions) and are considered separately here.

Figure 6.11(b) Mediolateral view of the scapulohumeral joint of a yearling Thoroughbred with osteochondrosis. There are extensive lucent areas in the subchondral bone of the distal scapula with surrounding sclerosis. There is considerable modelling of the caudal one-third of the glenoid cavity of the scapula and its ventral angle, resulting in loss of congruity between the scapula and humerus. There is an ill defined lucent area in the subchondral bone of the middle of the humeral head, but at post-mortem examination the overlying cartilage was intact and firmly adherent to the subchondral bone.

Figure 6.11(c) Mediolateral view of the scapulohumeral joint of a yearling Thoroughbred with osteochondrosis. There is extensive modelling of the distal scapula and proximal humerus. The outline of the caudal aspect of the glenoid cavity and of the ventral angle of the scapula is rather blurred due to new bone formation. There are ill defined lucent zones in the caudal aspect of the distal scapula.

Figure 6.12(a) Mediolateral view of a scapulohumeral joint of a 2-year-old Thoroughbred. There is a well defined single osseous cyst-like lesion in the distal scapula, surrounded by sclerosis. When first identified several months previously, the lesion was smaller, closer to the articular surface and less well demarcated without surrounding sclerosis. There is no detectable modelling of the scapula (compare with Figure 6.12b). Post-mortem examination revealed a true subchondral bone cyst.

Figure 6.12(b) Mediolateral view of a scapulohumeral joint of a 2-year-old Thoroughbred with two large osseous cyst-like lesions in the distal scapula. Note the modelling of the ventral angle of the scapula. The horse ultimately raced successfully despite radiographic persistence of the lesions.

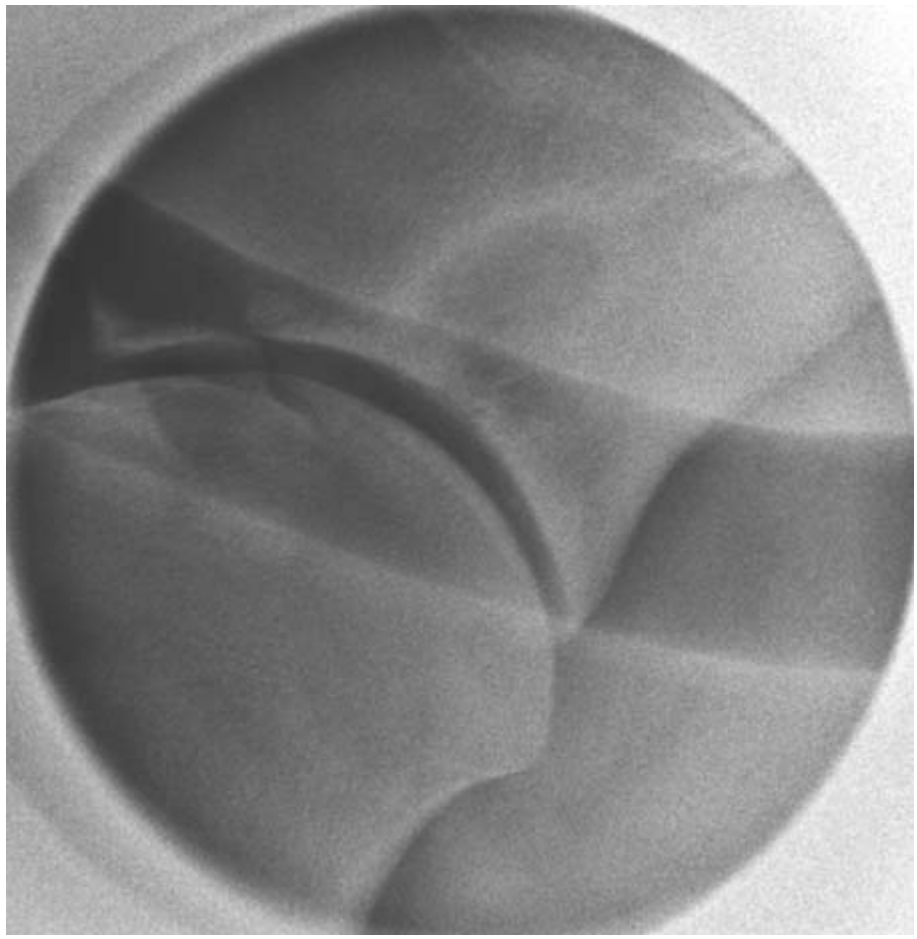


Figure 6.12(c) Coned mediolateral radiographic view of the left scapulohumeral joint of a 9-year-old Warmblood showjumper with sporadic lameness, which was also variable in severity. There is a large, well defined osseous cyst-like lesion in the centre of the distal aspect of the scapula, caudal to which are two less well defined areas of reduced radiopacity. Lameness was improved by intra-articular analgesia of the scapulohumeral joint.

A small lucent area within the sclerotic subchondral bone of the middle of the glenoid cavity of the scapula has been identified in normal horses (Figure 6.5, page 280) and is of questionable clinical significance. However, horses have been reported which were rendered sound by intra-articular anaesthesia and had this as the only detectable radiographic 'abnormality'; subsequent arthroscopic evaluation revealed focal lesions.

Osseous cyst-like lesions are not common. They may occur singly or there may be more than one (Figures 6.12a and 6.12b). They occur most frequently either in the middle of the distal scapula or the middle of the humeral epiphysis, and are usually surrounded by a rim of sclerotic bone. Associated lameness is usually improved by intra-articular anaesthesia, although it may not be abolished. Lesions in the distal scapula are usually close to the articular surface when first recognized, but appear to move further away with time and become surrounded by a broader rim of sclerotic bone, associated with which there may be improvement in lameness. Osseous cyst-like lesions in the distal scapula occur most commonly in young horses, but are occasionally seen in association with sudden-onset lameness in mature horses. In older horses the cyst-like lesions are often more difficult to detect radiographically and may be easily missed if the radiograph is underexposed (Figure 6.12c). Secondary modelling of the

Figure 6.13 Cranial 45° medial-caudolateral oblique radiographic view of a scapulohumeral joint and proximal humerus of an 8-year-old Thoroughbred gelding with moderate lameness, unaltered by any local analgesic technique. There was focal intense increased radiopharmaceutical uptake in the cranioproximal aspect of the humerus. There is an ill defined radiolucent area, an osseous cyst-like lesion, in the cranioproximal aspect of the humerus (arrows), which coincided with the region of increased radiopharmaceutical uptake. No radiographic abnormality was detectable in a mediolateral projection.

ventral angle of the scapula is a variable feature. Not all osseous cyst-like lesions behave similarly and some in the proximal humerus 'fill in' with resolution of lameness. Some young horses with osseous cyst-like lesions in the middle of the distal aspect of the scapula have shown resolution of lameness following intra-articular medication with corticosteroids, but the response in adult horses has been poor. Occasionally modelling of the distal scapula is seen in association with an osseous cyst-like lesion in the proximal humerus.

Poorly defined osseous cyst-like lesions have also been seen to develop in the cranioproximal aspect of the humerus, caudal to the humeral tubercles, following known trauma to the shoulder region (Figure 6.13). Associated lameness has generally resolved with conservative management. Some lesions have not been detectable in a mediolateral projection, but have been seen in a craniomedial-caudolateral oblique view. Such lesions are usually not improved by intra-articular analgesia or intrathecal analgesia of the intertubercular bursa, but are associated with focal increased radiopharmaceutical uptake.

Degenerative joint disease

Degenerative joint disease (DJD) of the scapulohumeral joint occurs rarely compared with the incidence in other joints, except as a sequel to

Figure 6.14 Mediolateral radiographic view of the left scapulohumeral joint of a 5-year-old Warmblood dressage horse which had become lame within 3 weeks of purchase from a dealer. The lameness was not altered by any local analgesic technique. There was mild increased radiopharmaceutical uptake in the distal caudal aspect of the scapula. There is extensive modelling of the ventral angle of the scapula and the proximal caudal aspect of the humerus. There is loss of joint surface congruity caudally in the scapulohumeral joint, due to flattening of the caudal aspect of the humerus. This is degenerative joint disease, probably secondary to osteochondrosis.

osteochondrosis, trauma, infection or an intra-articular fracture in which cases it inevitably follows rapidly. Some of the modelling of the scapula and humerus described in conjunction with osteochondrosis is due to secondary DJD. Radiographic features of DJD include loss of congruity between the outlines of the distal scapula and the proximal humerus due to flattening of the humeral head and/or modelling of the ventral angle of the scapula (Figure 6.14). Subtle abnormalities of the cranial aspects of the joint may also be seen, including small periarticular osteophytes, especially on the distal scapula. In addition there may be variations in opacity of the subchondral bone. Narrowing of the joint space may be seen in advanced cases. The prognosis for return to athletic function is extremely poor.

Mineralization in the tendon of biceps brachii

Mineralization in the tendon of biceps brachii can occur as a sequel to a fracture of the supraglenoid tubercle (Figure 6.15), but has also been described as a bilateral condition in association with DJD of the scapulohumeral joints. It can also occur as a sequel to chronic tendonitis of biceps

Figure 6.15 Mediolateral view of a scapulohumeral joint of an aged horse. There are discrete mineralized areas (arrows) in the tendon of biceps brachii. Note the modelled supraglenoid tubercle, subsequent to previous fracture, the articular fracture fragment and the abnormally pointed distal cranial aspect of the scapula.

brachii. Mineralization is most easily identified radiographically in a mediolateral view and is seen as a variably sized opacity in the soft tissues cranioproximal to the tubercles of the humerus. The lesion is easily missed if the radiographs are overexposed. Ultrasonography may give additional information. Prognosis for future soundness is guarded.

Lesions of the humeral tubercles

Trauma to the cranial aspect of the shoulder may result in lesions of the humeral tubercles that may be difficult to identify in standard radiographic projections of the shoulder. Nuclear scintigraphy may be necessary to highlight the presence of a potential lesion. A defect in the cortical bone may be detected in some horses using a flexed cranioproximal-craniodistal oblique 'skyline' view. The intermediate tubercle is most commonly affected.

In other horses ultrasonography has been required to identify the lesion. Lameness is usually acute in onset and not responsive to any local analgesic technique. Conservative management usually results in resolution of the lameness.

Congenital abnormalities of the bicipital apparatus

Congenital abnormalities of the tubercles of the humerus have been identified rarely in mature horses with chronic forelimb lameness. These include an abnormal shape (usually narrowed) of the intertubercular sulcus seen in a mediolateral view. Absence of the minor tubercle is best seen in a skyline view of the tubercles. Radiographic evidence of secondary osteoarthritis of the scapulohumeral joint may also be seen. Ultrasonography is useful to assess the intertubercular bursa and tendon of biceps brachii, which is usually luxated medially.

