Role of MR in Limb Fracture

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Purpose: In evaluation of the limb fracture, MR scan has been used in limited roles as evaluating the associated soft tissue injury not the fracture itself. This study aims at understanding the possible role of MR in fracture.

Methods and Materials: thirty three sets of MR scans in twenty nine patients were retrospectively analyzed. They included twelve tibial plateau fractures, four patellar fractures, four distal femur fractures, five epiphyseal fractures and four others.

Results: All MRs except two showed better image and more information about the extent of the injury (93.9%). Evaluation of cartilage (which was impossible on other modalities) was possible in 28 MR scans (84.8%). Surrounding marrow change associated with fracture was also able to be evaluated. Associated soft tissue injury or other abnormality could be evaluated - cruciate or collateral ligament injury, meniscus tear, chondromalacia or osteonecrosis. In epiphyseal injury, direct demonstrability of premature bony fusion on MR took a critical role in making a management plan.

Conclusion: MR scan in fracture has its value in evaluating the extent and degree of the injury and it is especially advantageous in detecting cartilage injury and early complication of growth plate injury.

Index Words: Extremities, MR studies Extremities, fractures Extremities, injuries Bones, MR studies

Over the recent short period, the clinical application of magnetic resonance (MR) imaging has markedly increased in musculoskeletal disorders. The main indications for musculoskeletal MR are neoplasms, inflammatory diseases and a variable condition called internal derangement of the knee (1-4). In other words, soft tissue evaluation has been the major aim to request MR due to its excellent soft tissue resolution. On the other hand, MR has not been widely applied to the traumatic disorders including fracture. Imaging diagnosis of fracture still depends on conventional plain radiography and sometimes on computed tomography or ultrasonography. Even when performing MR, the purpose of the MR imaging is to evaluate associated soft tissue injury and not to observe fracture itself. In fractures, a single minute difference such as the degree of depression or angulation can lead to the quite different management. So accurate preoperative diagnosis could take a critical role if properly done. In these context, the authors performed a retrospective analysis of thirty three MRs in twenty nine fractured patients as a preliminary study to understand the possible role of MR in fracture.

METHODS and SUBJECTS

Thirty three sets of MR scans (in 29 patients) performed at Kangdong Sacred Heart Hospital from May 1991 to March 1992 were reviewed. All of them had an acute physical trauma and traumatic bony abnormality on plain radiography. The interval between the onset of trauma and performance of MR was from one day to six months. Twenty one patients were male and eight were female. Nineteen patients were operated and the others were conservatively managed. super-
conductive 1.5T Magnetom (Siemens, Erlangen, FRG) was used and spin echo T1, T2, and 2D or 3D gradient echo images were obtained. Multiplanar scans of axial, coronal or sagittal plane were performed when necessary. The patients were classified into five groups according to the lesion site—that is, distal femur fracture, tibial plateau fracture, patellar fracture, epiphyseal fracture (Table 1) and others. Fracture was defined as a cortical disruption or low intensity intramedullary band on all pulse sequences of MR. The cases of stress fracture or intramedullary bone contusion whose plain radiographs were largely normal were excluded from the subject group. In each patient, direction or extent of the fracture, cartilage involvement, effusion, and associated soft tissue abnormalities were evaluated. In addition, any specific finding or special role of MR of the specific lesion site was sought.

**RESULTS**

There were twelve tibial plateau fractures, five epiphyseal fractures, four patellar fractures, four distal femoral fractures and four others. The last group included one talar neck fracture, one femoral head fracture, one radial head fracture, and one humeral epicondylar fracture. In all cases except two, the extent of the fracture was better evaluated on MR than on plain radiography (Fig. 1). In twenty-eight cases, evaluation of cartilage was possible, especially on 3D gradient echo images (84.8%). Surrounding marrow near the fracture line showed ill-defined geographic low intensity on T1 and high intensity on T2 and the extent and degree of marrow change were variable (Fig. 2).

**Table 1. Location of Epiphyseal Injury**

<table>
<thead>
<tr>
<th>No</th>
<th>Age</th>
<th>Sex</th>
<th>Location of the Fracture</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13</td>
<td>M</td>
<td>Distal tibia</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>F</td>
<td>Distal femur</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Proximal tibia</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>F</td>
<td>Distal femur</td>
</tr>
<tr>
<td>4</td>
<td>11</td>
<td>F</td>
<td>Distal tibia</td>
</tr>
<tr>
<td>5</td>
<td>13</td>
<td>M</td>
<td>Distal tibia</td>
</tr>
</tbody>
</table>

**Fig. 1.** Intraarticular fracture of proximal tibia. Spin echo T1-weighted coronal image shows detailed feature of complex injury including intraarticular involvement (arrow) and displacement (open arrow).

