Magnetic Resonance Imaging of the Pediatric Shoulder

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KEYWORDS

- Shoulder MR imaging • Children • Shoulder development
- Brachial plexus palsy • Shoulder infection
- Shoulder inflammation

THE PEDIATRIC SHOULDER

Growth and development of the shoulder is complex. Appropriate interpretation of magnetic resonance (MR) images of the shoulder in children requires an understanding of normal skeletal maturation and how it results in different patterns of injury. The ability of MR imaging to depict cartilage, marrow, and soft tissues without using ionizing radiation makes it extremely useful in children. This article describes the MR appearance of normal developmental changes, common injuries, and unique conditions that affect the shoulder throughout childhood.

GENERAL DEVELOPMENTAL PRINCIPLES

The development of the shoulder starts during the fourth week of embryonic life. At this time, mesenchymal cells derived from somatic mesoderm condense and form the upper limb bud. These cells will eventually give origin to bone, cartilage, and other soft tissues of the upper extremity. By the eighth week of gestation, all structural components of the shoulder girdle are present.[1] Ossification of the diaphysis of the humerus starts between the seventh and ninth weeks of gestation, and is followed by the formation of the scapula and midportion of the clavicle.[2,3] Vascular invasion of the humeral cartilaginous epiphysis, development of the marrow cavity, and somatic growth will continue to shape the shoulder throughout the remainder of fetal life.[4]

At birth, the proximal humeral epiphysis, acromion, coracoid, and lateral epiphysis of the clavicle are composed of hyaline cartilage, whereas the humeral diaphysis, midportion of the clavicle, and body of the scapula are ossified.[1] The primary physes of the clavicle and humerus are responsible for the longitudinal growth of these bones. The proximal physis of the humerus is responsible for approximately 80% of its overall elongation, whereas the lateral physis of the clavicle contributes little to the final length of the bone. Appositional growth of the diaphysis and metaphysis of the humerus and clavicle, and body of the scapula occurs by intramembranous ossification that originates from the periosteum and perichondrium.[5]

Throughout childhood, the cartilaginous epiphyses and apophyses of the shoulder develop secondary ossification centers.[6] These centers enlarge by endochondral ossification from a secondary physis.[7] The age at which each epiphysis or apophysis begins to ossify and grow varies between sites, which in turn results in the changing appearance of the shoulder at different stages of skeletal maturation. The subchondral marrow of a developing ossification center and its adjacent secondary

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physis is similar in architecture, composition, and MR imaging characteristics to the metaphysis and primary physis of long bones.[8] By the time skeletal maturity is reached, all epiphyseal cartilage has been replaced by mineralized bone, with the exception of articular cartilage.[6]

The growth of bones results in increased tension on the soft tissues of the shoulder girdle. The muscles, ligaments, tendons, and joint capsule, including the labroligamentous complex, grow in response to the traction exerted on them by the growing skeleton. The signal intensity (SI) on MR images of the subcutaneous tissues also changes during growth. In neonates and infants, there are prominent deposits of brown fat in the axillary, subscapular, and parascapular regions.[9] These normal deposits of brown fat show a slightly heterogeneous SI on T1-weighted images and may demonstrate patchy enhancement after the administration of intravenous contrast (**Fig. 1**), which can be a source of unnecessary concern.

TECHNIQUE

MR imaging of the pediatric shoulder is best performed with the patient in a supine position. Children younger than 7 years generally require sedation, whereas older patients are much more likely to tolerate the MR imaging examination without medication. The imaging protocol and the choice of appropriate coils depend on the size of the child and the clinical concern. In a young patient with a congenital or developmental abnormality, both shoulders should be imaged so that comparison can be made with the contralateral normal shoulder, as in the case of brachial plexus palsy. In these cases, a cardiac phased-array coil that covers both shoulder girdles is recommended. 3.0-T imaging is optimal. For a unilateral shoulder examination, infants and small children can be imaged using a small 4-channel multiflex coil. Older children (preteens) and adolescents are imaged using a small or large shoulder-array coil, respectively. A small field of view (FOV),

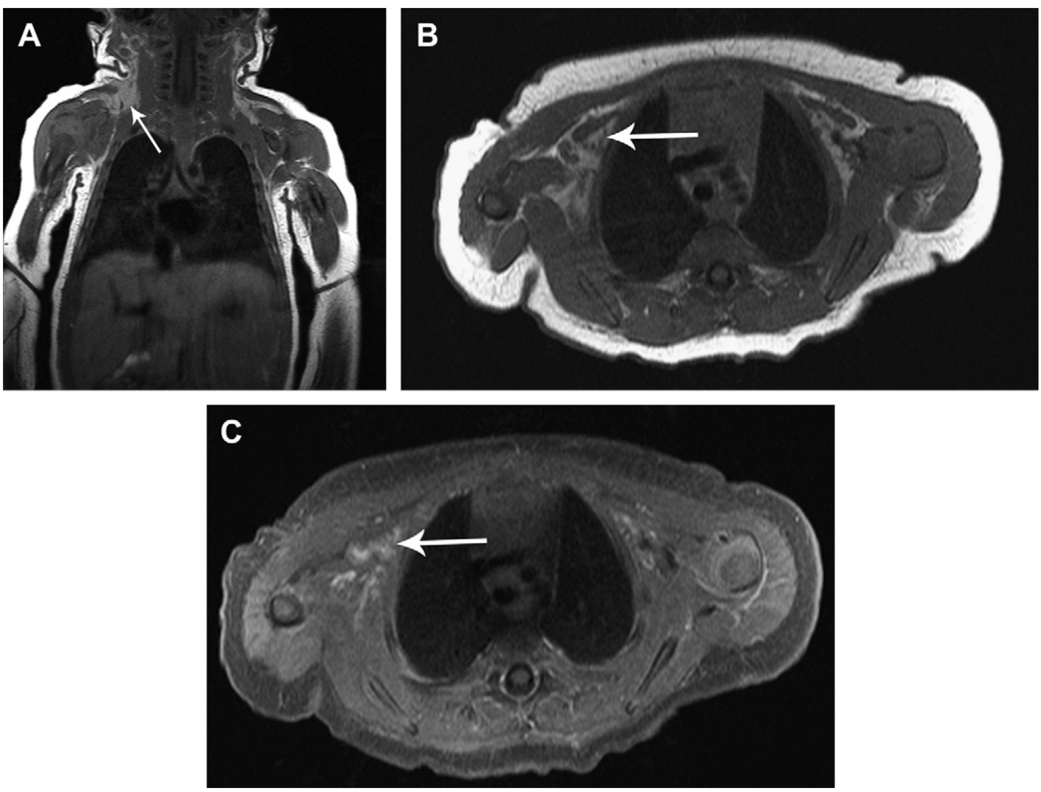

Fig. 1. Brown fat in a 1-month-old boy with a palpable right axillary mass. (*A*) Coronal and (*B*) axial T1-weighted MR images of the chest demonstrate intermediate SI in the subcutaneous tissues of the supraclavicular fossa, neck, and axilla (*arrows*). The absence of mass effect or infiltration of adjacent structures, as well as the location, are consistent with deposits of brown fat. (*C*) Axial fat-suppressed T1-weighted MR image following administration of intravenous gadolinium demonstrates patchy enhancement of these regions (*arrow*), secondary to the increased vascularity of brown adipose tissue.