Abnormalities of the scapulohumeral joint in Shetland Ponies and Miniature Horses

Dysplasia of the scapulohumeral joint, with or without subluxation of the scapulohumeral joint or secondary degenerative joint disease, has been seen in both Shetland Ponies and Miniature Horses (Figure 6.16). Unilateral degenerative joint disease, thought to be traumatic in origin, may occur in Shetland Ponies and Miniature Horses associated with sudden-onset, moderate to severe lameness. Radiographic abnormalities may not be present at the time of onset of lameness, and if mild may only be visible in a craniomedial-caudolateral oblique view. This view is also useful for assessment of congruity of the joint surfaces. Radiographic abnormalities include modelling of the articular margins of the glenoid cavity of the scapula and entheseophyte formation at the insertion of the joint capsule (Figures 6.16a–d). Mild subluxation of the joint is occasionally seen. Fragmentation of the ventral angle of the scapula has also been seen in young Shetland Ponies with acute-onset severe lameness (Figure 6.16d). Defective bone, possibly developmental in origin, may predispose to fracture. The response to intra-articular medication is poor and most ponies remain lame.

Infection

Septic arthritis of the scapulohumeral joint occurs most commonly in young foals and may result from osteomyelitis of the distal scapula or proximal humerus (type E) or the humeral physis (type P) (see Chapter 1, page 32). In adult horses septic arthritis is usually iatrogenic. Osteomyelitis of the distal scapula is characterized by lucent zones in the subchondral bone (Figure 6.17) and an irregular outline of the glenoid cavity. There may be periosteal new bone, especially on the caudodistal aspect of the scapula. Similar changes may be seen in the proximal humeral epiphysis. Osteomyelitis of the proximal humeral physis results in areas of lucency and an irregular width of the physis. This may be focal or extend along the entire

width of the physis, with or without new bone at the cortices. These changes must be differentiated from those due to osteochondrosis. Septic arthritis may result in apparent widening of the joint space due to excess synovial fluid. The granular opacity and irregular outline of incompletely ossified bones (see Figure 6.3, page 276) should not be confused with the results of infection.

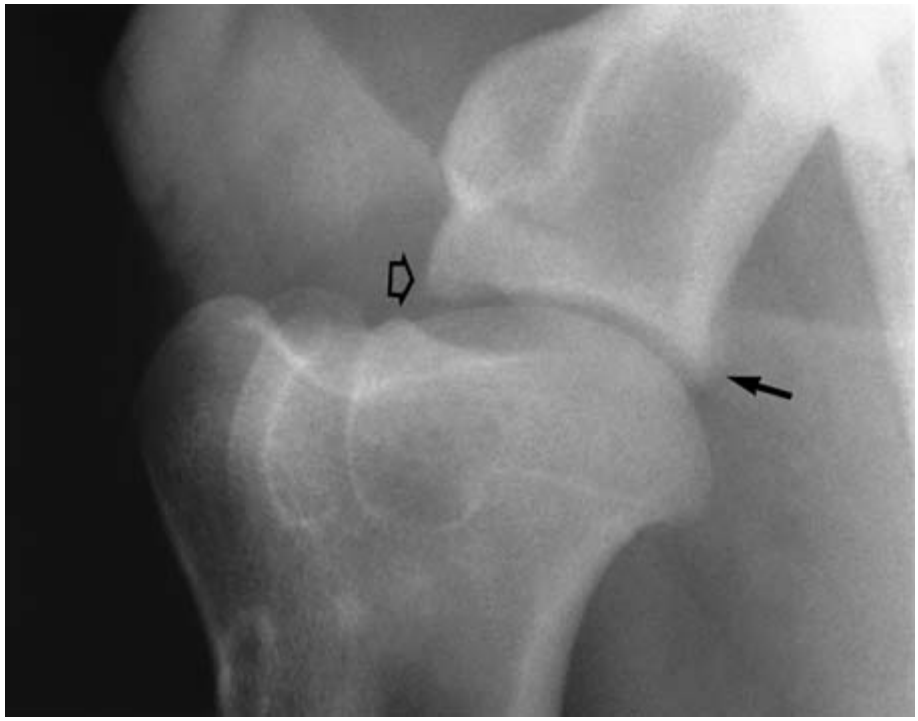


Figure 6.16(a) Craniomedial-caudolateral oblique view of a scapulohumeral joint of a Miniature Horse. No radiological abnormalities were detected in a mediolateral projection. In this oblique view there is poorly defined periosteal new bone on the ventral angle of the scapula (solid arrow). The craniolateral aspect of the scapula is less sharply defined than normal (open arrow).

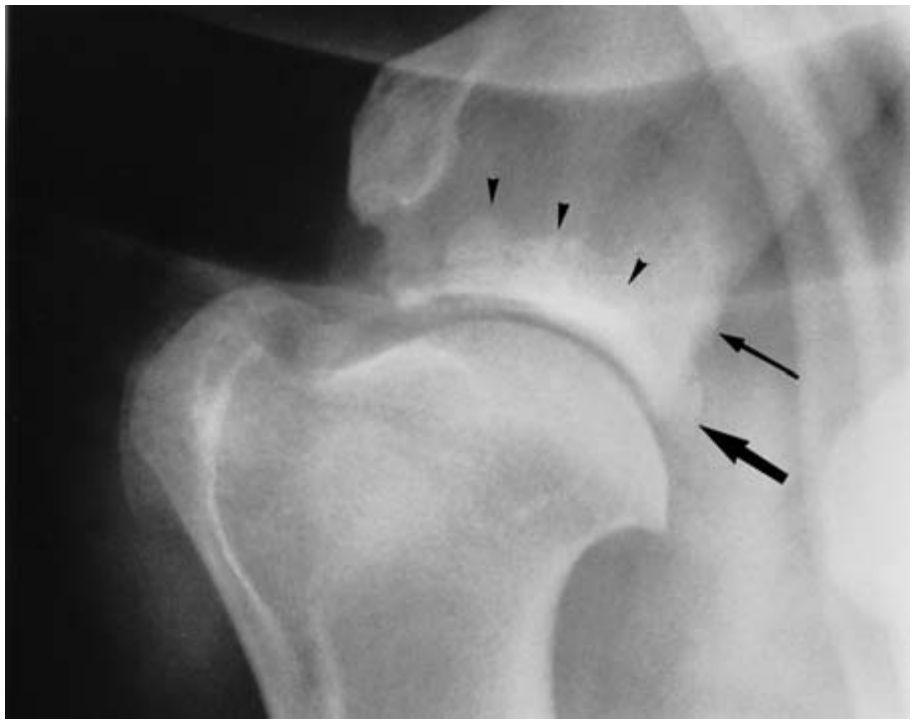


Figure 6.16(b) Mediolateral view of a scapulohumeral joint of a 4-year-old Shetland Pony. There is fairly extensive new bone on the caudal aspect of the ventral angle of the scapula (large arrow), extending proximally along the caudodistal margin of the scapula (small arrow). There is generalized increased opacity of the distal scapula (arrow heads), probably due to the extensive nature of the new bone formation around the distal scapula.

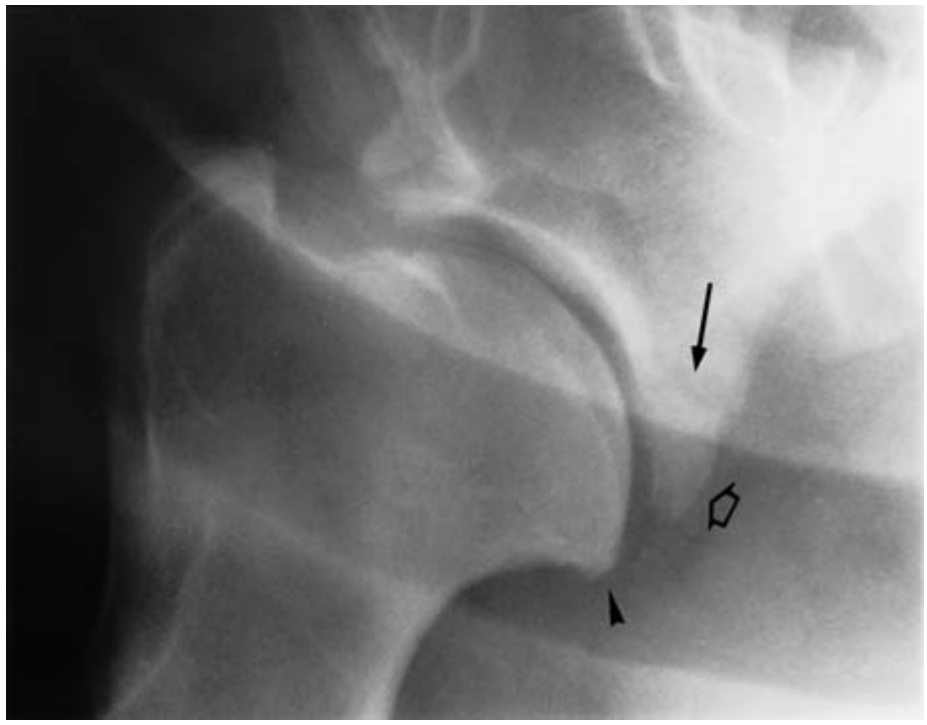


Figure 6.16(c) Mediolateral view of a scapulohumeral joint of a 4-year-old Shetland Pony. There is slight modelling on the articular margin of the proximocaudal aspect of the humerus (arrowhead). There is extensive new bone on the caudoventral aspect of the scapula, and an abnormal contour of the ventral angle of the scapula (open (arrow). There is an ill defined lucent line (solid arrow) crossing the ventral angle into the scapulohumeral joint. A large discrete fragment was identified at arthroscopic examination.

Figure 6.16(d) Mediolateral view of a scapulohumeral joint of a 5-year-old Shetland Pony. The joint surfaces of the scapula and humerus are abnormally flat and there is subluxation of the joint. There is extensive new bone on the caudoventral aspect of the scapula, and a separate mineralized opacity caudally.

Septic physitis in the proximal humeral physis has also been recognized in 2-year-old Thoroughbreds in race training with sudden onset of forelimb lameness. Radiographs are characterized by a large radiolucent zone in the caudal aspect of the physis, with surrounding sclerosis and periosteal new bone on the caudal physeal and metaphyseal regions of the proximal aspect of the humerus. Long-term antimicrobial therapy may be successful in the treatment of this condition.

Figure 6.17 Mediolateral view of a scapulohumeral joint of a 7-month-old Thoroughbred with osteomyelitis of the distal scapula and the proximal humerus and septic arthritis. Note the ill defined lucent zones in the distal scapula, the flattened shape of the humeral head due to its partial collapse and the widened joint space. There is periosteal new bone around the ventral angle of the scapula.

