MRI in the assessment of growth arrest

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Abstract Objective: To compare MRI with X-ray tomography in the
assessment of bone bridges across the growth plate. Materials and
methods: The investigation consisted of two parts. (1) Eleven children
with 13 epiphyses suspected of physeal growth arrests were examined
with conventional X-ray tomography and MRI. The bar was post-traumatic
in eight children, postinfectious in two and due to a congenital,
operated pes equinovarus in one. Three blinded radiologists separately
evaluated the examinations retrospectively. (2) The images of four
children with known physeal bars in the ankle were mixed with 36 normal
examinations obtained 1-year after trauma and evaluated blindly by
three radiologists. Results: In 5 of 13 epiphyses, the bony bridge was con-
sidered smaller on MRI than on X-ray tomography, in 7 of 13 it was
considered equal, while it was larger only in one. The interobserver
agreement (weighted kappa) was 0.8
(very good) for MRI, 0.76 (good) for
X-ray tomography and 0.60
(moderate) for radiographs. The
four bony bridges were easily de-
tected on MRI. Conclusions: Com-
pared to MRI, the size of bridges
was estimated larger by tomography
in about half of the patients.

Keywords Magnetic resonance
imaging · Growth arrest

Introduction

Early diagnosis, treatment and follow-up of fractures extending
to the growth plate are demanding. Such frac-
tures pose the risk of permanent damage to the growth
plate or formation of a bony bridge across an otherwise
viable growth plate. When a sufficiently large osseous
bridge develops across the phys, growth is disturbed,
which may result in progressive joint surface deformities,
angular deformities or length discrepancy of the extrem-
ities. These deformities are initially symptom free and
present themselves as clinical problems rather late.

The classification system of epiphyseal fractures
most widely used is that of Salter-Harris [1], originally
based on conventional radiographs. Although 30% of
all epiphyseal injuries will result in some shortening and
angulation, clinically significant functional alterations
develop in only 2% [2].

In follow-up, post-traumatic progressive growth dis-
turbances should be diagnosed as early as possible, with
conventional radiographs and clinical examination be-
ing of primary value. If necessary, conventional
tomography [3,4], and CT with 3D reconstruction [5]
have been used. Axial scintigraphy [6] and MRI [7, 8,9]
have also been recommended. Physeal mapping can be
performed on conventional X-ray tomography [4], CT
[5] and MRI [9]. On MRI, 3D gradient-echo sequences
(3DGE) with fat saturation have been recommended for
this purpose [9]. The size of the growth arrest is im-
portant when a decision on surgery is made [10].

In acute physeal fractures the usefulness of MRI is
MRI only in complex fractures if the initial fracture classification is uncertain. In this study the initial fracture classification was changed in only 1 patient of 29. However, patients requiring later surgical intervention showed pathological findings on MRI earlier than on conventional radiographs.

In two other studies, MRI was judged to be more valuable. In 14 children the classification was completely changed in two of nine fractures, and five radiographically occult fractures were also diagnosed [12]. In seven of ten patients the Salter-Harris fracture classification changed, and in four of these the therapy also [13].

So far, there have not been any studies comparing the validity of MRI with conventional tomography in growth arrest. We investigated 13 affected epiphyses in 11 children with both conventional tomography and MRI. To examine the usefulness of MRI in picking up growth arrest we analysed 40 post-traumatic children’s ankles, 4 of which had physeal growth arrest that had been confirmed by X-ray and conventional tomography.

### Materials and methods

Patients with a clinical suspicion of growth arrest and with representative plain film radiography, X-ray tomography and MRI during the years 1994 to 1999 were collected from the data files at the children’s hospital. In 11 patients the time interval between X-ray tomography and MRI was less than 70 days and they were included in this investigation. The aetiology of the growth arrest was fracture in 8 patients, infection in 2 and a complication of orthopaedic treatments in 1 (Table 1). A total of 13 affected epiphyses at various locations were identified. In 5 of the patients the growth arrest was later verified at operation.

Good-quality conventional radiographs were available in AP and lateral projections. X-ray tomography was made in both the AP and lateral directions in all but one patient. MR examination was made with a 1.5-T magnet (Siemens Vision) in ten patients and with a 0.1-T magnet (Picker) in one. T1-weighted spin-echo (T1SE) images in the sagittal and coronal directions were available in all patients; T2-weighted spin-echo (T2SE) images with or without fat suppression in the sagittal or coronal directions were available in many. A 3D sequence (either 3D dual echo in the steady state [DESS], or fast imaging with steady-state free precession [FISP]) without fat suppression had also been performed in 7 of 11 patients.

To determine the sensitivity of MRI in identifying post-traumatic growth arrest, the MRI examinations of four children with a growth arrest in the ankle were mixed with 36 ankle MRI exam-

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Gender</th>
<th>Diagnosis</th>
<th>Location</th>
<th>Size of bony bridge</th>
<th>Pathologic Harris-lines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>MRI = tomo</td>
<td>MRI tomo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>7 years, 3 months</td>
<td>M</td>
<td>St.p.fract.SH2</td>
<td>Femur dist.</td>
<td>1 1 1 x</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>14 years, 7 months</td>
<td>M</td>
<td>St.p.fract.</td>
<td>Tibia prox.</td>
<td>1 1 1 x</td>
<td>y y</td>
</tr>
<tr>
<td>3</td>
<td>12 years, 8 months</td>
<td>M</td>
<td>St.p.fract. and epiphyseodesis</td>
<td>Femur</td>
<td>1 2 1 MRI &lt; tomo</td>
<td>y y</td>
</tr>
<tr>
<td>4</td>
<td>9 years, 0 months</td>
<td>M</td>
<td>St.p.fract.oper.</td>
<td>Tibia cond.lat.humeri</td>
<td>2 2 2 x</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>5 years, 4 months</td>
<td>M</td>
<td>St.p.fract.SH4</td>
<td>capit.radii</td>
<td>1 1 1 x</td>
<td>y y</td>
</tr>
<tr>
<td>6</td>
<td>13 years, 11 months</td>
<td>F</td>
<td>St.p.fract.SH2</td>
<td>Tibia dist.</td>
<td>1 2 2 MRI &lt; tomo</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>12 years, 1 month</td>
<td>M</td>
<td>St.p.fract.SH4</td>
<td>Tibia dist.</td>
<td>1 1 1 x</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>14 years, 7 months</td>
<td>M</td>
<td>Pes equinovarus i.a oper.</td>
<td>Tibia dist.</td>
<td>1 2 3 MRI &lt; tomo</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>12 years, 6 months</td>
<td>M</td>
<td>St.p.fract.oper.</td>
<td>Femur dist.</td>
<td>1 2 1 MRI &lt; tomo</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>2 years, 6 months</td>
<td>M</td>
<td>St.p.osteomyelitis</td>
<td>Humerus prox.</td>
<td>1 1 1 x</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>4 years, 2 months</td>
<td>F</td>
<td>St.p.osteomyelitis</td>
<td>Femur dist.</td>
<td>3 2 2 MRI &gt; tomo</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td></td>
<td>MRI = tomo 7</td>
<td>MRI tomo</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: MRI = magnetic resonance imaging, tomo = tomography, X-ray = X-ray radiography, M = male, F = female.