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Further Imaging for Suspected Isolated Greater Trochanteric Fractures: Multiplanar Reformation Computed Tomography or Magnetic Resonance Imaging

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Background: Most isolated greater trochanter (IGT) fractures are treated conservatively. However, some require surgical fixation although indications for surgery have not yet been established. Many surgeons perform surgical fixation when the intertrochanteric extension crosses the midline on magnetic resonance (MR) images. Nevertheless, for mechanical strength, cortical bone integrity is more important than that of intramedullary cancellous trabeculae. We retrospectively evaluated the clinical usefulness of multiplanar reformation computed tomography (MPR CT) in determining treatment strategies for IGT fractures.

Methods: We evaluated 99 cases of suspected IGT fractures between October 2004 and December 2019. They were 66 women and 33 men with a mean age of 77 years. The mean follow-up period was 34 months. Most patients were evaluated with plain radiographs, followed by additional imaging study via MPR CT in 65 cases, magnetic resonance imaging (MRI) in 5 cases, and both in 17 cases. Typically, fractures were fixed surgically when a cortical breakage was detected in the intertrochanteric area on MPR CT, while fractures without evidence of cortical breakage on MPR CT were treated conservatively.

Results: In 13 out of 82 cases evaluated by MPR CT, incomplete cortical breakage in the intertrochanteric area was detected, of which 10 were treated surgically. The remaining 3 cases were treated conservatively due to patient's refusal, poor medical condition, and failure to detect breakage. Of 69 cases without cortical breakage, 61 cases were successfully treated conservatively. Among the 17 cases evaluated by both MPR CT and MRI, cortical breakage was detected in 3, of which the intertrochanteric extension crossed the midline on the MR image only in 1 case. Of the remaining 14 cases without breakage, the intertrochanteric extension crossed the midline in 5. Among these 5 cases, 3 were treated conservatively.

Conclusions: The results suggest that MPR CT is a useful imaging modality for further evaluation of IGT fractures. It was especially valuable in evaluating cortical bone integrity, which may be more critical for fracture stability.

Keywords: *Greater trochanteric fracture, Multiplanar reformation computed tomography, Magnetic resonance imaging*

Most isolated greater trochanter (IGT) fractures, a relatively rare fracture type, are traditionally treated conservatively. Many IGT fractures have an intramedullary signal change of various extents in the intertrochanteric area on magnetic resonance imaging (MRI). Schultz et al.[1] defined the IGT fracture with the intertrochanteric extension on MRI as an incomplete intertrochanteric (IIT) fracture. Given that IIT fractures can progress to complete fractures, some need to be surgically fixed. However, the indication for surgical fixation has not been clearly established. Many

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surgeons perform surgical fixation when the intertrochanteric extension crosses the midline on the mid-coronal MR image.[1-5] However, some studies reported successful results following conservative treatment for fractures with the intertrochanteric extension of various extents.[6-9] In the author's institution, multiplanar reformation computed tomography (MPR CT) has been the primary further imaging modality for suspected IGT fracture cases as national health care insurance does not cover MRI. If MRI was determined necessary according to MPR CT results, it was selectively performed. In the current study, we retrospectively evaluated the clinical usefulness of MPR CT in determining treatment strategies for IGT fractures.

METHODS

The current study is a retrospective study and the design and protocol were approved by the Institutional Review Board of Seoul National University Hospital (IRB No. H-2004-107-1118). The requirement for informed consent was waived.

Between October 2004 and December 2019, 108 cases of suspected IGT fractures were treated at our institution, composing the study sample. Excluding 9 cases with inadequate follow-up, 99 cases were included in the final evaluation. In 90 cases, IGT fractures were detected on initial plain radiographs. In the remaining 9 cases, no fracture was identified, but the GT fracture was found by MPR CT, which was performed because symptoms and signs suggested high possibility of GT fractures. The sample comprised 66 women and 33 men with a mean age of 77 years (range, 39–98 years). All conservatively treated cases were followed up for a minimum of 2 months, and the average follow-up period was 34 months (range, 0.75–150 months). All patients were assessed by plain radiographs after trauma such as slip down or direct contusion and further evaluated with MPR CT and/or MRI in most cases. In addition to plain radiographs, further imaging was conducted using MPR CT in 65 cases, MRI in 5 cases, and both MPR CT and MRI in 17 cases. In the remaining 12 cases, no additional imaging was done.

