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# Incomplete Intertrochanteric Fracture: A Pattern Analysis Using Multiplanar Reformation Computed Tomography

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**Background:** Incomplete fractures are assumed to occur in the intertrochanteric area as fractures at other sites, but reports of incomplete intertrochanteric fractures (IIFs) are rare. In 1999, Schultz et al. defined isolated greater trochanter fractures (GTFs) as IIFs when intertrochanteric extension is observed on magnetic resonance (MR) images. On multiplanar reformation computed tomography (MPR CT) images acquired for further study of apparently isolated GTFs, we noted incomplete cortical breakage in the intertrochanteric area. We then found that the fracture line was incomplete on plain radiographs in some intertrochanteric fractures. We evaluated IIFs and apparently isolated GTFs using MPR CT and analyzed the fracture patterns of IIFs that were confirmed using MPR CT.

**Methods:** Between February 2006 and June 2019, 36 cases of IIF were detected using MPR CT in 36 patients. They were 17 women and 19 men with a mean age of 74.7 years (range, 26–94 years). Plain radiographs and MPR CT images were evaluated by two experienced orthopedic surgeons. In addition, MR imaging was performed in 5 cases.

**Results:** Plain radiographs showed no evidence of fracture in 2 cases, isolated GTF in 7 cases, and IIF in 27 cases. In all cases, incomplete cortical breakage in the intertrochanteric area was confirmed on MPR CT images. Cortical breakage was located in the anterior portion of the intertrochanteric area, whereas the posterior portion remained intact in all cases. The detection rate of cortical breakage was higher on coronal or sagittal images than that on axial images. On MR images of 5 cases, intertrochanteric extensions were found in the medullary space. All extensions originated in the greater trochanter area and extended anteriorly in the axial plane and inferomedially in the coronal plane. On the T1-weighted mid-coronal image, the extension reached or passed the midline in 3 cases, and cortical breakage was detected in only 2 cases.

**Conclusions:** In all cases of IIF, cortical breakage was detected in the anterior portion of the proximal femur, leaving the posterior cortex intact. This finding is notably different from that of intertrochanteric extension (from posterior to anterior) detected on MR images of isolated GTFs.

**Keywords:** *Intertrochanteric fracture, Incomplete, Pattern analysis, Three-dimensional computed tomography*

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An incomplete fracture is a fracture that does not extend through the full transverse width of a bone. Similar to fractures occurring at other sites, it is believed that incomplete fractures occur in the intertrochanteric area. However, the descriptions of incomplete intertrochanteric fractures (IIFs) are very limited and only two were found in our English literature search. In 1974, Tronzo[1] classified inter-

trochanteric fractures based on their reduction potential and defined type 1 as incomplete fractures. He classified intertrochanteric fracturs as incomplete when the lesser trochanter remained intact because these fractures could be reduced anatomically by simple traction. This did not mean that some cortical bone remained intact. In 1999, Schultz et al.[2] defined a greater trochanter fracture (GTF) as an IIF when it exhibited findings of intertrochanteric extension on magnetic resonence (MR) images. After publication of this report, many authors have been quoting it as a reference.[3-12] However, this intertrochanteric extension was a signal change in the medullary space and did not indicate cortical breakage. The extension started from posterolateral portion of the intramedullary space and progressed vertiically or obliquely to anteromedial portion without evidence of cortical breakage in the intertrochanteric area. It is quite contrary to coventional imcomplete fractures such as greenstick or torus fractures, in which cotical breakage is incomplete with some portions remain intact.

Since 2006, multiplanar reformation computed tomography (MPR CT) has been used for further evaluation of apparently isolated GTFs, and the treatment method is decided based on MPR CT findings in our institution. With MPR CT evaluation, some apparently isolated GTFs were found to have cortical breakage in the intertrochanteric area. The breakage did not involve the whole cortex with some portion remaining intact. We also found that the fracture line was not completely circumferential in some intertrochanteric fractures on plain radiographs and these incomplete fractures were evaluaed with MPR CT. In this study, we analyzed the patterns of cortical breakage in IIFs that were confirmed using MPR CT and compared with the intertrochanteric extension on MR images.

## METHODS

This study was conducted in compliance with the principles of the Declaration of Helsinki. Its design and protocol were retrospective and approved by the Institutional Review Board of Seoul National University Hospital (IRB No. H-1803-035-926). Informed consent was waived.