**Fig. 2.** Abnormal marrow signal of injured patient. Intramedullary injury of the tibia appears as low intensity on T1-weighted image (a) and high signal intensity on T2-weighted image (b).
Associated injuries or abnormality found on MR included tear of collateral or cruciate ligament, meniscal injury, chondromalacia or osteonecrosis etc. (Table 2). In distal femoral fractures (n=4), all four were condylar fractures. All of them had combined tibia fracture, fibular fracture or patellar fracture. In tibial plateau fractures (n=12), the type of the injury was as shown on Table 3. On MR, the extent and nature of fracture were better evaluated. In the complex knee injuries, misdiagnoses of intact anterior and posterior cruciate ligaments as tear were made in two cases each, due to overlapped hematoma and soft tissue debris (Fig. 3). In patellar fractures (n=4), quadriceps tendon and patellar tendon were also evaluable (Fig. 4). In our series, Table 3. Type of Tibial Plateau Fractures (n=12) by Hohl’s Classification

<table>
<thead>
<tr>
<th>Type</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of cases</td>
<td>2</td>
<td>6</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

- Type I: nondisplaced split
- Type II: local central depression
- Type III: displaced local split depression
- Type IV: displaced, total depression but not comminuted
- Type V: nondisplaced local split without depression
- Type VI: displaced, comminuted

Table 4. Summary of MR Findings of ‘Others’ Group

<table>
<thead>
<tr>
<th>No</th>
<th>Age</th>
<th>Sex</th>
<th>Location of Fracture</th>
<th>Additional MR Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9</td>
<td>M</td>
<td>Talar neck fracture</td>
<td>Better evaluation of extent and joint effusion</td>
</tr>
<tr>
<td>2</td>
<td>51</td>
<td>F</td>
<td>Femur head fracture</td>
<td>Better evaluation of extent, direction &amp; cartilage</td>
</tr>
<tr>
<td>3</td>
<td>23</td>
<td>M</td>
<td>Radial head fracture</td>
<td>Better evaluation of depression and cartilage</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>M</td>
<td>Humeral epicondylar fracture</td>
<td>No additional MR findings</td>
</tr>
</tbody>
</table>

Fig. 3. Erroneous evaluation of cruciate ligaments. Thickening and increased signal of anterior cruciate ligament (a, arrow) and posterior cruciate ligament (b, arrow) suggested tear, but proved to be false positive findings due to hematoma.

Fig. 4. Quadriceps tendon injury. Distal portion of quadriceps tendon has increased signal (arrow) on T1-weighted image and soft tissue debris occupies widened patellofemoral space.
three quadriceps tendon ruptures were found, but no patellar tendon injury. In epiphyseal fractures (n=5), the MR could directly demonstrate bony fusion and cartilaginous portion (Fig. 5). On follow up scans, more detailed nature was demonstrable due to subsided edema. Associated osteonecrosis or coexisting minor trauma was also demonstrated (Fig. 6). In the remainder (n=4, Table 4), all other than humeral epicondylar fracture showed better demonstration of fracture extent. the latter was of poor quality due to motion and technical factor. Degree of depression of fractured portion in radial head fracture was excellently demonstrated on MR, which was of prognostic value (Fig. 7).

DISCUSSION

Suspected meniscus or ligament tear has been the commonest indication for knee MR and MR shows an excellent result in evaluating soft tissue structures at least as good as diagnostic arthroscopy and arthrography, if not better(1-6). Besides soft tissue injury, various bony or cartilaginous injury has begun to become a target of MR imaging—those are occult intraosseous fracture, stress fracture, osteochondral abnormality(7-10). On MR, fracture is defined as a low intensity linear band with or without connection to the cortex, which is surrounded by broader area of marrow abnormality of low T1 and high T2 signal intensity(8). In contrast to the plain radiography in which cortical disruption is the only indicator for injury, marrow abnor-

Fig. 5. Epiphyseal injury with premature fusion. T2-weighted coronal image of the ankle shows interrupted growth plate of distal tibia and bony bridge formation (arrow).