In MPR CT, axial images were taken to a specific thickness, followed by reconstruction to obtain sagittal and coronal images. Several types of CT scanners were used in this study, including Aquilion One or Aquilion Lightning (Canon Healthcare, Otawara, Japan), Brilliance 64 (Philips Healthcare, Best, the Netherlands), ICT 256 (Philips Healthcare), Ingenuity (Philips Healthcare), Lightspeed Ultra (GE Healthcare, Waukesha, WI, USA), Mx8000 (Philips Healthcare), Sensation 16 (Siemens Healthcare, Erlangen, Germany); and SOMATOM definition or SOMATOM force (Siemens Healthcare). A cortical breakage in the intertrochanteric area was examined carefully on axial, coronal, and sagittal CT images.

MR imaging was performed using various machines: a 3.0-T system (Magnetom Skyra or Magnetom Verio, Siemens Healthcare) or a 1.5-T system (Achieva or Intera, Philips Healthcare; Signa HDx or Signa Excite, GE Healthcare). Axial, coronal, and sagittal MR images were scrutinized to evaluate the intertrochanteric extension in the intramedullary space, as well as evidence of cortical breakage in the intertrochanteric area.

Both MPR CT and MRI were evaluated by two orthopedic surgeons (KK and HJK), focusing on cortical breakage and the extent of intertrochanteric extension, respectively. Typically, fractures were fixed surgically when a cortical breakage was detected in the intertrochanteric area on MPR CT images regardless of whether or not the intertrochanteric extension passed the midline on the mid-coronal MR image. All surgical fixations were performed by two experienced surgeons (JJY and HJK) using a compression hip screw (CHS; Zimmer, Warsaw, IN, USA) or a proximal femoral nail (Proximal femoral nail antirotation, Synthes, Solothurn, Switzerland; Gamma3 nail, Stryker, Mahwah, NJ, USA; Compression hip nail, TDM, Seoul, Korea). Fractures without the evidence of cortical breakage on CT images were treated conservatively though some cases without the intertrochanteric cortical breakage on CT images were surgically fixed due to uncertainty or anxiousness. For conservative treatment, patients were trained for tolerable weight-bearing gait using bilateral crutches or a walker.

RESULTS

Further evaluation imaging (MPR CT and MRI), findings, and treatment methods are summarized in Fig. 1. In 13 out of 82 cases evaluated by MPR CT, incomplete cortical breakage in the intertrochanteric area was detected. In all cases, the cortical breakage was located in the anterior part of the intertrochanteric area while the posterior part remained intact (Fig. 2). Cortical breakage was detected on coronal images in 12 cases, on sagittal images in 12 cases, and on axial images in 9 cases. Among these 13 cases, 10 were treated surgically using a CHS or a proximal femur nail. It was determined to treat conservatively for the remaining 3 cases: 1 young reliable patient who refused surgery and kept non-weight-bearing using crutches, 1 patient who was a poor surgical candidate due to underlying comorbidities, and 1 patient whose cortical breakage along