Luxation of the scapulohumeral joint

Luxation of the scapulohumeral joint causes firm swelling in the shoulder region and severe lameness. The humerus may be displaced proximally and cranially (Figure 6.18) or proximally and caudally and is readily seen radiographically in a mediolateral projection, the proximal humerus being superimposed over the distal scapula. An oblique view is invaluable for determining whether the luxation is medial or lateral and for identification of any concurrent fracture. A simple luxation must be reduced rapidly, with the horse anaesthetized. Full return to athletic function has been recorded. The presence of a concurrent fracture warrants a guarded prognosis.

Fractures

Fractures of the shoulder region are usually the result of a fall, a kick or a collision with a solid object. They cause moderate to severe lameness with a variable amount of soft-tissue swelling, with or without audible or palpable crepitus.

Figure 6.18 Mediolateral view of a scapulohumeral joint of a mature pony with cranioproximal luxation of the humerus. Craniomedial-caudolateral oblique views should also be obtained to ensure that there is no concurrent fracture. This luxation was successfully reduced and the pony ultimately resumed full athletic function.

Fracture of the supraglenoid tubercle

This is the most common fracture in the shoulder region. The fracture may be simple or comminuted and there is often an articular component. There may be a separate fracture through the glenoid notch (this represents the separate centre of ossification of the cranial part of the glenoid cavity of the scapula). The supraglenoid tubercle is usually displaced cranially and distally resulting in a non-union fracture. Lameness may initially improve, but usually persists unless the fracture is treated surgically. Mineralization in the tendon of biceps brachii may be a sequel.

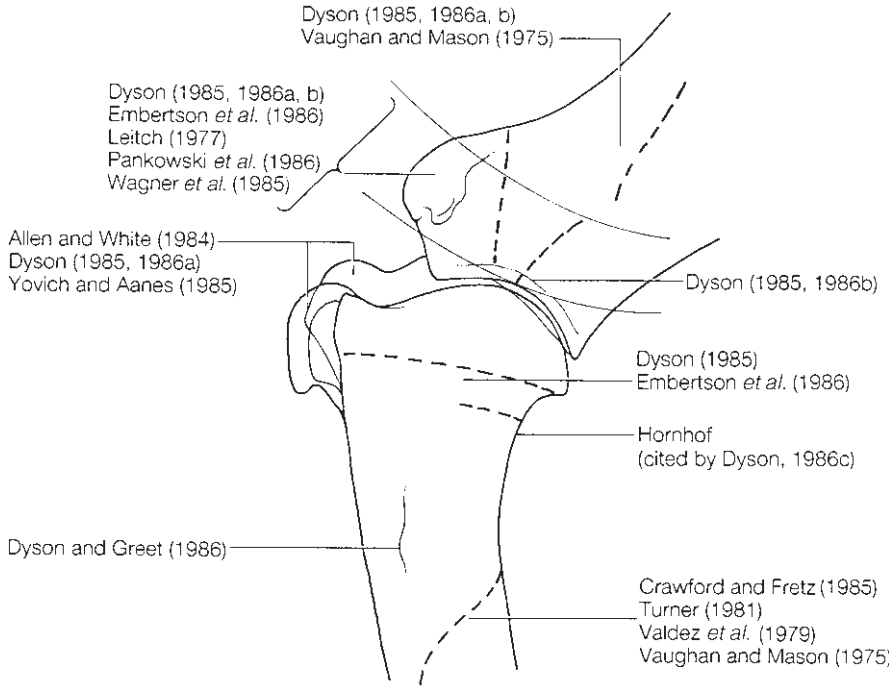


Figure 6.19 Location of common fractures of the scapula and humerus, and recommended references (see 'Further reading').

Other fractures

Other common sites of fractures are illustrated in Figure 6.19. Fractures restricted to the glenoid cavity of the scapula may be difficult to identify in a mediolateral view, but may be seen in an oblique projection. Fractures of the body or neck of the scapula are not uncommon and may be articular. Short fractures of the neck and body are easily overlooked due to superimposition of the cervical and thoracic vertebrae and the ribs. A fracture of the scapular spine may be very difficult to identify radiographically except in tangential views. Such fractures are sometimes associated with a chronic draining sinus due to sequestrum formation.

Fractures of the deltoid tuberosity and the greater, lesser and intermediate tubercles of the humerus may only be identifiable in a craniomedial-caudolateral oblique projection (Figure 6.20), cranioproximal-craniodistal oblique view or, for the greater tubercle, a caudolateral-craniomedial oblique view. Fatigue (stress or fissure) fractures of the caudal aspect of the proximal humeral metaphysis or cranial aspect of the distal humeral metaphysis occur occasionally. They can be difficult to identify radiographically in the acute phase, although they may be demonstrable using nuclear scintigraphy. Fractures of the humeral diaphysis are usually oblique or spiral with considerable overriding, with or without comminution. The prognosis for a fracture in the shoulder region depends on its location and configuration, and readers are advised to consult the references listed under 'Further reading'.

Figure 6.20 Craniomedial-caudolateral oblique view of a proximal humerus of a 3-year-old Thoroughbred. There is a non-displaced fracture of the deltoid tuberosity. No abnormality was detectable in a mediolateral view. The filly was treated conservatively and made a complete recovery.

Humeroradial, humeroulnar and radioulnar (elbow) joints and radius

RADIOGRAPHIC TECHNIQUE

Equipment

The elbow joint and the radius are readily examined radiographically using a portable machine, with the horse standing. Sedation and administration of analgesics may facilitate positioning of the limb. Digital systems or fast screens are recommended, but a grid is not essential. An aluminium wedge filter is useful; otherwise it may be necessary to obtain two mediolateral views to obtain correct exposures of the olecranon of the ulna and the humeroradial joint.

Positioning

Mediolateral view

For radiography of the elbow the horse is positioned with the limb to be radiographed next to the cassette. The x-ray machine is placed on the opposite side of the horse. The forelimb to be examined is protracted so that the olecranon of the ulna is cranial to the muscles of the contralateral limb. The x-ray beam is centred approximately at the junction between the cranial two-thirds and caudal one-third of the forearm, at the level of the proximal articular surface of the radius.

The majority of the radius can be examined radiographically with the horse bearing weight on the limb. The x-ray beam is centred at the point of interest and is aligned at right angles to the limb.

Craniocaudal views

Craniocaudal radiographic views of the elbow joint are usually obtained with the horse bearing weight on the limb, and the cassette held caudal to the forearm, beneath the thorax. It is helpful to rotate the cassette so that it can be held as high under the thorax as possible. It may be necessary to direct the x-ray beam approximately 10–15° from cranioproximally to caudodistally, depending on the shape of the rib cage, in order to examine the distal humerus and the humeroradial joint properly. Unfortunately this technique will cause some distortion of the radiographic image.

Alternatively the limb may be protracted, the cassette held parallel with the ulna and the x-ray beam directed perpendicular to it. There is more likely to be movement blur using this technique, and if there is a fracture of the ulna it may be difficult to straighten the limb adequately. Good-quality craniocaudal views, with minimal distortion, are obtained more readily with the horse anaesthetized.

The radius is radiographed with the horse bearing weight on the limb. The beam is centred at the area of interest.

Oblique views

A craniomedial-caudolateral oblique view is the easiest oblique view to obtain with the horse bearing weight on the limb (see Figure 6.25, page 308). A craniolateral-caudomedial oblique view of the proximal radius is feasible, but due to the relative positions of the sternum and distal humerus, it is impractical to obtain a similar view of the humerus.

RADIOGRAPHIC ANATOMY, NORMAL VARIATIONS AND INCIDENTAL FINDINGS

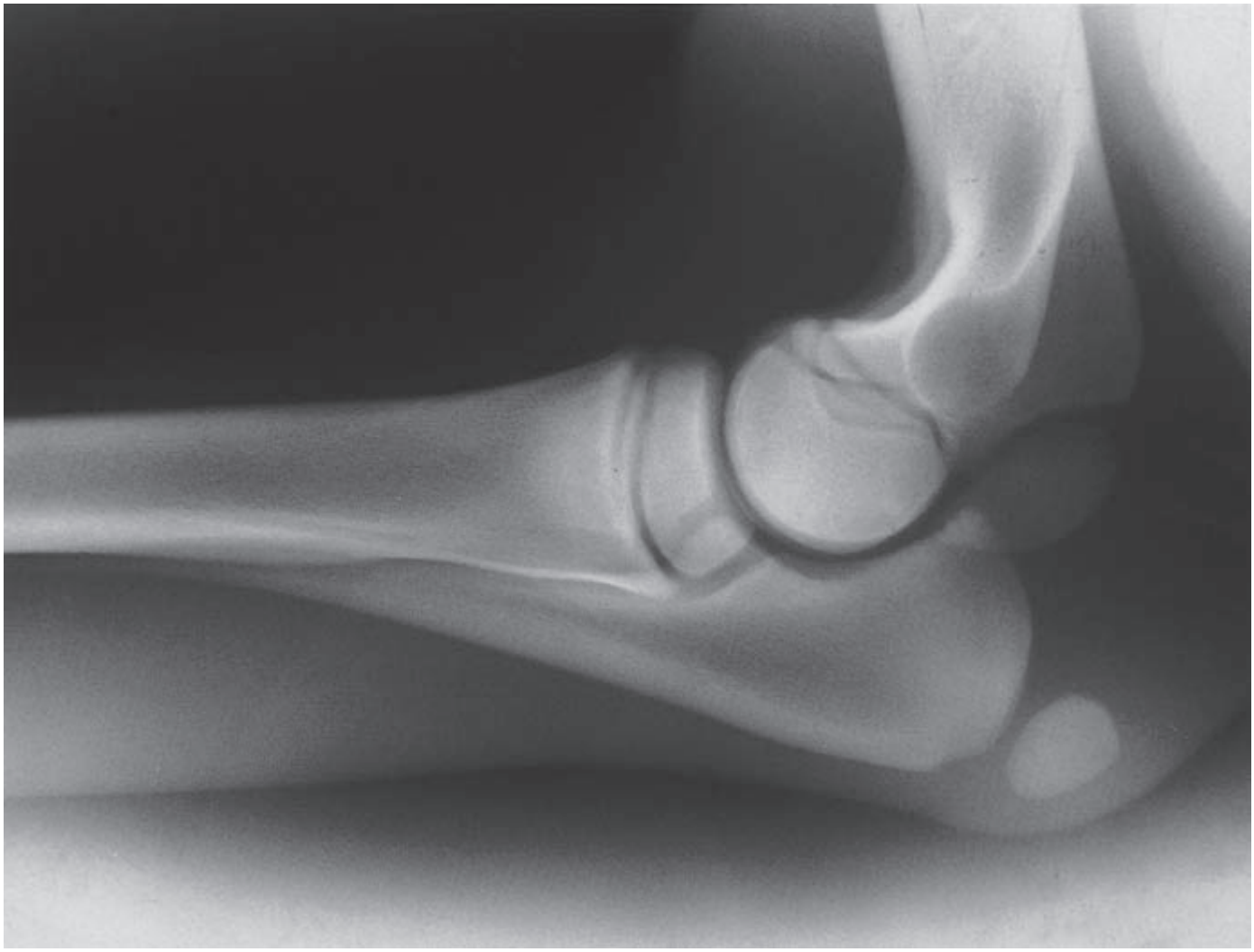
Birth to 3 years old

The distal humerus develops from three ossification centres: the diaphysis, the distal epiphysis and the epiphysis of the medial epicondyle. The radius has a single proximal epiphysis and the ulna has a single proximal apophysis (Figure 6.21); the ulna may also have a separate centre of ossification for the anconeal process (Figure 6.22). At birth the ossification centres are rounded and may be irregular in outline because they are incompletely ossified. The apophysis of the ulna is small and widely separated from the metaphysis. It gradually enlarges to cover the proximal ulnar metaphysis by 10–12 months. The physis appears very irregular (Figure 6.22) and remains open until 24–36 months after birth. The distal humeral physes and the proximal radial physis close between 11 and 24 months. The distal radial physis closes by between 22 and 42 months of age; there is a separate centre of ossification of the lateral styloid process which fuses with the rest of the distal epiphysis within the first year of life.