Fig. 6. Combined osteonecrosis in epiphyseal injury. T1-weighted coronal image shows obliteration of growth plate of distal tibia (arrow) and osteonecrosis (open arrow).

Fig. 7. Depressed fracture of radial head.
a. 3D sagittal image of the elbow shows fracture of radial head with minimal depression (arrow).
b. T1-weighted axial image shows intact cartilage without disruption (arrow)
mality on MR can demonstrate intramedullary abnormality or minute fracture missed on other modalities (11-14). The abnormal marrow signal in injured patients is thought to be due to edema, hemorrhage, trabecular distortion or microfracture, but it is not histologically verified yet(8, 9).

We thought of the potential role of MR in known fracture patients, although no previous work has been done as far as we knew. For technical aspect, three-dimensional gradient echo scan had some advantages such as thin continuous section, multiplanar reconstructing ability, and better imaging of cartilaginous structure, so differentiation of joint effusion and cartilage was possible and cartilage injury itself was evaluated. But more motion artifact was noted on three dimensional image and coronal scan was of poor quality, so careful patient selection and imaging plan were necessary. Precise evaluation of direction and extent of fracture is essential for decision making for treatment plan and localization of displaced fragment is necessary to obviate unnecessary manipulation. And sometimes as already seen above, whether to operate or not depends on the degree of comminution or involvement of cartilage, and helpful information on such a viewpoint cannot be obtained by other imaging modalities besides MR. For example, Hohl's classification is most commonly applied to tibial plateau injury and it has clinical significance in determining treatment modality, because it can somewhat suggest associated medial collateral ligament injury(15). In our series, the discrepancy between the injury type of Hohl's classification by MR and that by plain radiography was retrospectively noticed in one case. Growth plate injury is another good candidate for MR imaging in which direct demonstration of premature bone fusion is possible (16-17). Notwithstanding all the advantages of MR mentioned above, MR still has some drawbacks in traumatology imaging. The precise soft tissue evaluation is not always possible in complex injury due to structural derangement and masking by hematoma especially for cruciate ligaments. And there is no specificity in marrow injury, so MR cannot say whether the lesion is a transient one or it might cause permanent sequela, unless follow-up examination be performed.

In briefly summing up, fracture MR has its value in evaluating the extent and degree of the injury and it is especially advantageous in detecting cartilage injury and early complication of growth plate injury. Further study would be made in the direction of improving specificity of the finding and evaluating the chronicity of the injury. Now, we might suggest that the possible indications for MR in fracture patients be suspected association of soft tissue injury, unexplained (no fracture line on plain film, no soft tissue injury on arthroscopy) knee pain after trauma, intraarticular fracture, and epiphyseal injury.

REFERENCES

사지 골절 환자에서의 자기공명영상의 역할

서귀숙 · 염효근 · 이기병 · 남궁숙 · 윤규섭 · 배상훈

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목적: 사지골절환자의 진단에 있어 자기공명영상은 동반된 연부조직 손상의 평가 등의 제한된 목적으로 주로 사용되었고 골절 자체의 평가에는 잘 사용되지 않아왔다. 이 연구는 골절의 평가에 있어 자기공명영상의 의의를 알아보고자 하였다.

대상 및 방법: 29명의 골절환자에서 시행한 33예의 자기공명영상을 후향적으로 분석하였다. 12예의 경골 근위부 골절, 4예의 대퇴골 원위부 골절, 5예의 골단판 골절, 기타 4예가 있었다.

결과: 2예를 제외한 모든 자기공명영상에서 손상의 범위가 더 잘 관찰되었으며(93.9%), 다른 영상기법으로는 관찰할 수 없었던 연부 기교시가 28예에서 가능하여(84.8%) 손상상태의 진단과 치료 방침의 결정에 도움을 주었다. 주골절에 동반된 골수 조직의 이상도 자기공명영상으로 관찰할 수 있었다. 십자인대, 측방인대, 반월판 손상 등 연부조직의 이상과 골괴사 등 동반된 이상 소견을 동시에 관찰할 수 있었다. 골단판 골절에서는 조기 골유합을 직접 나타냄으로써 손상 상태의 파악에 큰 도움을 주었다.

결론: 골절의 진단에 있어 자기공명영상은 손상의 정도 및 범위를 평가할 수 있으며 특히 연골 손상 및 골단판 손상의 판별에 유용하였다.