Intertrochanteric fractures that had incomplete, not circumferential, cortical breakage in the intertrochanteric area confirmed by MPR CT were included in the final analysis. Fractures in children or secondary to bone pathologhy other than osteoporosis were excluded. Between February 2006 and June 2019, 36 IIF cases of 36 patients were evaluated with MPR CT. Nine cases were suspected or apparently IGT fractures but confirmed to be IIF by further evaluation with MPR CT, and 27 cases showed incomplete cortical breakage in the intertrochanteric area on plain radiographs (anteroposterior and translateral views). The patients included 17 women and 19 men with a mean age of 74.7 years (range, 26–94 years) at the time of injury. The right side was affected in 17 cases and the left side in 19 cases. Their body mass index was 19.99 kg/m$^2$ on average (range, 14.29–25.11 kg/m$^2$). Based on bone mineral density in 25 cases and Singh index in 11 cases, there were 24 cases of osteoporosis and 11 cases of osteopenia. Seven cases were taking medicine for osteoporosis and 5 cases had a osteoporotic fracture in other sites (3 in vertebral body and 2 in contralateral hip) earlier (Table 1). In all cases, hip pain developed after a low-energy injury, such as a slip down or a trip and fall. A 39-year-old man fell down on the ground while sitting on a standing bicycle and this was the highest-energy trauma in this series.

In most cases, CT was taken at other hospital. Axial CT images were acquired with slice thicknesses ranging from 1 to 3 mm using one of several CT scanners: Aquilion One, Canon Healthcare, Irvine, CA, USA; Asteion, Toshiba Medical System, Tokyo, Japan; Brilliance 64, ICT 256, Mx16 or Mx 8000, Philips Healthcare, Best, Netherlands; Emotion 16 or SOMATOM definition, Siemens Healthcare, Erlangen, Germany; and Lightspeed Ultra or Lightspeed VCT, GE Healthcare, Waukesha, WI, USA. Coronal and sagittal images were obtained by the reformation of axial images. In 5 cases, 1.5- or 3.0-T MR images taken at other hospital were also available. All images were examined by two experienced orthopedic surgeons (HJK and KK) in consensus with a special focus on the location and extent of the cortical breakage.

**Table 1.** Demographics of Patients

| Variable | Female | Male |
|---|---|---|
| No. of patients | 17 | 19 |
| Side (right : left) | 9 : 8 | 8 : 11 |
| Age (yr) | 72.9 (26–91) | 76.4 (39–94) |
| Body mass index (kg/m$^2$) | 19.41 (14.29–15.22) | 20.26 (15.81–23.74) |
| Bone mineral density | | |
| Osteoporosis | 13 | 11 |
| Osteopenia | 4 | 7 |
| Normal | 0 | 1 |
| Osteoporosis treatment | 3 | 4 |

Values are presented as median (range).

## RESULTS

On plain radiographs, no fracture was detected in 2 cases, isolated GTF in 7 cases, and IIF in 27 cases. In all cases, incomplete cortical breakage in the intertrochanteric area was confirmed on MPR CT images. All cortical breakages were located in the anterior portion of the intertrochanteric area, whereas the posterior cortex remained intact (Figs. 1-3).

On plain radiographs, an incomplete fracture line was found on the anteroposterior view in 3 cases, on the translateral view in 4 cases, and on both views in 20 cases. On MPR CT images, cortical breakage was detected on axial images in 3 cases, coronal images in 2 cases, axial and coronal images in 1 case, axial and sagittal images in 3 cases, coronal and sagittal images in 6 cases, and images of all planes in 21 cases. Overall, coritcal breakage was revealed on axial images in 28 cases (77.8%) and coronal or sagittal images in 30 cases (83.3%).

Cortical breakage detected on plain radiographs and MPR CT images was located in the anterior portion of the intertrochanteric area, whereas the posterior cortex remained intact. There were no cases in which cortical breakage involved the posterior cortex only, whereas the anterior cortex remained intact.