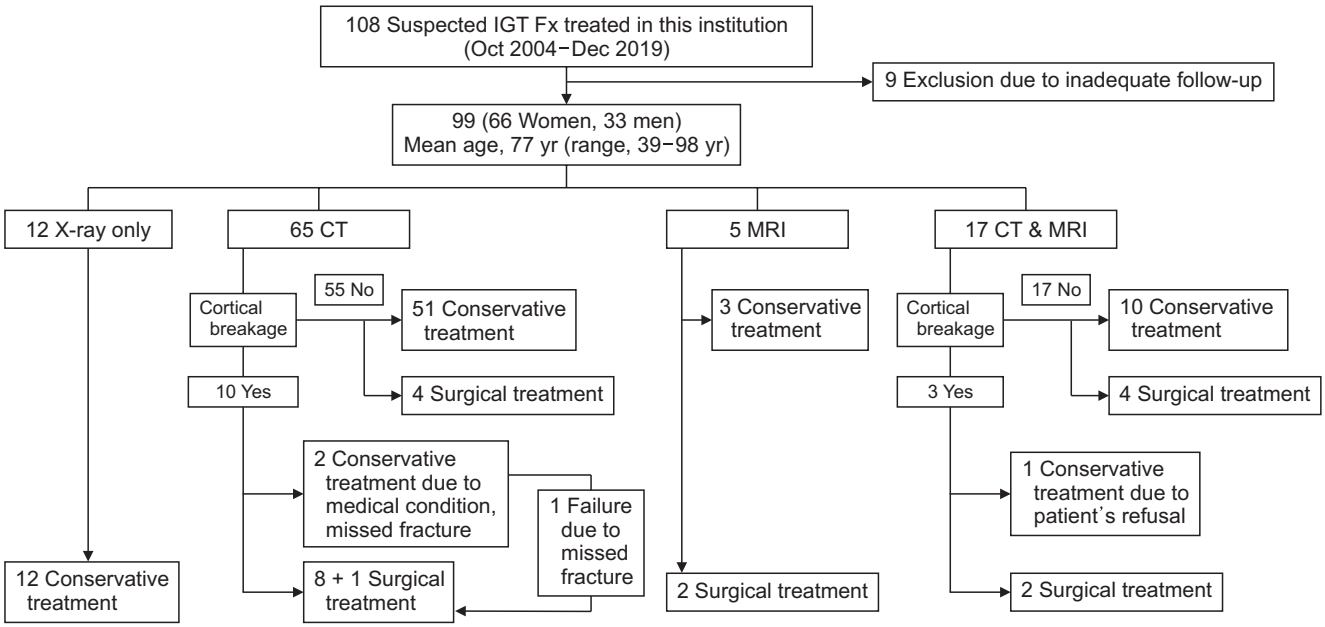

Fig. 1. Treatment summary. IGT: isolated greater trochanter, Fx: fracture, CT: computed tomography, MRI: magnetic resonance imaging.

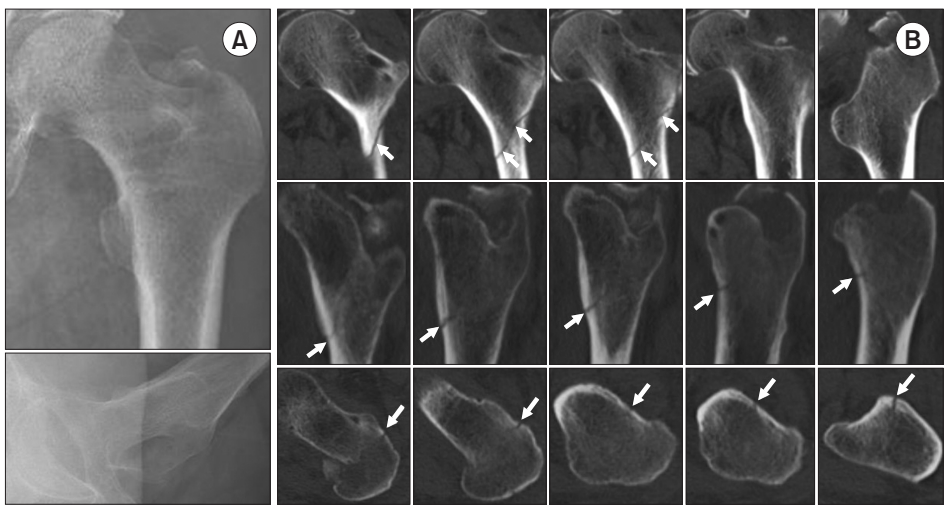

Fig. 2. (A) Anteroposterior and translateral radiographs of a 91-year-old man showing an isolated greater trochanter fracture. (B) Computed tomography images showing a cortical breakage in the anterior portion of the intertrochanteric area (arrows). The posterior portion remained intact.

the anterior cortex was initially overlooked on imaging study. The last one eventually developed a complete fracture 2 weeks later and underwent surgery (Fig. 3).