Skeletally mature horse

Mediolateral view

There is little variation in the normal radiographic appearance of the adult elbow except as a result of positioning (Figure 6.23). The anconeal process of the ulna may be sharply pointed or rounded. The trochlear notch of the ulna is divided into an articular zone proximally and a synovial fossa distally, separated by a distinct ridge. It is important to differentiate between these two areas when assessing a fracture involving the trochlear notch. The interosseous space between the ulna and radius may be clearly or poorly defined, depending upon the angle of projection. The ulna is incomplete in the majority of horses and fuses distally with the radius. Some horses have a vestigial distal ulna (see Figures 5.11a and 5.11b, page 249) and occasionally the ulna is complete. The cranial margin of the proximal articular surface of the radius has several 'lips' which must not be confused with osteophyte formation.



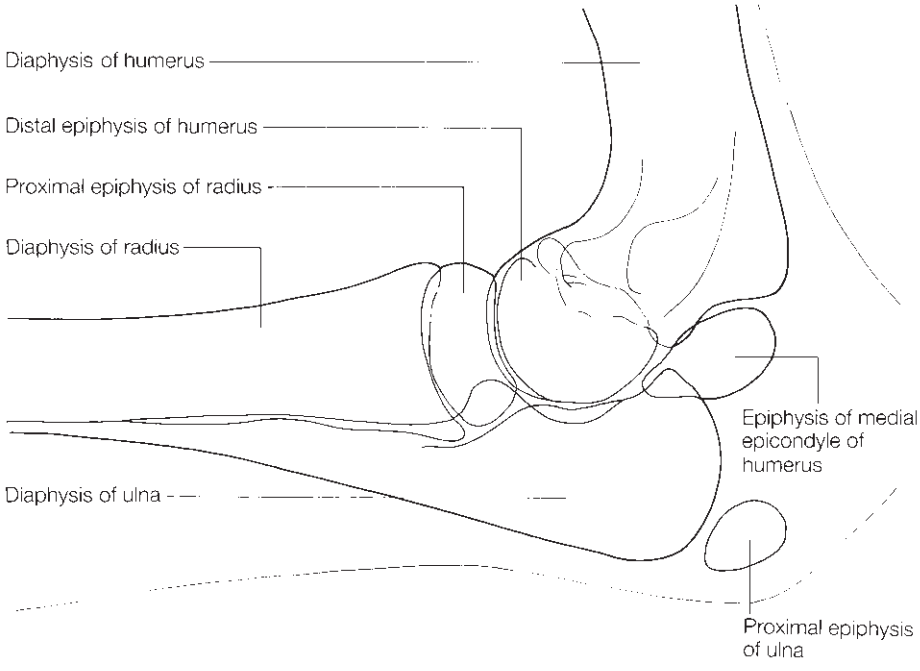


Figure 6.21 Mediolateral view and diagram of a normal elbow of a 12-day-old foal. Note the position of the incompletely ossified proximal epiphysis of the ulna.

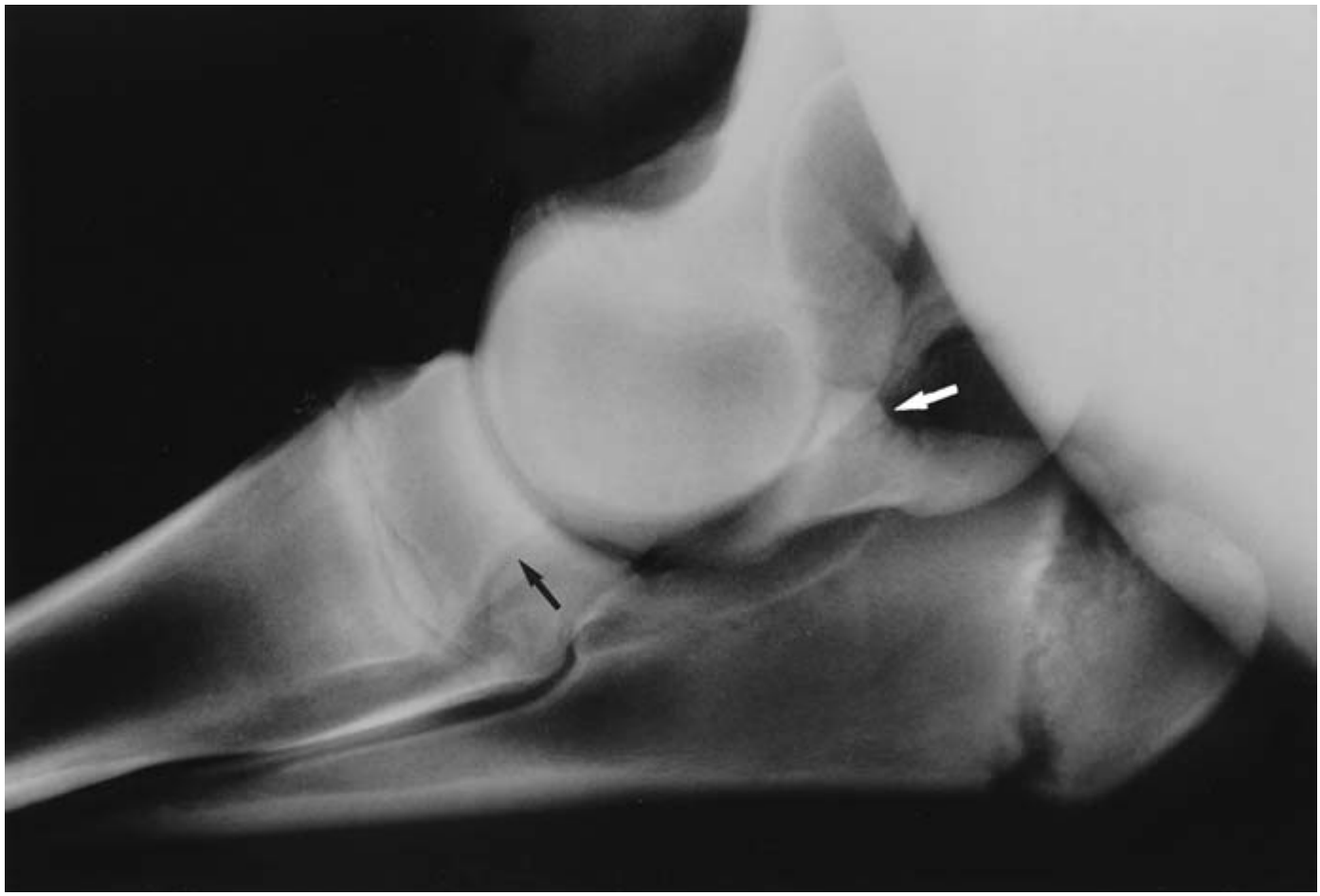


Figure 6.22 Mediolateral view of a normal elbow of an 11-month-old filly. The proximal ulnar epiphysis has enlarged compared with Figure 6.21 and is fusing with the metaphysis, but the physis is extremely irregular. There is a radiolucent line (black arrow) in the caudal aspect of the proximal radial physis which represents part of the radioulnar articulation. Positioning is not ideal, since the opacity of the pectoral muscles is superimposed over the proximal aspect of the ulna. The anconeal process (white arrow) is a separate centre of ossification.

The radial tuberosity is smoothly outlined, but may appear irregular in a slightly oblique mediolateral projection. The medial aspect of the head of the radius is wider craniocaudally than the lateral aspect. Therefore the radioulnar articulation is not in a single plane, and in a mediolateral view the articulation of the lateral aspect of the ulna with the proximal radius is seen as a lucent line through the caudal aspect of the radius (Figure 6.22).

There is an irregularly outlined bony prominence, the transverse crest, on the distocaudal aspect of the radius. Its size depends on the angle of projection, since slight obliquity will enhance it. The mottled opacity of the torus carpeus (chestnut) on the caudal aspect of the radius must not be confused with dystrophic mineralization of soft tissues. Other radiographic characteristics of the distal radius are discussed in Chapter 5 (pages 239–248).