MR imaging was performed in 5 cases. In all cases, intertrochanteric extensions were found in the medullary space (Figs. 2 and 3). All extensions originated in the greater trochanter area and extended anteriorly in the axial plane and inferomedially in the coronal plane. On T1-weighted mid-coronal image, the extension reached the midline in 2 cases (Fig. 2) and passed the midline in 1 case. In these 3 cases, the extension did not reach the medial cortex, and no cortical breakage was detected on images of any planes. In 2 cases, the extension reached the medial cortex and cortical breakage was detected on images of all planes (Fig. 3).

Thirty-three cases were treated by internal fixation, using a compression hip screw in 22 cases and a proximal femoral nail in 11 cases. One patient was treated conservatively because of a poor general condition; this patient died 2 months later in a bedridden state. One young and otherwise healthy patient maintained non-weight-bearing with crutches for 2.5 months, and the fracture healed. One patient refused surgery and used crutches, but the fracture was completely displaced 3 weeks later.

## DISCUSSION

In all cases of this study, the cortical bone was broken in the anterior portion, whereas the posterior portion remained intact. There were no cases in which the anterior cortex remained intact, with the posterior cortex broken. We retrospectively reviewed the images of all intertrochanteric fractures that we treated in the last 20 years. Thirty out of a total of 1,100 cases were IIFs, and in all of them, cortical breakage was located in the anterior portion, and some portion of the posterior cortex remained intact. These observations suggest that cortical breakage starts from the anterior portion and progresses to the posterior portion, eventually resulting in a complete fracture in the intertrochanteric area. This progression of cortical break-

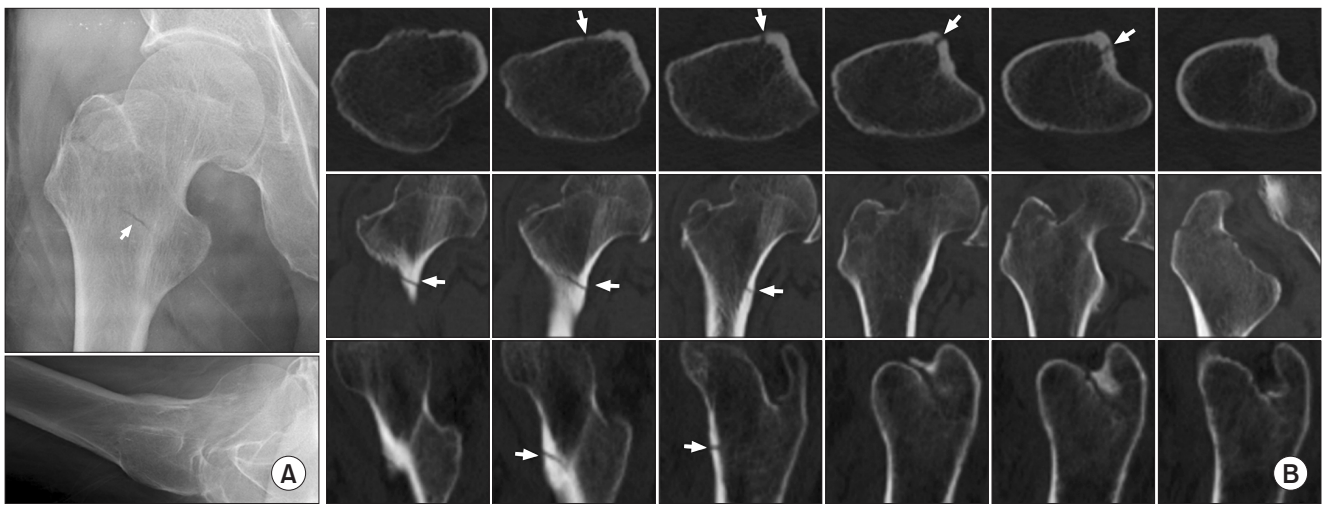


**Fig. 1.** A 78-year-old man. (A) An intertrochanteric fracture line (arrow) was detectable only on the anteroposterior view of plain radiographs. (B) Anterior cortical breakage (arrows) in the intertrochanteric area was detected on multiplanar reformation computed tomography images of all planes. The posterior portion of the cortex remained intact.