In 69 cases, no cortical breakage was detected in the intertrochanteric area on CT images, of which 8 cases were treated surgically and 61 were treated conservatively with successful results. Among the 17 cases evaluated by both MPR CT and MRI, cortical breakage was detected in 3 cases on CT images. There was no evidence of cortical breakage in the remaining 14 cases. Cortical breakage was not detected on MR images in any of these cases. Of the 3 cases with cortical breakage on CT images, the intertrochanteric extension crossed the midline on the mid-coronal MR image only in 1 case (Fig. 4). Among the 14 cases without cortical breakage, the intertrochanteric extension crossed the midline in 5 cases, of which 2 cases were surgically fixed and the other 3 cases were treated successfully without surgery (Fig. 5). Table 1 summarizes the demographics of the patients with both MPR CT and MRI including the results of cortical breakage and intertrochanteric extension and treatment methods.

Among the 5 cases evaluated by only MRI, 2 cases were treated surgically, and 3 cases conservatively. Of the 2 cases with surgical treatment, the intertrochanteric extension crossed the midline on the mid-coronal MR image in only 1 case. Similarly, of the 3 cases with conservative

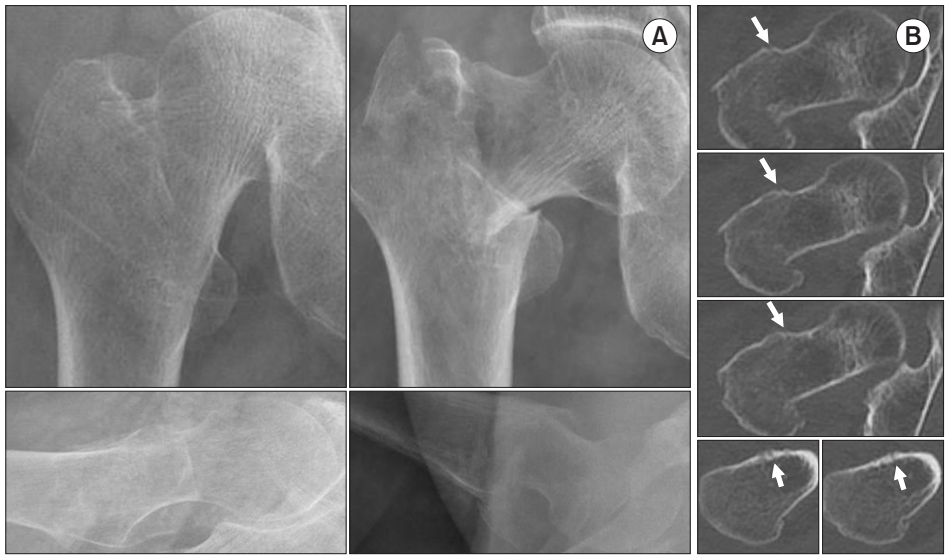

Fig. 3. (A) Anteroposterior and translateral radiographs of a 90-year-old woman. No cortical breakage was identified in the intertrochanteric area on computed tomography (CT) images except an isolated greater trochanter fracture. Therefore, conservative treatment was used initially. Two weeks after conservative treatment was initiated, a complete fracture developed. (B) The initial CT images reviewed retrospectively revealed a breakage (arrows) in the anterior cortex that had failed to be recognized on the initial examination.