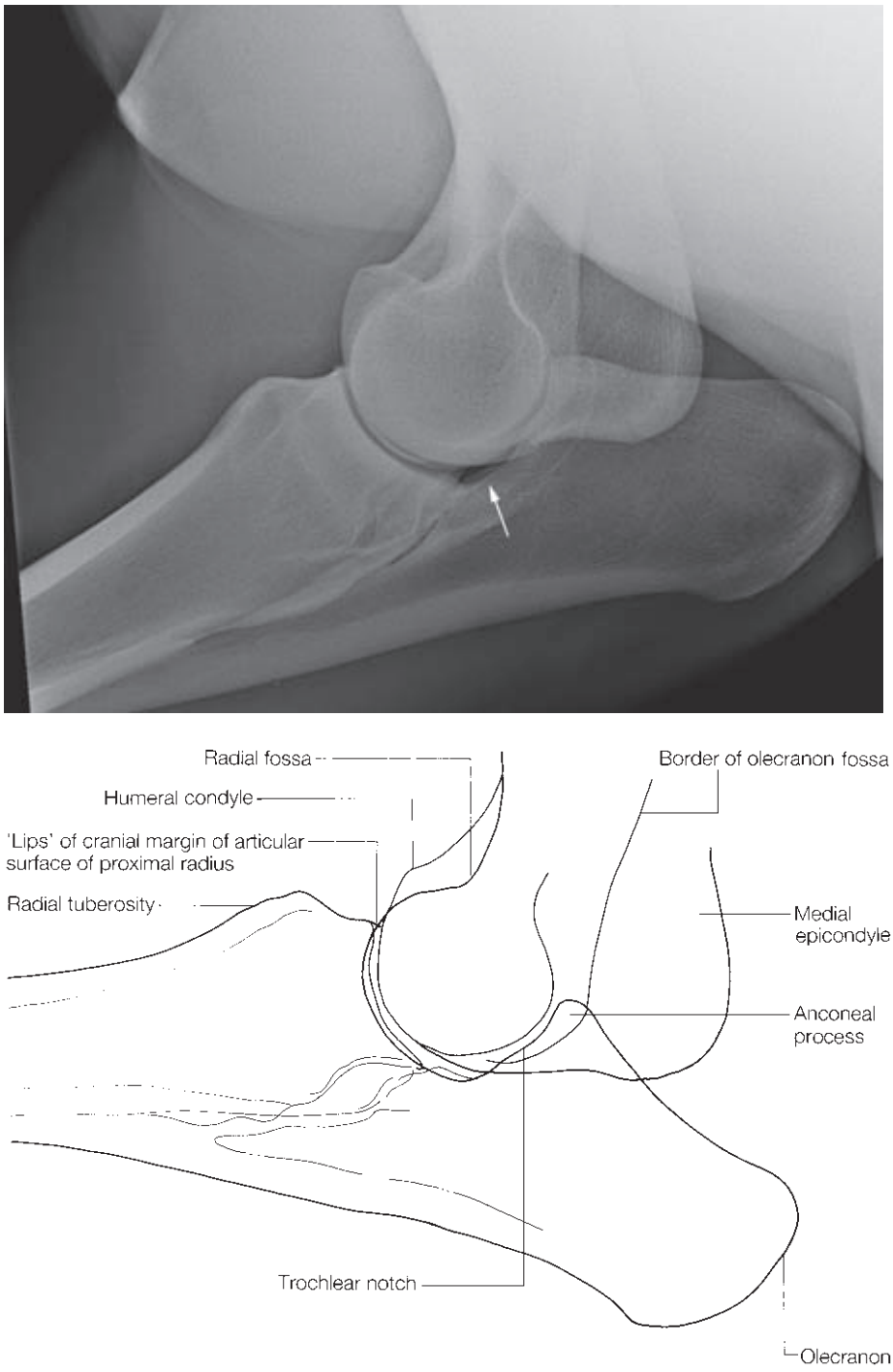


Figure 6.23 Mediolateral view and diagram of a normal adult elbow. The non-articular portion of the trochlear notch of the ulna is arrowed.

Figure 6.24 Craniocaudal view and diagram of a normal adult elbow. Lateral is to the right.

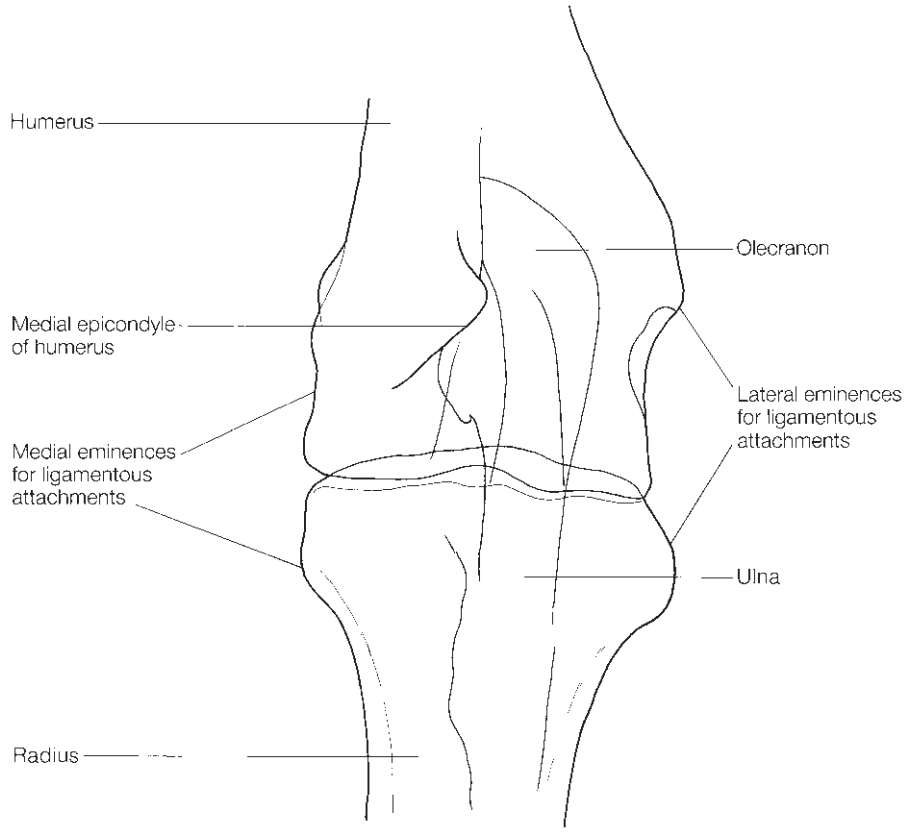


Figure 6.24 *Cont'd*

Craniocaudal views

The humeroradial joint space often appears wider medially than laterally. There are smoothly outlined eminences on the medial and lateral aspects of the distal humerus and proximal radius for attachment of the collateral ligaments (Figure 6.24).

SIGNIFICANT RADIOLOGICAL ABNORMALITIES

Osteochondrosis

Osteochondrosis of the elbow in the horse is rare. It has been documented at post-mortem examination involving the medial condyle of the humerus and the medial proximal aspect of the radius. Lameness associated with a separate bone fragment detached from the anconeal process of the ulna has been described in a 2-year-old Standardbred. The lameness was relieved by intra-articular anaesthesia of the elbow. The anconeal process is best assessed in a mediolateral view, and detachment of its apex may be an osteochondritic lesion. Care must be taken in the assessment of young foals in which the anconeal process may be a separate centre of ossification.

Figure 6.25 Craniomedial-caudolateral oblique view of a normal adult elbow.

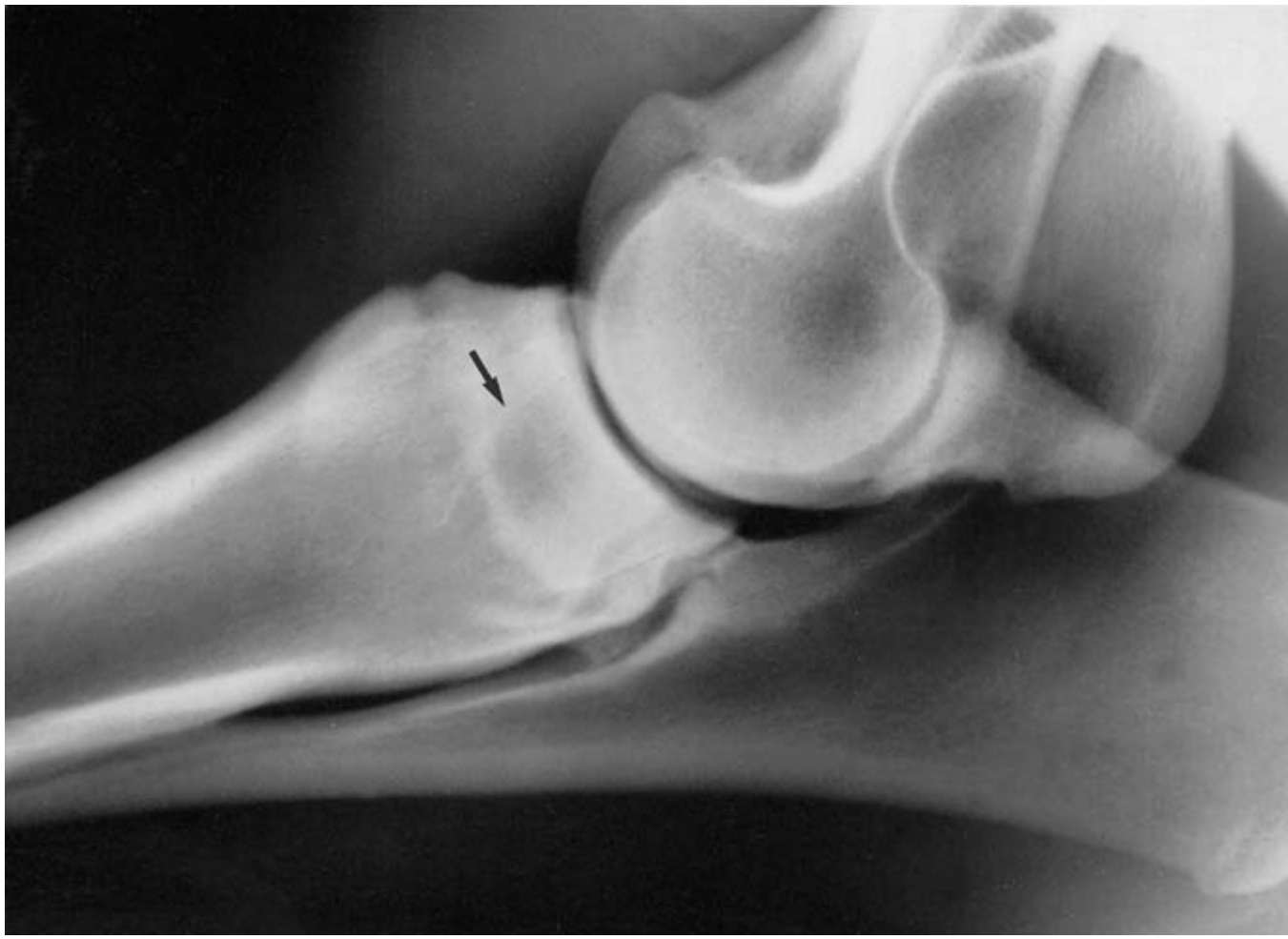
Osseous cyst-like lesions

Osseous cyst-like lesions occasionally occur close to the elbow joint and are usually seen in young horses. They occur most commonly in the medial aspect of the proximal radial epiphysis in association with periosteal reactions at the site of insertion of the medial collateral ligament of the humeroradial joint (Figures 6.26a and 6.26b). These cyst-like lesions may ultimately 'fill-in' radiographically, but degenerative joint disease may be a sequel. The response to conservative treatment has been variable; surgical treatment might yield better results. The joint should be inspected carefully for evidence of secondary degenerative joint disease, before contemplating surgery.

Osseous cyst-like lesions occur less commonly in the distal aspect of the radius. Surgical treatment may be successful.