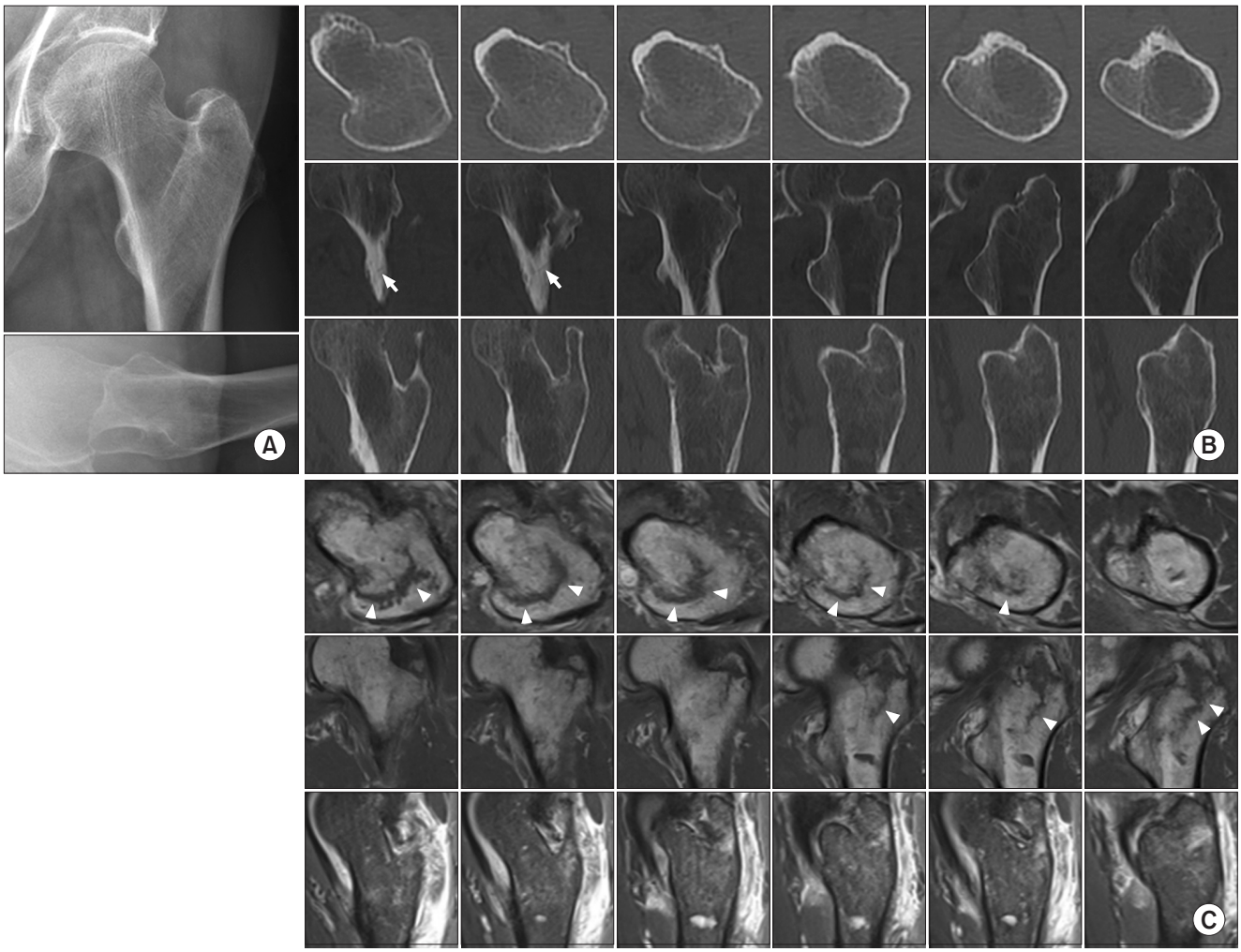


**Fig. 2.** A 71-year-old man. (A) No definite fracture line was observed on plain radiographs. (B) Cortical breakage (arrows) was detected on coronal multiplanar reformation computed tomography images. No breakage was shown on axial or sagittal images. (C) Intertrochanteric extension (arrowheads) was observed in the intramedullary area on magnetic resonance images, but with no evidence of cortical breakage. The intertrochanteric extension did not reach the medial or anterior cortex. On the mid-coronal image, the extension did not pass the midline.

age is notably different from the intramedullary intertrochanteric extension observed on MR images of apparently isolated GTFs, which extends from posterior to anterior and from lateral to inferomedial.[2-15] Further studies on these contradictory findings in the intramedullary and cortical areas might establish the fracture mechanism of this injury.

