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CASE REPORT

Avulsion Fracture of the Pelvis: Separation of the Secondary Ossification Center in the Superior Margin of the Acetabulum

O. NAŇKA,[1*] P. HAVRÁNEK,[2] T. PEŠL,[2] AND J. DUTKA[3]

[1]*Institute of Anatomy, First Faculty of Medicine, Charles University, Praha, Czech Republic*
[2]*Regional Paediatric Trauma Center, Thomayer Teaching Hospital, Praha, Czech Republic*
[3]*Department of Imaging and Interventional Radiology, Institute of Clinical and Experimental Medicine, Praha, Czech Republic*

A 13-year-old female sustained a rare avulsion fracture of the secondary ossification center in the superior margin of the acetabulum as the result of contraction of the reflected head of the rectus femoris muscle. Diagnosis was made from plain films and CT scans with 3D image reconstruction. The patient was treated non-operatively by bed rest with semiflexion of the hip and knee, and appropriate analgesia. Clin. Anat. 16:458–460, 2003.

Key words: traumatology; pelvis; secondary ossification center; physis; muscle insertion

INTRODUCTION

Skeletal pelvic injuries caused by avulsion occur in adolescents as epiphyseal separations or fractures. These are represented mainly by: 1) physeal injuries, where separation of the secondary ossification center occurs in the growth cartilage (physis), the weakest part of the immature skeleton (so-called epiphyseal separation), and 2) a break line transecting the secondary ossification center (so-called epiphyseal fracture) (Havránek, 1991; Rockwood et al., 1996). Secondary ossification centers are either on the ends of long bones and termed true epiphyses (previously termed pressure epiphyses), or at the insertion site of a muscle and termed apophyses (previously termed traction epiphyses).

In avulsion fractures the apophysis is typically separated from the bone by a sudden, uncoordinated contraction of an inserting muscle or by a violent passive movement. There are reports in the literature of such pelvic avulsion fractures: avulsion of the iliac crest, anterior superior iliac spine, anterior inferior iliac spine, pubic tubercle, and ischial tuberosity (Havránek, 1991; Rockwood et al., 1996). We have treated all of these types of avulsion fractures.

The pelvic bones ossify from three primary centers: iliac, ischial, and pubic. The iliac center appears above the greater sciatic notch prenatally at about the ninth week and the ischial center appears in the body during the fourth and fifth months (Delaere et al., 1992). At birth, some parts of the pelvic bone are still cartilaginous: the iliac crest and the floor and inferior margin of the acetabulum. The cartilaginous acetabular cup exhibits a triradiate stem extending to the medial surface of the hip bone and a Y-shaped epiphyseal plate between the ilium, ischium, and pubis (bipolar physis). At birth the acetabulum also includes the anterior inferior iliac spine. The cartilage along the inferior margin of the acetabulum extends to the ischial tuberosity and contributes to the conjoined ischiopubic ramus. This cartilage also continues to the pubic symphyseal surface and along the pubic tubercle and pubic crest (Houštěk et al., 1956; Borovanský et al., 1972; Čihák, 1987). The acetabular labrum, which is composed of fibrocartilage, forms along the margin of the acetabular cartilage. The joint capsule

*Correspondence to: Ondřej Naňka, MD, Institute of Anatomy, First Faculty of Medicine Charles University, U nemocnice 3, Praha 2, 128 00 Czech Republic.
E-mail: Ondrej.Nanka@lf1.cuni.cz

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Fig. 1. **A:** X-ray showing an avulsion fracture of the left upper acetabular rim secondary ossification center, the insertion site of the reflected head of the rectus femoris muscle. Arrow, the displaced bone fragment. **B:** The same case after healing of the fracture.

inserts several millimeters peripheral to the rim of the labrum into fibrous tissue covering the outer surface of the acetabular cartilage (Williams et al., 1995). The ossifying ischial ramus and inferior pubic ramus fuse to form a continuous bony conjoined ramus at the seventh or eighth year. Some secondary centers of ossification appear in adolescence and fuse between the 15th and 25th year: usually there are two centers for the iliac crest and single centers for the ischial tuberosity, anterior superior iliac spine, anterior inferior iliac spine, and symphyseal surface of the pubis. The pubic tubercle and crest may also have separate secondary ossification centers (Williams et al., 1995).

Between the ages of eight and nine years, three major secondary ossification centers appear in the acetabular cartilage. The largest appears in the anterior wall of the acetabulum and fuses with the pubis at 18 years; the second largest appears in the iliac acetabular cartilage superiorly and fuses with the ilium at 18 years; and the smallest center appears in the posterior ischial acetabular cartilage and fuses with the ischium at 17 years (Ponseti, 1978). These secondary ossification centers expand toward the rim of the acetabulum and contribute to its depth; however, during development, the acetabulum increases in width at a faster rate than in depth (Doskočil, 1995). Fusion of the three bones forming the acetabulum occurs between the 16th and 18th year.

