3 Ultrasonography of Tendons and Ligaments

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CONTENTS

3.1 Introduction 39
3.2 Normal Anatomy 39
3.2.1 Tendons 39
3.2.2 Ligaments 40
3.3 Examination Techniques and Normal Imaging Findings 40
3.3.1 US 40
3.3.2 MR imaging 42
3.4 Tendon Abnormalities 43
3.4.1 Overuse Injuries 43
3.4.2 Avulsion Injuries 43
3.4.3 Snapping Hip 46
3.4.4 Degenerative and Inflammatory Conditions 47
3.5 Ligament Abnormalities 50
3.6 Conclusion 51

References and Further Reading 51

3.1 Introduction

Magnetic resonance (MR) imaging has become established as an essential cross-sectional imaging technique for the examination of children with disorders of the musculoskeletal system. However, recent advances in ultrasound (US) technology have substantially enhanced the role of this technique to detect, localize and characterize a variety of disorders affecting tendons and ligaments in children. Although only early work is currently available in the literature on this subject, the applications of this method are maturing, and sonography is becoming the primary imaging technique for the detection, localization and characterization of a variety of tendon and ligament disorders in infants, children and adolescents.

The aim of this chapter is to describe the value of US and MR imaging in children and adolescents with a variety of diseases affecting tendons and ligaments.

3.2 Normal Anatomy

3.2.1 Tendons

Tendons are structures joining the muscles to bones that allow joint movement or the maintenance of a fixed position against a loading force. There are two types of tendon, type 1 and type 2.

Type 1 tendons are long and cross one or more joints before reaching their insertions. They can reflect over bony surfaces (bony grooves or protuberances), fibrous bands or osteofibrous tunnels, and at these locations they are always surrounded by a synovial sheath made of a combination of visceral and parietal layers. The visceral layer is tightly attached to the outer tendon surface and moves with the tendon during isotonic contraction of the muscle. The parietal layer is a lax structure that surrounds the visceral synovium and blends with it at the periphery of the sheath to form the mesotendon. The main functions of the synovial sheath are to diminish friction between the tendons and the surrounding structures, thus allowing easy and smooth gliding in all positions of the adjacent joint. The sheath also forms the mesotendon that houses tendon vessels. A thin film of synovial fluid is normally found inside the tendon sheath and this may be seen in certain locations using US. For example, synovial fluid can rarely be demonstrated around the flexor digitorum tendons of the fingers, while a
small amount of fluid can usually be detected in the tendon sheath of the tibialis posterior tendon and should be regarded as a normal finding.

Tendon sheaths may sometimes communicate with the adjacent articular synovial cavities. Under normal conditions a communication is present between the ankle joint and the medial tendons (tibialis posterior, flexor digitorum communis and flexor hallucis longus tendons). Therefore, excess fluid within these tendon sheaths associated with an ankle joint effusion is not necessarily the result of disease of the tendon; it may be due to leakage of fluid from an abnormal joint to a normal tendon sheath. On the other hand, some synovial sheaths do not communicate normally with the adjacent joints and even a small effusion inside them must be regarded as abnormal.

Typical examples of type 1 tendons are the flexor and extensor digitorum tendons of the hand and the ankle tendons. Due to their anatomy and the tearing forces that can develop during loading, these tendons are prone to develop friction changes and eventually partial or complete tears. Because the sheath of type 1 tendons is covered by synovium, they are commonly involved by systemic disorders that produce synovitis such as juvenile rheumatoid and seronegative arthritides.

Type 2 tendons are thicker, have a straight course and lack a synovial sheath. The paratendon is an outer envelope comprising two connective layers separated by a small amount of loose connective tissue which surrounds these tendons allowing a gliding plane with the surrounding tissue. Examples of type 2 tendons are the Achilles tendon and the quadriceps tendon.

Both types of tendon are formed by densely packed bundles of collagen fibres (type I collagen). These bundles are invested by the endotendineum and peritendineum, a network of loose connective tissue septa containing elastic fibres and vessels, which give some flexibility to the tendons. Endotendineum septa are in continuity with the epiten- dineum, a dense connective tissue layer tightly bound to the tendon surface.

### 3.2.2 Ligaments

Ligaments are flattened or cord-like periarticular structures which join two or more articular bone ends. Some ligaments, such as the anterior shoulder ligaments, are embedded in the joint capsule and cannot be differentiated from it. Other ligaments, such as the lateral collateral ligament of the knee, lie in a more peripheral location and have no relationship with the capsule. Some ligaments are formed by a single bundle of fibres, for example the anterior talofibular ligament. Others, such as the anterior cruciate ligament of the knee, are composed of multiple bundles which are subjected to different degrees of tension depending on joint position. The primary function of ligaments is to counteract excessive articular excursion, thus preventing joint subluxation and dislocation. They also maintain the position of the articular ends in the optimum alignment during movement, limiting wear and preventing early osteoarthritis. As ligaments contain a few elastic fibres scattered amongst the more resilient collagen fibres, they are slightly elastic and allow minor stretching.

### 3.3 Examination Techniques and Normal Imaging Findings

#### 3.3.1 US

US examination of tendons and ligaments is best performed with high-frequency broadband (frequency range 5–15 MHz) linear array transducers to obtain a very high spatial resolution in the near field. These structures are mostly located near to the skin surface and in children they are inevitably smaller than in adults. When available small-footprint transducers are preferred as a large field-of-view is rarely required. In addition, small-sized transducers perform better around the curvature of joints and during joint or tendon motion. In infants and smaller children, large amounts of gel or a thin stand-off pad can be useful to improve the probe contact with the skin.

The sonographic appearance of tendons in children is similar to that described in adults. The main differences are due to their smaller overall size and the site of insertion into bone. When examined in the longitudinal plane, tendons appear as hypoechoic structures with well-defined echogenic (bright) margins and a fibrillar appearance due to the bundles of tendon fibres. They are anisotropic structures, which means that they may appear hypoechoic when the US beam is not precisely perpendicular to their long axis. This is because the