In an experimental study using porcine femoral bones, Ingari et al.[16] found that the intramedullary signal change on MR images of proximal femoral fractures corresponded to trabecular impaction histologically. In the current study, we reviewed CT images with special attention to changes in the trabecular bone in the intertrochanteric area. It was difficult to compare these findings with those on the contralateral side because of the different positioning of each leg, but findings suggesting trabecular bone impaction were observed in 10 cases on images of some or all planes (Fig. 4). If this finding of trabecular bone impaction is accepted, a possible scinario for the development of intertrochanteric fractures caused by low-energy injuries is that the angulation force of the anterior apex in the intertrochanteric plane causes impaction of the posterior trabeculae with elastic deformation of the posterior cortex, distraction-type breakage of the anterior cortex, and comminuted breakage of the posterior cortex in sequence.

MR imaging was less sensitive for detecting cortical breakage than CT. Among the 5 cases evaluated with MR imaging, in addition to MPR CT, MR images revealed cortical breakage in only 2 cases. Furthermore, the intertrochanteric extension reached the midline, but did not

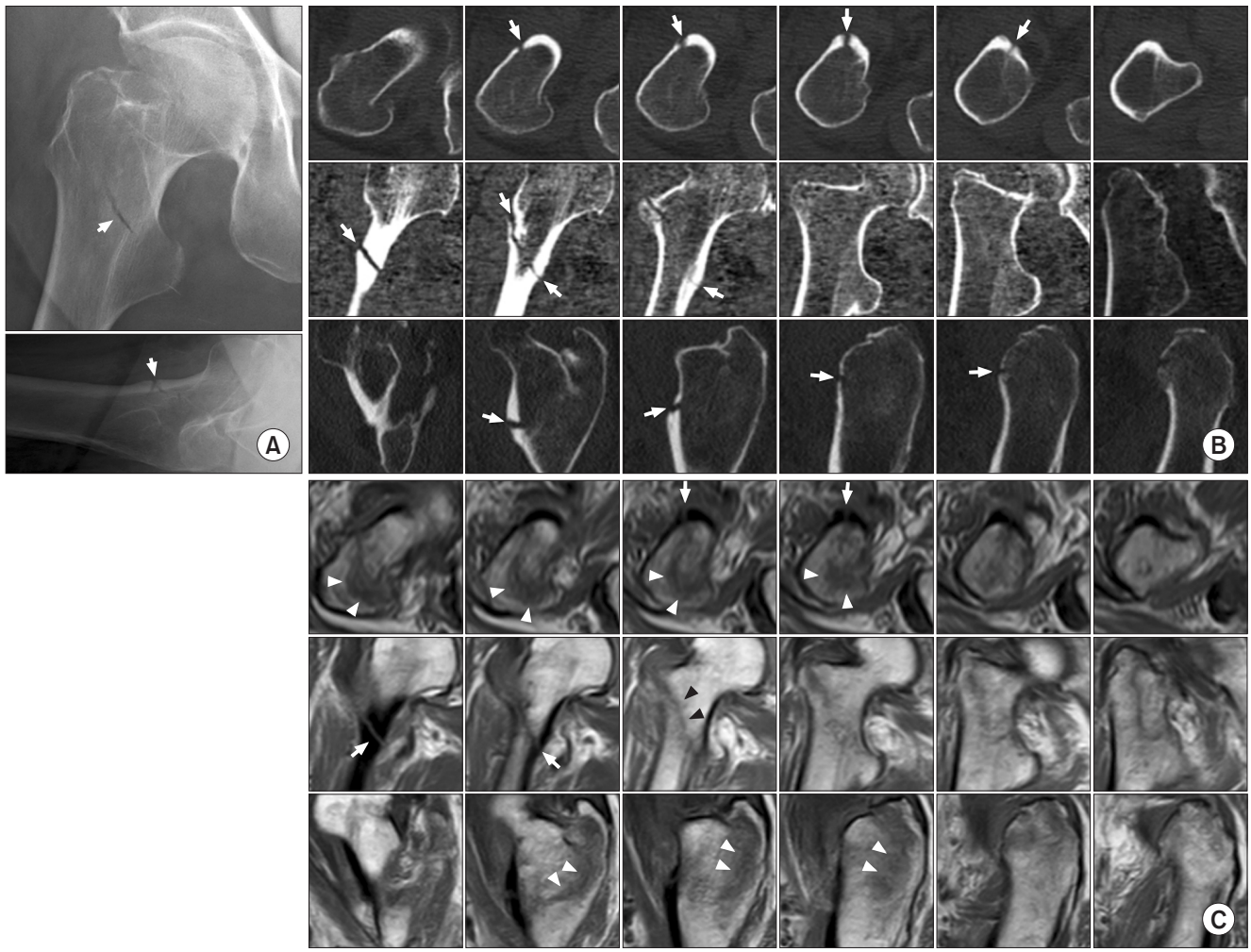


**Fig. 3.** An 86-year-old woman. (A) An incomplete fracture line (arrows) was visible on both views of plain radiographs. Cortical breakage was localized to the anterior portion of the intertrochanteric area. (B) Cortical breakage (arrows) was detected on multiplanar reformation computed tomography images of all planes. (C) Intertrochanteric extension (arrowheads) to the medial and anterior cortices was observed on magnetic resonance images. Cortical breakage (arrows) was detected on all plane images.

cross the midline unequivocally despite definite cortical breakage on MPR CT images in 2 other cases. These findings suggest that the extent of intertrochanteric extension on MR images is not a reliable guideline for the indication of surgical fixation for isolated GTFs because surgical fixation should be considered when intertrochanteric extension is detected regardless of its extent.[2,5-10,13]

For mechanical stability, the integrity of the cortical bone should be maintained. If some portion is broken, there is a high probability of progression to a complete fracture with load bearing. Despite some intramedullary damage, we can expect the bone to withstand load bearing if the cortical bone is intact.[2,6,13] We now perform surgical fixation only for the cases with cortical breakage on MPR CT images. This principle cannot guarantee absolutely the absence of misdiagnosis, but can prevent unnecessary surgery in many cases.

There are some limitations of this study. The number of cases was relatively small. Given the rarity of IIFs, it was only natural, and there was no problem in the interpretation of the results because cortical breakage was located in the anterior portion and the posterior cortex remained intact in all cases. MPR CT images were aquired using many different machines of different providers. Most patients presented with computed tomography (CT) images taken at other hospitals and we took CT images only when they were not available. The same went for MR images. In all cases, we used MR images taken at other hospitals and did not take MR images for suspected IGT fractures or suspected IIT fractures when MPR CT images