Degenerative joint disease

Degenerative joint disease of the humeroradial, humeroulnar and radioulnar joints is uncommon except as a sequel to an osseous cyst-like lesion,



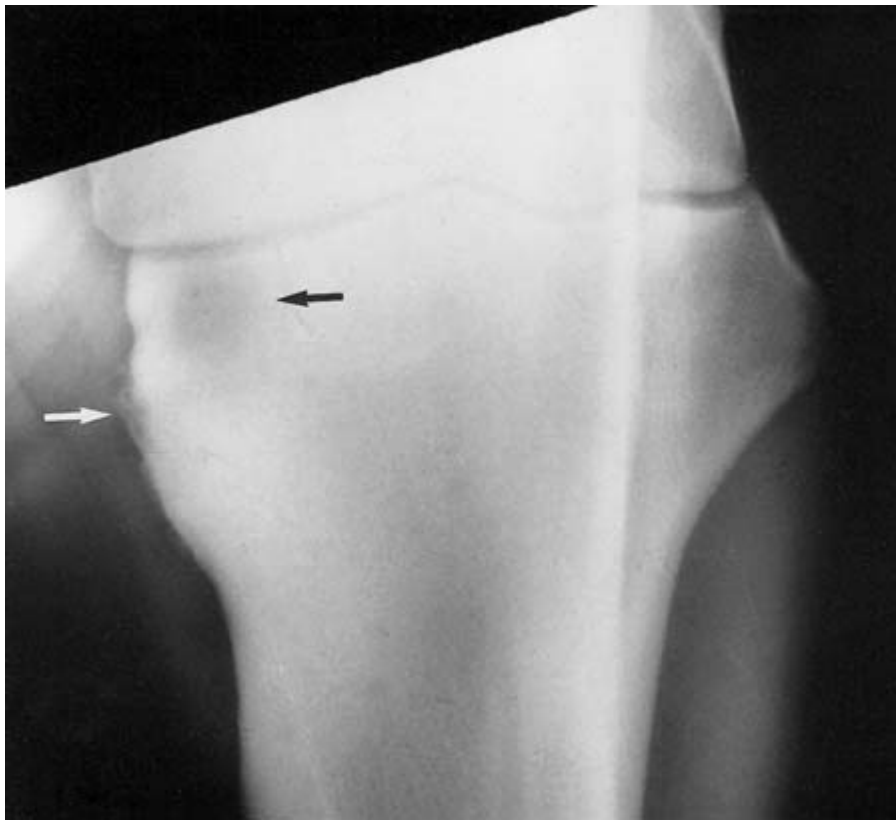


Figure 6.26(a) Mediolateral view of an elbow of a 2-year-old Thoroughbred. There is an irregularly outlined radiolucent area (arrow) in the proximal radial epiphysis and the physis is remodelled. (See also Figure 6.26(b).) The filly was treated conservatively and raced successfully.

Figure 6.26(b) Craniocaudal view of the same elbow as Figure 6.26(a). Lateral is to the right. The osseous cyst-like lesion (black arrow) is in the medial part of the epiphysis. There is periosteal new bone (white arrow) in the region of insertion of the medial collateral ligament.

Figure 6.27(a) Mediolateral view of an elbow joint of an event horse with radiographic evidence of degenerative joint disease. There is osteophyte formation on the cranioproximal aspect of the radius (compare with Figure 6.23) and modelling of the anconeal process of the ulna. Lameness was substantially improved by intra-articular analgesia.

collateral ligament damage or an articular fracture. In a mediolateral view the 'lips' of the proximal articular surface of the radius (see page 302) should not be confused with osteophytes. Craniocaudal views are more helpful for the diagnosis of degenerative joint disease. Typically, osteophyte formation is seen on the medial and lateral aspects of the distal humerus and/or the proximal radius (Figures 6.27a and 6.27b). In advanced cases there may be narrowing of the humeroradial joint space with subchondral bone sclerosis. The prognosis for return to athletic function is poor.

Periosteal proliferative reactions (enthesopathy) at the site of insertion of biceps brachii on the radial tuberosity

Entheseous new bone, with or without discrete bony fragments, may develop at the insertion of biceps brachii on the radial tuberosity, and is best seen

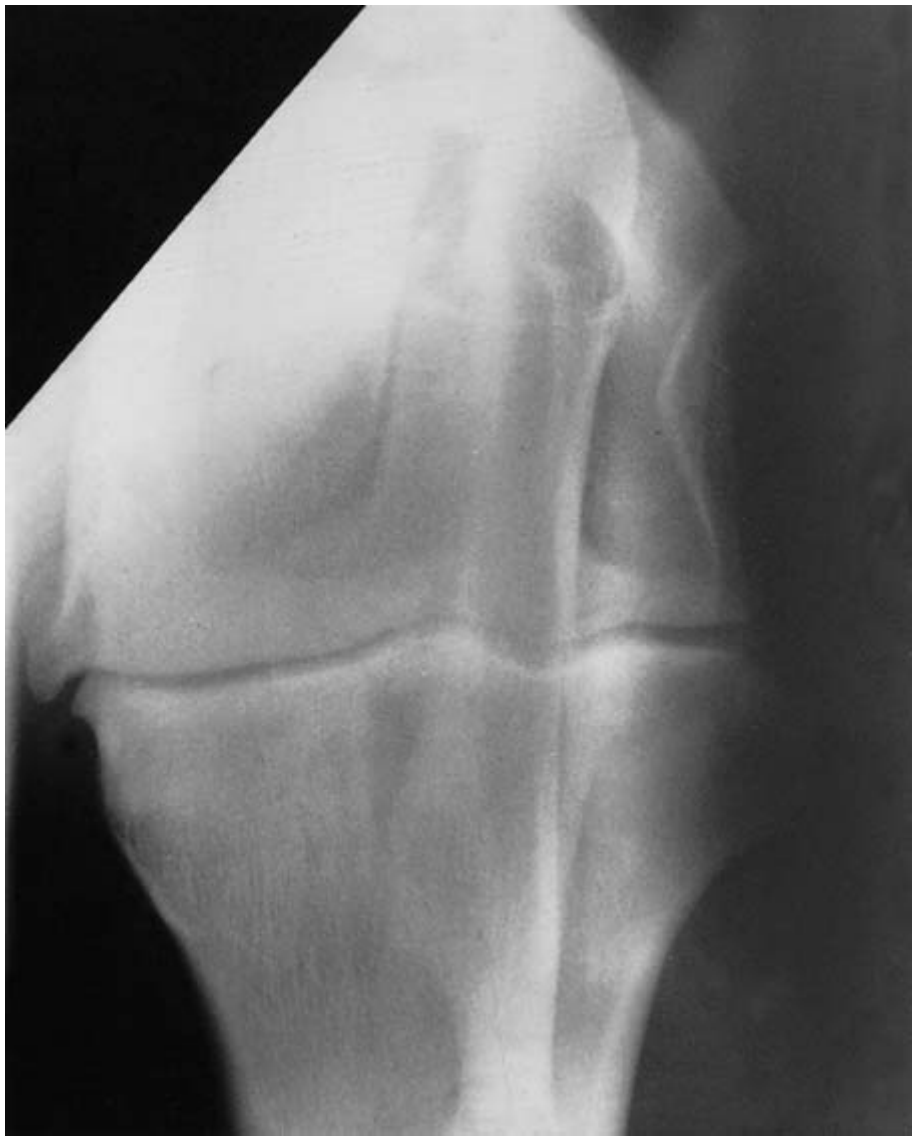


Figure 6.27(b) Craniocaudal view of an elbow (same horse as Figure 6.27a). Lateral is to the right. There is considerable osteophyte formation on the medial aspect of the humeroradial joint and rather irregular opacity of the subchondral bone on the medial aspect of the joint.

on a mediolateral view (Figure 6.28). New bone may not be identifiable until 3–6 weeks after the onset of lameness, so nuclear scintigraphy is more sensitive in the acute phase and may help to interpret the significance of entheseous new bone in a horse with more chronic lameness. In the acute phase there may be some pain on manipulation of the joint, but in more chronic cases there may be no localizing signs. Lameness may resolve with rest, but often persists.

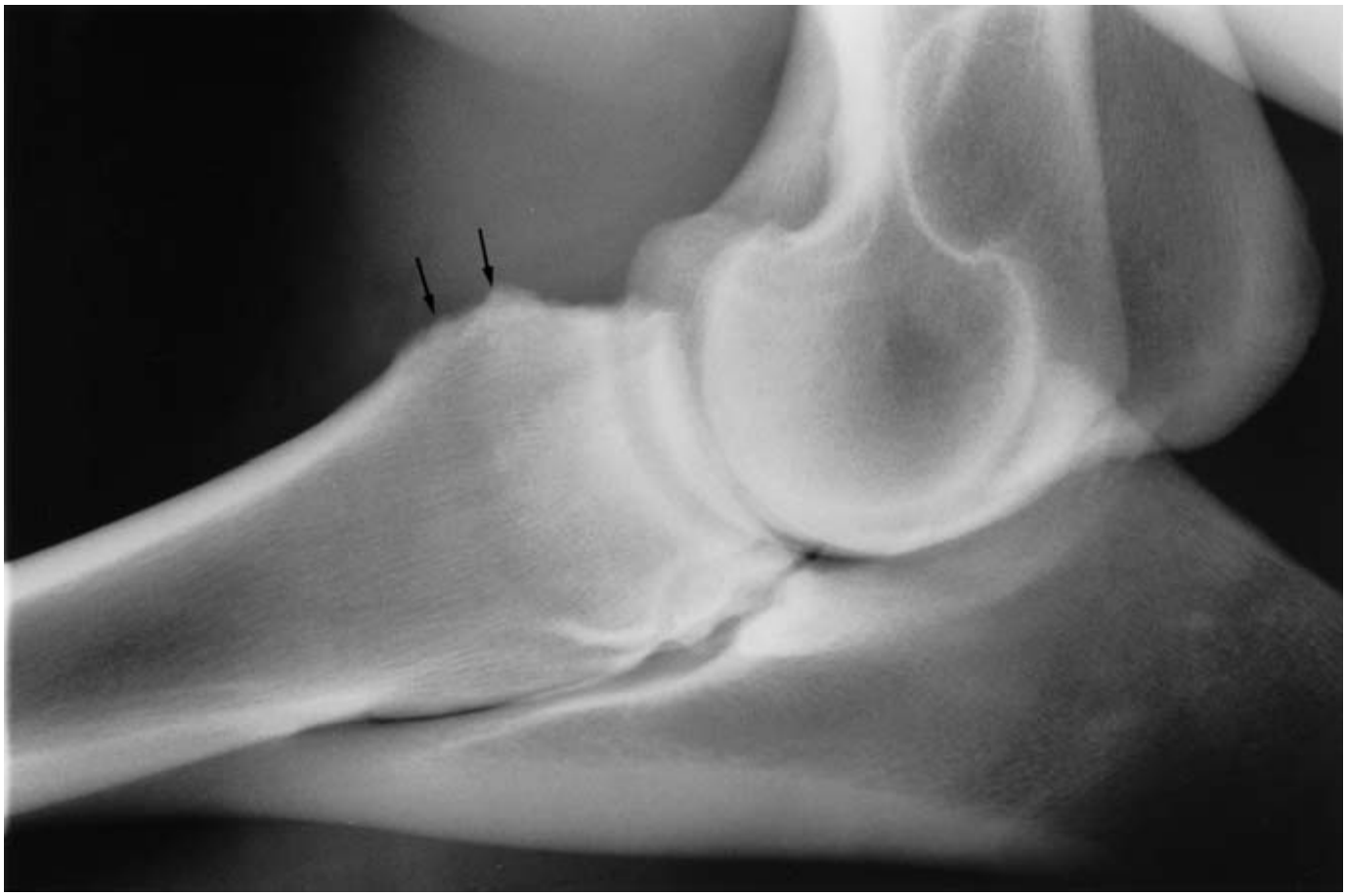


Figure 6.28 Mediolateral view of an elbow of a 7-year-old advanced event horse, with lameness of several months' duration. There is periosteal new bone formation on the cranioproximal aspect of the radius (arrows), which represents entheseophyte formation at the insertion of biceps brachii.

