Physeal Injury

The physis is the weakest point in the axial skeleton when subjected to tensile forces. Partial or complete physeal separations can occur at the vertebral endplates, odontoid synchondrosis, apophysis etc (Fig. 8.11). By age 8 all the ossification centers have fused with the exception of the apical odontoid epiphysis, ring apophysis, and the secondary ossification centers of the neural arches that appear at puberty. At 7−8 years of age, small linear foci of ossification develop in the endplate cartilages. Abnormalities of the ossified displaced portion seen radiographically are the mainstay of diagnosis. Diagnosis of this injury before the appearance of ossification in the ring apophysis is difficult if not impossible.

Physeal injuries can occur anywhere in the spine but are very important in the sub-axial portion of the cervical spine where they usually involve the inferior growth plate and can be multiple. Although strictly speaking the Salter−Harris classification refers to epiphyseal/physeal interface injuries, one can apply the same classification to injuries in the growth zones of the vertebral body even though they are at the apophyseal/physeal junction. The vertebral endplate injury is often subtle and can separate from the body with perfect relocation following a complete Salter−Harris type I injury, which is more common in infants and young children and may be a factor in SCIWORA. Salter−Harris type III injuries occur in older children and adolescents as the physis begins to close. Due to the difficulties in identifying injuries to the cartilaginous components of the spine on radiographs, the true incidence of these injuries is not known, especially as the injured segments can recoil to virtually normal alignment.

Radiographically the clues include widening of the intervertebral disk space and identification of the displacement of the calcified components of the apophysis from their normal location in relation to the vertebral bodies. The type I injuries are more difficult to detect radiographically than type III injuries. In the cervical spine the type I Salter−Harris injuries usually involve the inferior endplate (Fig. 8.12). The absence of well-developed uncinate processes in children less than 8 years of age may predispose to this type of injury and in turn to SCIWORA. After this age the protective effect of the uncinate process makes this type of injury unlikely and only partial in nature (type III). In type I injuries, as the shearing forces pass through a purely cartilaginous plane there is minimal trauma to the adjacent vertebral body. Furthermore as these injuries are also associated with distracting forces, the vertebral bodies even on MR imaging may not show any evidence of injury (Fig. 8.13). Radiography is much better at depicting subtle displacement of the fractured apophysis than

Fig. 8.10 Lateral radiographs of the thoracolumbar junction of a boy taken on the day (a) and 4 weeks (b) after a fall from a tree showing clear evidence of an acute intraosseous disk herniation at the L1 vertebral level with reduced T12/L1 disk height.
MR imaging, particularly as the normal appearing ossification components of the ring apophysis are not well depicted by MR imaging (see Fig. 8.15). The type I injuries clearly indicate a highly unstable spine status even when they recoil to virtual anatomical alignment (Fig. 8.14). In the odontoid peg the injury’s potential for healing without surgery after closed reduction is high but operative treatment is usually required in injuries of the sub-axial position of the spine. As the type III and type IV injuries indicate incomplete separation from the vertebra (Figs. 8.15, 8.17), they heal well by conservative treatment and immobilization (Fig. 8.16). Physeal injuries are also seen in the thoracolumbar spine and the type I Salter–Harris endplate separation is often a component of flexion-distraction seat-belt injuries.

In cervical ring apophyseal avulsion injuries avulsion of the ring apophysis anteriorly occurs at the superior apophysis in hyper-flexion injury, while extension trauma causes avulsion of the inferior ring apophysis. Jonsson et al study commented on the chronic appearance of these injuries. Follow-up of avulsion of the superior apophysis was associated with a bow-shaped superior border, whereas previous avulsion of the inferior ring apophysis demonstrated a large “osteophyte” projecting from the corner of the involved vertebral body (Fig. 8.16).
Fig. 8.12  Salter–Harris type I injury through the inferior physis of the C5 vertebra with distraction of the C5/C6 interfacetal and interspinous distance (a). Note the inferior apophysis of C5 has an intact relationship with the C5/C6 disk (arrow). The unstable nature of this injury is highlighted by the failed conservative treatment with a chronic dislocation on the follow-up radiograph (b).

Fig. 8.13  Bilateral C5/C6 facet dislocation with a type I Salter–Harris injury through the inferior physis of C5, which along with the intact C5/C6 disk (arrows) prevented relocation of C5 on C6 (a, b) on skull traction. c Eventual relocation showing the separation of C5 from C6 through the inferior physis of C5.
Fig. 8.14 Bilateral posterior neural arch fractures at C2 with markedly widened prevertebral soft tissue space and focal kyphotic deformity at C2/C3 level. Note the trans-physeal separation (Salter–Harris type I) through the inferior endplate of C2 (arrow) on the radiograph (a) and STIR sagittal image (b), along with the C1/C2 soft tissue injury and absence of any bone marrow edema in the C2 vertebra.

Fig. 8.15 C4/C5 cervical injury of the posterior ligamentous complex (arrow) associated with a Salter–Harris type III injury of the physis involving the anterosuperior corner of the C5 vertebra. Note the displacement of the fractured ring apophysis on the radiograph (a), the difficulty in appreciating this on the MR T2 sagittal image (b), and the multiple injuries in the cervical and upper thoracic vertebral bodies, including damage to the posterior ligaments (arrow).