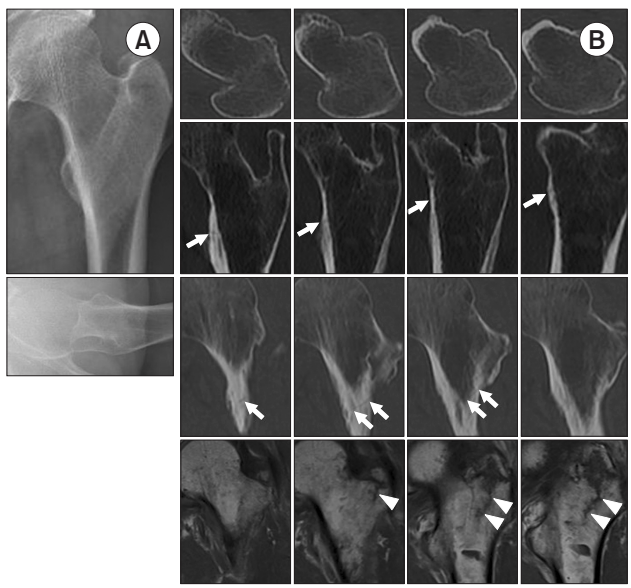

Fig. 4. (A) Anteroposterior and translateral radiographs of a 71-year-old man showing an isolated greater trochanter fracture. (B) Computed tomography images showing an anterior cortical breakage (arrows), and magnetic resonance images showing that the intertrochanteric extension did not cross the midline (arrowheads). It was fixed with a compression hip screw.

treatment, the intertrochanteric extension crossed the midline on the mid-coronal MR image in 1 case, which was treated successfully.

Twelve cases, in which the IGT fracture was detected on plain radiographs but no further imaging was performed because of the patient's refusal, were treated conservatively without failure.

DISCUSSION

MRI is a highly sensitive tool, superior to MPR CT in detecting occult fractures and intramedullary intertrochanteric extension of IGT fractures.[10-12] However, in IGT fractures, a key factor in an appropriate treatment decision is choosing between surgical fixation and conservative treatment. Indications for surgical fixation based on the intertrochanteric extension on MRI vary greatly. Many surgeons proceed with surgical fixation when the intertrochanteric extension on the mid-coronal MR image crosses the midline,[1-5] some perform surgical fixation for all cases with the intertrochanteric extension regardless of extent,[13] and others in cases with further extension.[14,15] However, some reports of successful conservative treatment results for IGT fractures with intertrochanteric extension beyond the midline have been published.[7,9] Thomas et al.[6] suggested that the sensitivity of MRI is so high that there is a risk of unnecessary surgery due to the overestimation of a fracture, which should be avoided. In our study, among the 17 cases evaluated by both MPR CT and MRI, MR images showed intertrochanteric extension crossing the midline although CT images showed no cortical breakage in 5 cases. Of these 5 cases, 3 cases were treated successfully without surgery (Pt #7, #9, and #11). This result is consistent with other reports,[7-9] suggesting the limitation of the intertrochanteric extension on MRI. In other words, it may not be reasonable to decide whether to perform surgery based only on the extent of the intertrochanteric extension on MRI. Furthermore, in 2 of the 3 cases in which cortical breakage was detected on MPR CT, the intertrochanteric extension did not cross the midline on the mid-coronal

Table 1. Demographics of Patients with Both MPR CT and MRI

No.	Sex	Age (yr)	Plain radiograph	MPR CT	MRI	Treatment
1	F	91	No evidence of fracture	No ACB	OM	CHS
2	M	71	IGT fracture	ACB	TM	CHS
3	M	64	IGT fracture	No ACB	OM	PFNA
4	F	73	IGT fracture	No ACB	TM	PFNA
5	M	91	IGT fracture	ACB	TM	PFNA
6	F	82	IGT fracture	No ACB	TM	PFNA
7	F	89	IGT fracture	No ACB	OM	Conservative
8	F	87	IGT fracture	No ACB	TM	Conservative
9	F	85	IGT fracture	No ACB	OM	Conservative
10	F	82	IGT fracture	No ACB	TM	Conservative
11	F	81	IGT fracture	No ACB	OM	Conservative
12	F	78	IGT fracture	No ACB	TM	Conservative
13	F	71	IGT fracture	No ACB	TM	Conservative
14	M	55	IGT fracture	No ACB	TM	Conservative
15	M	39	IGT fracture	ACB	OM	Conservative
16	F	83	No evidence of fracture	No ACB	TM	Conservative
17	M	45	IGT fracture	No ACB	TM	Conservative

MPR: multiplanar reconstruction, CT: computed tomography, MRI: magnetic resonance imaging, ACB: anterior cortical breakage, OM: extension line over the midline, CHS: compression hip screw, IGT: isolated greater trochanter, TM: extension line to the midline, PFNA: proximal femoral nail antirotation.