Entheseous new bone at the sites of attachment of the collateral ligaments of the humeroradial joint

Sprain of the lateral collateral (or, less commonly, the medial collateral) ligament of the humeroradial joint may be followed by the development of entheseous new bone on the humeral epicondyle and proximal radius, best seen in a craniocaudal projection (Figure 6.29). Occasionally a fragment may be avulsed, especially from the proximal attachment. Diagnostic ultrasonography is useful to determine the degree of ligamentous damage. Chronic instability of the joint makes degenerative joint disease a likely sequel.

Periosteal reaction at the site of origin of the accessory ligament of the superficial digital flexor tendon

Periostitis may develop proximal to the transverse ridge, on the distal caudomedial aspect of the radius, secondary to tearing of the attachment of the

Figure 6.29 Craniocaudal view of an elbow of a 10-year-old riding school pony with chronic lameness. Lateral is to the right. There is extensive new bone on the lateral aspect of the epicondyle of the humerus (arrow heads). There is periosteal roughening and new bone on the lateral and medial aspects of the proximal radius (small white arrows). This is entheseophyte formation at the sites of attachment of the collateral ligaments of the humeroradial joint. There is also mineralization in the soft tissues laterally (large white arrow). There was also slight osteophyte formation on the articular margins of the joint, seen only in a mediolateral view.

accessory ligament of the superficial digital flexor tendon (the superior or radial check ligament). Clinical signs include very subtle lameness, sometimes associated with distension of the carpal sheath in acute cases. This injury may occur concurrently with superficial digital flexor tendonitis and it is therefore prudent to examine the tendon ultrasonographically. Radiographic changes are usually only detectable in chronic cases, and rest (for 2 months) generally results in resolution of clinical signs.

Luxation of the elbow joint

Luxation of the elbow joint is not common and has only been reported concurrent with a fracture of the radius or ulna.

Infection

Infection occurs most commonly in young foals but, since the lateral aspect of the radius is poorly protected by soft tissues, a deep wound in this area may penetrate the elbow joint capsule or cause localized infection. This may spread to the joint or result in osteomyelitis of the radius or ulna in an adult horse. If the degree of lameness associated with a wound in the elbow region is unexpectedly severe, or if there is a discharging sinus, radiographic examination is indicated. Injection of as much radiopaque contrast medium as possible, via a Foley catheter, should establish whether a sinus communicates with the joint capsule or with sequestered bone (Figure 14.9b, page 707). It may also demonstrate a filling defect representing a foreign body. Ultrasonographic evaluation may also be helpful.

Osteochondroma of the distal radius

Distension of the carpal sheath, lameness and resentment of pressure applied to the distal caudal aspect of the radius may be associated with an osteochondroma on the distal diaphysis or the metaphysis of the radius.

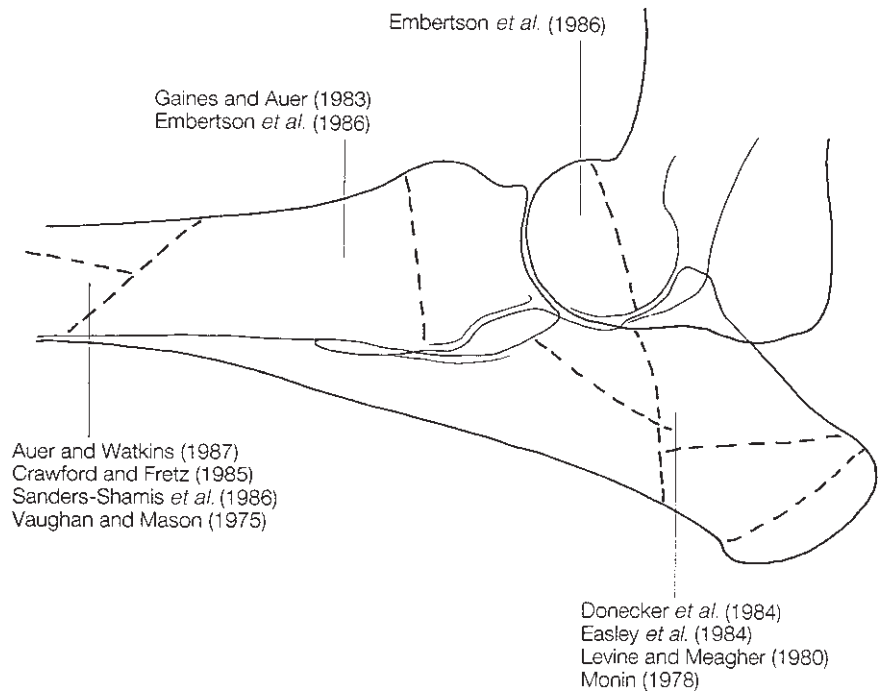


Figure 6.30 Location of common fractures in the elbow region, and recommended references (see 'Further reading').

Radiographically this appears as a variably shaped bony protuberance on the distocaudal aspect of the radius usually proximal to the physeal scar (see Figure 5.22, page 264). This mass has a thin cortex which appears to be continuous with the cortex of the radius. Sequential radiographs may demonstrate progressive enlargement of the mass. Treatment by surgical removal of the abnormal bone is usually successful in resolving both the lameness and carpal sheath swelling.

Hereditary multiple exostosis

Hereditary multiple exostosis is a rare condition characterized by multiple bony projections on growing long bones, the ribs, the pelvic bones and the dorsal spinous processes of the thoracic and lumbar vertebrae. These swellings are present at birth and may enlarge progressively until skeletal maturity. They may be asymptomatic unless impinging upon adjacent soft tissues, but may cause distension of synovial structures. The radiographic appearance is similar to that of solitary osteochondroma. There is no known treatment, but it is a hereditary condition, transmitted by an autosomal dominant gene.

Figure 6.31 Mediolateral view of an adult elbow with a comminuted fracture of the olecranon. Although one of the fracture lines enters the trochlear notch of the ulna, it involves the non-articular area.

Hypertrophic osteopathy

This condition is discussed in detail in Chapter 1 (page 22). Periosteal new bone along the diaphysis and the metaphyses of the radius may be due to hypertrophic osteopathy. The multifocal nature of the disease should help to differentiate it from other causes of periostitis.

Fractures (Figure 6.30, page 314)

Physeal fractures

Fractures of the distal physis of the humerus occur occasionally and warrant a poor prognosis. In an immature horse, the open proximal physis of the ulna should not be confused with a fracture. The apophysis may be displaced proximally (Salter-Harris type 1 fracture) (see Chapter 1, page 25) and it is important to compare its position with a horse of similar age. Radiographic examination of the contralateral limb provides an ideal comparison. These fractures and both proximal and physeal fractures of the radius have a fair prognosis.

Ulnar fractures

Fracture of the olecranon of the ulna is a common sequel to trauma in the elbow region. Lameness is usually severe and the horse may stand with the elbow 'dropped'. There may or may not be associated soft-tissue swelling. Radiographic examination of a suspected facture should include both mediolateral and craniocaudal views in order to assess its configuration accurately. A fracture which enters the trochlear notch must be assessed carefully to determine whether or not it involves the articular or non-articular region (Figure 6.31). Provided that ulnar fractures are recognized and treated early, the prognosis depends primarily on whether the fracture is simple or compound, the extent of comminution and the degree of displacement of the fracture fragments. Internal fixation offers the best chance for full return to athletic function.

Radial fractures

Radial fractures are a common result of trauma and occur in many configurations, incomplete parasagittal (see page 317), comminuted, transverse and physeal being the most frequent. Multiple radiographic views may be necessary to assess the full extent of a fracture. Repair may be successful in immature horses, but the prognosis in adult horses for complete fractures is extremely guarded. Incomplete fissure (stress) fractures or incomplete fractures resulting from kick injuries (Figures 6.32a and 6.32b) often heal with conservative treatment (3–6 months' box rest) provided external stability is maximal.

Fatigue or stress fractures of the radial diaphysis occur in young (2- and 3-year-old) Thoroughbreds in training. Although they may not be detectable radiographically in the acute phase, there may be localized increased opacity of the medulla. Nuclear scintigraphy is a more sensitive diagnostic

Figure 6.32(a) Craniomedial-caudolateral oblique radiographic view of the radius of a 16-year-old hunter, which had been kicked on the antebrachium 2 weeks previously. There was a discharging wound and the horse was non-weight-bearing on the limb. There is an oblique radiolucent line (arrows), representing an incomplete fissure fracture.

Figure 6.32(b) Craniomedial-caudolateral oblique view of the same horse as in Figure 6.32(a), obtained 10 days later. The fracture line is now much more obvious (arrows), extends much further proximally than was previously apparent and is surrounded by some more opaque bone, representing callus.

technique. Medullary sclerosis in the mid-diaphyseal region reflects endosteal callus and should be differentiated from an enostosis-like lesion.

Enostosis-like lesions

The radius is one of the more common sites for enostosis-like lesions, which are seen most commonly in young Thoroughbred racehorses and cause acute, often severe lameness. There are usually no localizing clinical signs and diagnosis is usually dependent on the identification of focal increased radiopharmaceutical uptake in the radial diaphysis, often close to the nutrient foramen. Radiographic examination reveals focal increased opacity. Lameness usually resolves with time, although in some horses it shifts between limbs.