CASE REPORT

A 13-year-old female presented with post-traumatic pain in the region of the left hip. The mechanism of injury was described as an unintended "split" on a slippery surface, that is, a forced and swift hip hyperextension on the right side together with hyperflexion of the hip on the injured left side. Physical examination showed pain on flexion and hyperextension of the left hip and tenderness lateral to the left groin. A pelvic X-ray revealed displacement of the left secondary ossification center of the superior margin of the acetabular rim (acetabular epiphysis in radiodiagnostic manuals) as compared to the right side (Fig. 1A). X-ray localization corresponded to the clinically most painful area. This diagnosis was confirmed by CT imaging with 3D reconstruction (Fig. 2A,B). These findings indicate an avulsion apophyseal fracture, a separation in the upper acetabular rim, rather than a fracture of the anterior inferior iliac spine.

The patient was treated with three weeks of bed rest followed by nonweightbearing for several weeks. After two months of rehabilitation, the patient healed completely without sequelae (Fig. 1B).

DISCUSSION

The localization and mechanism of injury suggested that the apophysis of the upper acetabular rim was torn away by a strong, swift contraction of the reflected head of the rectus femoris muscle. The rectus femoris has two heads: a straight head originating on the anterior inferior iliac spine and a reflected head originating on the region immediately above the upper acetabular rim. The straight head is involved in the beginning of hip flexion and, when it leaves the axis of pull, its function as a flexor is taken over by the reflected head (Doskočil et al., 1987). In our case contraction of the reflected head during hyperflexion

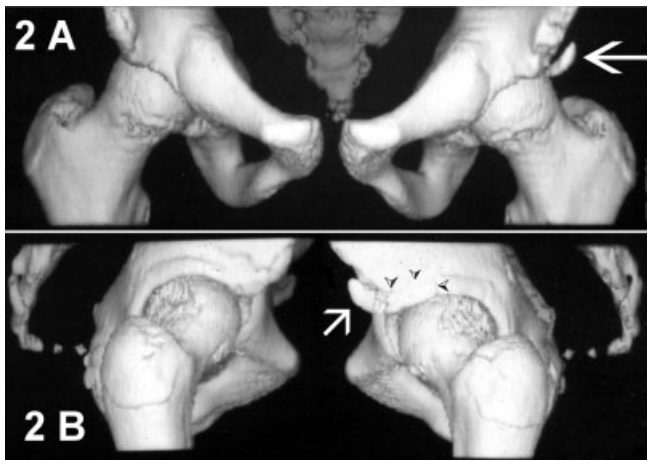

Fig. 2. **A:** 3D reconstruction on AP view of the same avulsion fracture of the left acetabular rim shown in Figure 1A (arrow indicates displaced fragment). **B:** Lateral view of the uninjured right hip and the traumatized left hip. Arrow, the displaced bone fragment; arrowheads, fracture line.

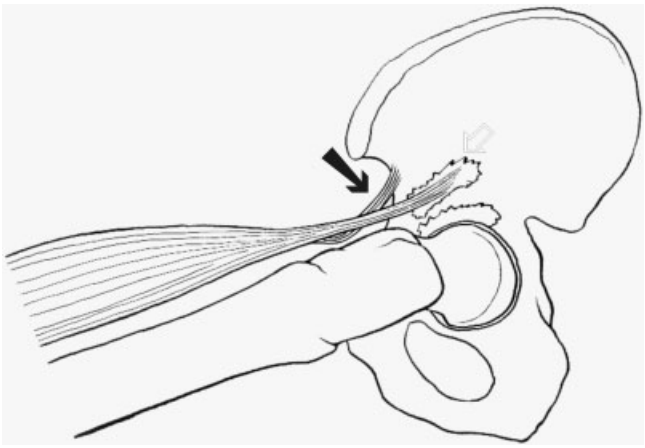

Fig. 3. Schematic drawing of the mechanism of injury. The straight head of the rectus femoris muscle is slack during hyperflexion of the hip joint; the reflected head is taut. The black arrow indicates the straight head originating on the anterior inferior iliac spine. The white arrow indicates the tendon of the reflected head, which originated on the upper acetabular rim, and an avulsed bone fragment.

enabled avulsion of the secondary ossification center of the upper rim of the acetabulum (Fig. 3).

We found two similar cases described in the literature, in two males, 13 and 16 years old, where a similar avulsion was caused by a swift movement during football. Each diagnosis was made from X-ray examination and, in one case, was verified during surgery (Caudle and Crawford, 1988; Deehan et al., 1992). We verified our case by 3D CT reconstruction, which permitted differentiation from an avulsion of the anterior inferior iliac spine.

Classification of fractures of the pelvis in children is usually according to the scheme proposed by Key and Conwell (Havránek, 1991; Rockwood et al., 1996) whereby avulsion fractures are categorized in the group of fractures without pelvic ring disruption (Group I). They describe three types of avulsions: anterior superior iliac spine, anterior inferior iliac spine, and ischial tuberosity. Rockwood et al. (1996) do not mention avulsion fracture of the upper acetabular rim, which according to the general Ogden classification of physeal injuries, would be a Type 3C: an impinging non-articular epiphysis (Havránek, 1991).

On the basis of this case, we suggest that avulsion of the secondary ossification center of the ilium in the upper rim of the acetabulum (i.e., the acetabular epiphysis), caused by the pull of the reflected head of rectus femoris muscle, be added to the present classification of pelvic avulsion fractures. This fracture can be treated like other avulsion fractures without substantial displacement by three weeks of bed rest with semiflexion of the hip and knee.

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