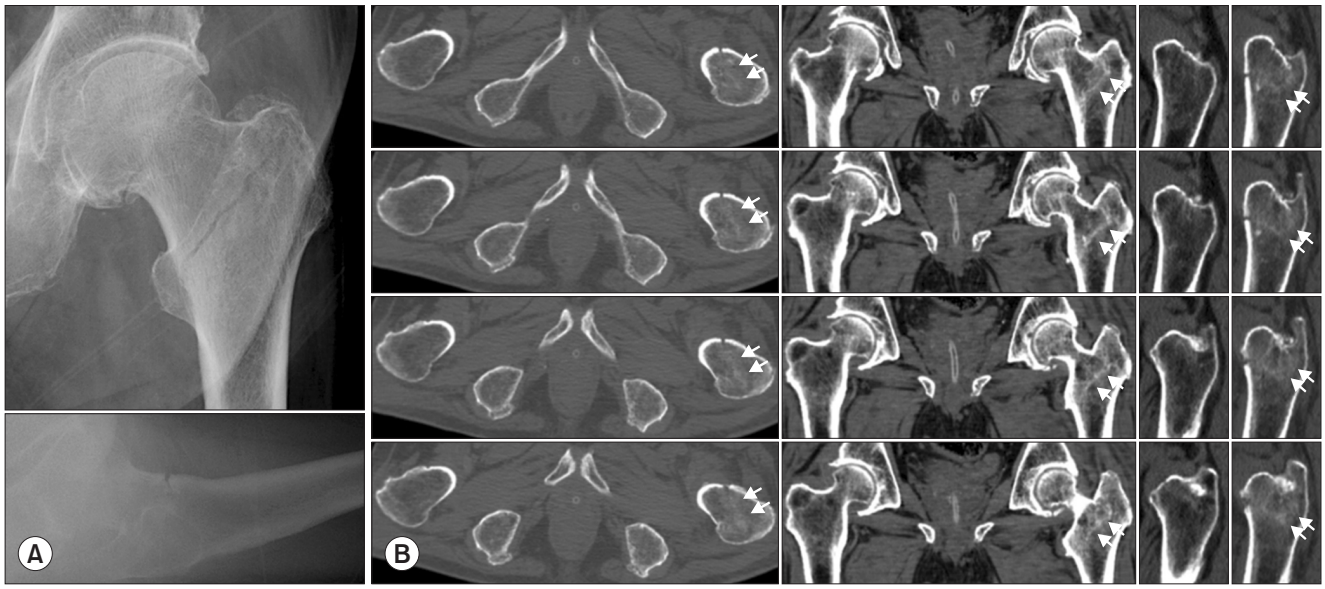


**Fig. 4.** An 88-year-old man. (A) An incomplete fracture line was visible on both views of plain radiographs. (B) Sclerotic changes (arrows) suggesting trabecular bone impaction were observed on multiplanar reformation computed tomography images of all planes.

were available.

## CONFLICT OF INTEREST

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

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## REFERENCES

1. Tronzo RG. Symposium on fractures of the hip: special considerations in management. Orthop Clin North Am. 1974;5(3):571-83.
2. Schultz E, Miller TT, Boruchov SD, Schmell EB, Toledano B. Incomplete intertrochanteric fractures: imaging features and clinical management. Radiology. 1999;211(1):237-40.
3. Craig JG, Moed BR, Eyler WR, van Holsbeeck M. Fractures of the greater trochanter: intertrochanteric extension shown by MR imaging. Skeletal Radiol. 2000;29(10):572-6.
4. Omura T, Takahashi M, Koide Y, et al. Evaluation of isolated fractures of the greater trochanter with magnetic resonance imaging. Arch Orthop Trauma Surg. 2000;120(3-4):195-7.
5. Feldman F, Staron RB. MRI of seemingly isolated greater trochanteric fractures. AJR Am J Roentgenol. 2004;183(2):323-9.
6. Alam A, Willett K, Ostlere S. The MRI diagnosis and management of incomplete intertrochanteric fractures of the femur. J Bone Joint Surg Br. 2005;87(9):1253-5.
7. LaLonde B, Fenton P, Campbell A, Wilson P, Yen D. Immediate weight-bearing in suspected isolated greater trochanter fractures as delineated on MRI. Iowa Orthop J. 2010;30:201-4.
8. Lee KH, Kim HM, Kim YS, et al. Isolated fractures of the greater trochanter with occult intertrochanteric extension. Arch Orthop Trauma Surg. 2010;130(10):1275-80.
9. Chung PH, Kang S, Kim JP, et al. Occult intertrochanteric fracture mimicking the fracture of greater trochanter. Hip Pelvis. 2016;28(2):112-9.
10. Moon NH, Shin WC, Do MU, Woo SH, Son SM, Suh KT. Diagnostic strategy for elderly patients with isolated greater trochanter fractures on plain radiographs. BMC Musculoskelet Disord. 2018;19(1):256.
11. Park JH, Shon HC, Chang JS, et al. How can MRI change the treatment strategy in apparently isolated greater tro-

chanteric fracture? Injury. 2018;49(4):824-8.

12. Noh J, Lee KH, Jung S, Hwang S. The frequency of occult intertrochanteric fractures among individuals with isolated greater trochanteric fractures. Hip Pelvis. 2019;31(1):23-32.
13. Sankey RA, Turner J, Lee J, Healy J, Gibbons CE. The use of MRI to detect occult fractures of the proximal femur: a study of 102 consecutive cases over a ten-year period. J Bone Joint Surg Br. 2009;91(8):1064-8.
14. Chatha H, Ullah S, Cheema Z. Review article: Magnetic resonance imaging and computed tomography in the diagnosis of occult proximal femur fractures. J Orthop Surg (Hong Kong). 2011;19(1):99-103.
15. Kim SJ, Ahn J, Kim HK, Kim JH. Is magnetic resonance imaging necessary in isolated greater trochanter fracture?: a systemic review and pooled analysis. BMC Musculoskelet Disord. 2015;16:395.
16. Ingari JV, Smith DK, Aufdemorte TB, Yaszemski MJ. Anatomic significance of magnetic resonance imaging findings in hip fracture. Clin Orthop Relat Res. 1996;(332):209-14.