FURTHER READING

Allen, D. and White, N. (1984) Chip fracture of the greater tubercle of a horse. *Comp. Cont. Educ.*, **6**, S39–41

Auer, J. and Watkins, J. (1987) Treatment of radial fractures in adult horses: an analysis of 15 clinical cases. *Equine vet. J.*, **19**, 103–110

Bertone, A., McIlwraith, C., Powers, P., Stashak, T., Aanes, W. and Turner, A. (1986) Subchondral osseous cystic lesions of the elbow of horses: conservative versus surgical treatment. *J. Am. Vet. Med. Ass.*, **189**, 540–546

Bohn, A., Papageorges, M. and Grant, B. (1992) Ultrasonographic evaluation and surgical treatment of humeral osteitis and bicipital tenosynovitis in a horse. *J. Am. Vet. Med. Ass.*, **201**, 305–306

Booth, T. (1999) Lameness associated with the bicipital bursa in an Arab stallion. *Vet. Rec.*, **145**, 194–198

Boswell, J., Schramme, M., Wilson, A. and May, S. (2000) Radiological study to evaluate suspected scapulohumeral joint dysplasia in Shetland ponies. *Equine vet. J.*, **32**, 510–514

Boys Smith, S. and Singer, E. (2007) Mineralisation of the biceps brachii tendon in a 6-year-old Cob mare. *Equine vet. Educ.*, **19**, 74–79

Brown, M. and MacCallum, F. (1974) Anconeal process of ulna: separate centre of ossification in the horse. *Br. Vet. J.*, **130**, 434–438

Chopin, J., Wright, J., Melville, L. and Robinson, W. (1997) Lateral collateral ligament avulsion of the humeroradial joint in a horse. *Vet Radiol. and Ultrasound*, **38**, 50–54

Coudry, V., Allen, K. and Denoix, J.-M. (2005) Congenital abnormalities of the bicipital apparatus in four mature horses. *Equine vet. J.*, **37**, 272–275

Crawford, W. and Fretz, P. (1985) Long bone fractures in large animals: a retrospective study. *Vet. Surg.*, **14**, 295–302

Crawley, G. and Grant, B. (1986) Repair of elbow joint luxation without concomitant fracture in a horse. *Equine Pract.*, **8**(5), 19–26

Davidson, E. and Martin, B. (2004) Stress fracture of the scapula in 2 horses. *Vet. Radiol and Ultrasound*, **45**, 407–410

Derungs, S., Fuerst, A., Haas, C., Geissbuhler, U. and Auer, J. (2001) Fissure fractures of the radius and tibia in 23 horses: a retrospective study. *Equine vet. Educ.*, **13**, 313–318

Donecker, J., Bramlage, L. and Gabel, A. (1984) Retrospective analysis of 29 fractures of the olecranon process of the equine ulna. *J. Am. Vet. Med. Ass.*, **185**, 183–189

Doyle, P. and White, N. (2000) Diagnostic findings and prognosis following arthroscopic treatment of subtle osteochondral lesions in the shoulder joint of horses. *J. Am. Vet. Med. Ass.*, **217**, 1878–1882

Dyson, S. (1985) Sixteen fractures of the shoulder region in the horse. *Equine vet. J.*, **17**, 104–110

Dyson, S. (1986a) Shoulder lameness in the horse: an analysis of 58 suspected cases. *Equine vet. J.*, **18**, 29–36
Dyson, S. (1986b) The differential diagnosis of shoulder lameness in the horse. *Thesis*, Fellowship of the Royal College of Veterinary Surgeons
Dyson, S. (1986c) Interpreting radiographs 7: Radiology of the equine shoulder and elbow. *Equine vet. J.*, **18**, 352–361
Dyson, S. and Greet, T. (1986) Repair of a fracture of the deltoid tuberosity of the humerus in a pony. *Equine vet. J.*, **18**, 230–232
Easley, K., Schneider, J., Guffy, M. and Boero, M. (1984) Equine ulnar fractures: a review of 25 clinical cases. *Equine Vet. Sci.*, **3**(1), 5–12
Edwards, G. and Vaughan, L. (1978) Infective arthritis of the elbow joint in the horse. *Vet. Rec.*, **103**, 227–229
Embertson, R., Bramlage, L. and Gabel, A. (1986) Physeal fractures in the horse II: management and outcome. *Vet. Surg.*, **14**, 295–302
Firth, E., Dik, K., Goedegebuure, S., Hagens, F., Verberne, L., Merkens, H. and Kersjes, A. (1980) Polyarthritis and bone infection in foals. *Zbl. Vet. Med.*, **B27**, 102–124
Fitch, G. and Martinelli, M. (1998) Conservative management of a sequestrum involving the radial cortex in 2 horses. *Equine vet. Educ.*, **10**, 228–232
Forresu, D., Lepage, O. and Cauvin, D. (2006) Septic bicipital bursitis, tendonitis and arthritis of the scapulohumeral joint in a mare. *Vet. Rec.*, **159**, 352–354
Fugaro, M. and Adams, S. (2002) Biceps brachii tenotomy or tenectomy for the treatment of bicipital bursitis, tendonitis and humeral osteitis in 3 horses. *J. Am. Vet. Med. Ass.*, **220**, 1508–1511
Gaines, J. and Auer, J. (1983) Treatment of a Salter Harris Type III epiphyseal fracture in a young horse. *Comp. Cont. Educ.*, **5**, S102–106
Hardy, J., Marcoux, M. and Eisenberg, H. (1986) Osteochondrosis-like lesion of the anconeal process in 2 horses. *J. Am. Vet. Med. Ass.*, **189**, 802–803
Kay, A. (2006) An acute subchondral cystic lesion of the equine shoulder causing lameness. *Equine vet. Educ.*, **18**, 316–319
Leitch, M. (1977) A review of treatment of tuber scapulae fractures in the horse. *J. Equine Med. Surg.*, **1**, 234–240
Levine, S. and Meagher, D. (1980) Repair of an ulnar fracture with radial luxation in a horse. *Vet. Surg.*, **9**, 58–60
Mackey, V., Trout, D., Meagher, D. and Hornhof, W. (1987) Stress fractures of the humerus, radius and tibia in horses. *Vet. Radiol.*, **28**, 26–31
Meagher, D., Pool, R. and Brown, M. (1979) Bilateral ossification of the tendon of biceps brachii muscle in the horse. *J. Am. Vet. Med. Ass.*, **174**, 282–285
Meagher, D., Pool, R. and O'Brien, T. (1973) Osteochondrosis of the shoulder joint in the horse. *Proc. Am. Ass. Equine Pract.*, **19**, 247–256
Mez, J., Dabareiner, R., Cole, R. and Watkins, J. (2007) Fracture of the greater tubercle of the humerus in horses: 15 cases (1986–2004). *J. Am. Vet. Med. Assoc.*, **230**, 1350–1355
Monin, T. (1978) Repair of physeal fractures of the tuber olecranon in the horse using a tension band method. *J. Am. Vet. Med. Ass.*, **172**, 287–290
Nixon, A., Stashak, T., McIlwraith, W., Aanes, W. and Martin, G. (1985) A muscle separating approach to the equine shoulder joint for the treatment of osteochondritis dissecans. *Vet. Surg.*, **5**, 247–256
Nyack, B., Morgan, J., Pool, R. and Meagher, D. (1981) Osteochondrosis of the shoulder joint of the horse. *Cornell Vet.*, **71**, 149–163
Oikawa, M. and Narama, I. (1998) Enthesopathy of the radial tuberosity in two Thoroughbred racehorses. *J. Comp. Path.*, **118**, 135–143
Ordidge, R. (2001) Pathological fracture of the radius secondary to an aneurysmal bone cyst. *Equine vet. Educ.* **13**, 239–242
O'Sullivan, C. and Lumsden, J. (2003) Stress fractures of the tibia and humerus in Thoroughbred racehorses: 99 cases (1992–2000). *J. Am. Vet. Med. Ass.*, **222**, 491–498
Pankowski, R., Grant, B., Sande, R. and Nickels, F. (1986) Fracture of the supraglenoid tubercle: treatment and results in 5 horses. *Vet. Surg.*, **15**, 33–39
Parks, A. and Nickels, F. (1986) Scapular sequestrum in a horse: a case report. *Vet. Surg.*, **15**, 389–391
Ramzan, P. and Pilsworth, R. (2001) Suspected septic physitis of the proximal humerus in two cases of Thoroughbred horses age two years. *Equine vet. J.*, **33**, 514–518

Ramzan, P. (2002) Enostosis-like lesions: 12 cases. *Equine vet. Educ.* **14**, 143–148
Ramzan, P. (2004) Osseous cyst-like lesion of the intermediate tubercle of a horse. *Vet. Rec.*, **154**, 534–536
Sanders-Shamis, M., Bramlage, L. and Gabel, A. (1986) Radius fractures in the horse: a retrospective study of 47 cases. *Equine vet. J.*, **18**, 432–437
Semevolos, S., Watkins, J. and Auer, J. (2003) Scapulohumeral arthrodesis in Miniature horses. *Vet. Surg.*, **32**, 416–420
Swineboard, E., Dabareiner, R., Swor, T., Carter, K., Watkins, J. et al. (2003) Osteomyelitis secondary to trauma involving the proximal end of the radius in horses: five cases (1987–2001). *J. Am. Vet. Med. Ass.*, **223**, 486–491
Swor, T., Watkins, J., Bahr, A. and Honnas, C. (2003) Results of plate fixation of type 1b olecranon fractures in 24 horses. *Equine vet. J.*, **35**, 670–675
Swor, T., Watkins, J., Bahr, A., Epstein, K. and Honnas, C. (2006) Results of plate fixation of type 5 olecranon fractures in 20 horses. *Equine vet. J.*, **37**, 30–34
Tudor, R., Crosier, M., Love, N. and Bowman, K. (2001) Radiographic diagnosis: fracture of the caudal aspect of the greater tubercle of the humerus in a horse. *Vet. Radiol. and Ultrasound*, **42**, 244–245
Turner, A.S. (1981) Long bone fractures in horses Part 1. Initial management. *Comp. Cont. Educ.*, **3**, S347–353
Valdez, H., Morris, D. and Auer, J. (1979) Compression plating of long bone fractures in foals. *J. Vet. Orthop.*, **1**, 10–18
Vaughan, L. and Mason, B. (1975) *A Clinicopathological Study of Racing Accidents in Horses*, Adlard and Son, Bartholomew Press, Dorking, Surrey
Wagner, P., Watrous, B., Shires, G. and Riebold, T. (1985) Resection of the supraglenoid tubercle of the scapula in a colt. *Comp. Cont. Educ.*, **7**, S36–40
Wilson, R. and Reynolds, W. (1984) Scapulohumeral joint luxation with treatment by closed reduction in a horse. *Aust. Vet. J.*, **61**, 300–301
Yovich, J. and Aanes, W. (1985) Fracture of the greater tubercle of the humerus in a filly. *J. Am. Vet. Med. Ass.*, **187**, 74–75
Zamos, D. and Parks, A. (1992) Comparison of surgical and non-surgical treatment of humeral fractures in horses: 22 cases (1980–1989). *J. Am. Vet. Med. Ass.*, **201**, 114–116