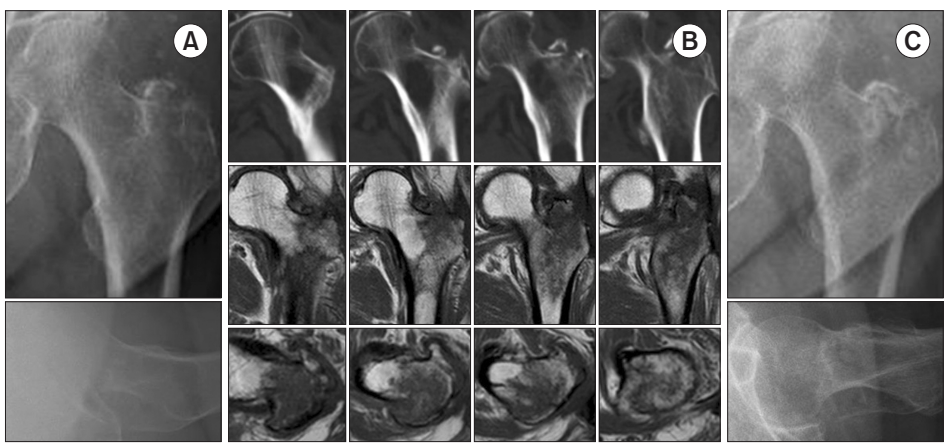

Fig. 5. (A) Anteroposterior and translateral radiographs of an 89-year-old man showing an isolated greater trochanter fracture. (B) Computed tomography images showing intact cortical bone, and magnetic resonance images showing intertrochanteric extension crossing the midline. (C) Anteroposterior and translateral radiographs showing that the intertrochanteric area remained intact following full weight-bearing activity after 2 months of conservative treatment.

MR image (Pt #2 and #5). These findings imply that the degree of intertrochanteric extension on MR images does not accurately reflect the actual cortical bone integrity.

Thomas et al.[6] reported successful results of conservative treatment for 20 cases of CT-diagnosed IGT fractures without further evaluation of the degree of intertrochanteric extension on MRI. In our study, MPR CT was performed on 82 patients, and in 69 of these cases, no cortical breakage was detected. Eight out of 69 cases were treated with surgical fixation based on MRI findings or simply because of anxiety or possible uncertainty. The remaining 61 cases were treated conservatively with success-

ful results. Ingari et al.[16] reported that the low signal band of the proximal femoral fracture observed in MRI was not edema or hemorrhage, but trabecular impaction. For mechanical strength, however, cortical bone integrity is more important than that of intramedullary cancellous trabeculae. While MR imaging has an advantage in detecting an occult fracture and viewing intramedullary extension, MPR CT is more sensitive in detecting cortical bone integrity, which may be more critical for fracture stability. Our results suggest that conservative treatment can be used if cortical breakage is not detected on MPR CT regardless of the extent of the intramedullary intertrochanteric extension on MR images, which is also supported by the results of a small number of cases by Kim et al.[17]

This study has some limitations. Firstly, this is a retrospective study performed in a single institution. Due to the limitations of the retrospective study design, the clinical protocol for IGT fractures were not strictly followed. For example, in 5 cases evaluated by only MR imaging, MR imaging was firstly performed in other clinics or institutions. Then the patients were referred to our clinic, and treatment strategies were determined without additional MPR CT evaluation. There were 12 cases, in which IGT fractures were detected on plain radiographs but no further imaging was performed because of patient's refusal. In addition, some cases without cortical breakage were treated by surgical fixation due to uncertainty or anxiousness. Secondly, both MPR CT and MR images were available only in 17 cases. Therefore, it was difficult to compare the superiority of MPR CT and MR imaging because the number of cases was insufficient. Nevertheless, the number of cases of this study was large enough to suggest the advantage of MPR CT and the limitation of MRI in deciding an appropriate treatment strategy.

It is essential to perform further imaging in patients with suspected IGT fractures. MR imaging is advantageous for detecting occult fractures or visualizing intramedullary extension but does not accurately reflect cortical bone integrity, which is more critical for fracture stability. The result of this study suggests that MPR CT is a useful imaging modality for further evaluation of suspected IGT fractures. It was especially valuable in deciding the necessity of surgical fixation.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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