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의학석사 학위논문

# Diagnosis and Treatment of Isolated Greater Trochanter Fractures: MPR CT or MRI

대전자 단독골절의 진단과 치료 : 다면상  
재구성 전산화단층촬영 또는 자기공명영상

2021년 2월

서울대학교 대학원  
의학과 정형외과학전공

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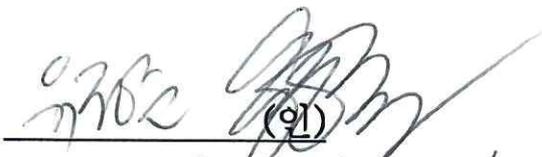
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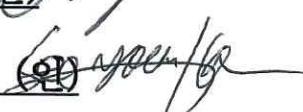
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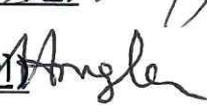
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## Abstract

# Diagnosis and Treatment of Isolated Greater Trochanter Fractures: MPR CT or MRI

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### Aims

Most isolated greater trochanter (IGT) fractures were treated conservatively. However, some require surgical fixation, though the indication for surgery has not yet been established. Many surgeons perform surgical fixation when the intertrochanteric extension crosses the midline on MRI. Nevertheless, for mechanical strength, cortical bone integrity is more important than that of intramedullary cancellous trabeculae. In addition, there is no clear consensus on when to consider MPR CT or MRI in IGT fractures.

In the current study, we proposed the following questions : [1] Can the intertrochanteric extension on MRI be a reasonable indication in choosing a treatment method for the IGT fractures? [2] does the degree of intertrochanteric extension on MRI reflect the actual cortical bone integrity? [3] compared to MRI, what is the value of MPR CT in IGT fractures? ,and [4] As in our treatment guidelines, is it reasonable to perform MRP CT first and then consider MRI as needed?

#### Patients and methods

We evaluated 100 cases of suspected IGT fracture between October 2004 and December 2019. They were 67 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 study via MPR CT in 66 cases, 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 83 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. In 70 cases without cortical breakage, 62 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 midline on MRI only in 1 case. In the remaining 14 cases without breakage, the intertrochanteric extension crossed the midline in 5. Among these 5 cases, 3 were treated conservatively.

#### Conclusion

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.

**Keyword: Isolated fracture of the greater trochanter; Intertrochnateric fracture; CT, Spiral Computed; Magnetic resonance imaging.**

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## Introduction

Most isolated greater trochanter (IGT) fractures, a relatively rare fracture type, were 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 defined the IGT fracture with the intertrochanteric extension on MRI as an incomplete intertrochanteric (IIT) fracture (1). 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 surgeons perform surgical fixation when the intertrochanteric extension crosses the midline on the mid-coronal MR image (1-5). However, some studies reported positive results following conservative treatment for fractures with the intertrochanteric extension of various extent (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 it was determined that MRI was necessary according to the MPR CT result, it was selectively performed.

In our study, we proposed the following questions : [1] Can the intertrochanteric extension on MRI be a reasonable indication in choosing a treatment method for the IGT fractures? [2] does the degree of intertrochanteric extension on MRI reflect the actual cortical bone integrity? , and [3] compared to MRI, what is the value of MPR

CT in IGT fractures? ,and [4] As in our treatment guidelines, is it reasonable to perform MRP CT first and then consider MRI as needed?

## Methods

The current study's design and protocol were retrospective, which was approved by the Institutional Review Board (IRB No. H-2004-107-1118).

Between October 2004 and December 2019, 108 cases of suspected IGT fracture were treated in the current institution, comprising the study sample. Excluding 8 cases with inadequate follow-up, 100 cases were included in the final evaluation. The sample was comprised of 67 women and 33 men with a mean age of 77 years (range, 39-98). 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). 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 66 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 are 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; Brilliance 64, Philips healthcare; ICT 256, Philips healthcare; Ingenuity, Philips healthcare; Lightspeed Ultra, GE healthcare; Mx8000, Philips healthcare; Sensation 16, Siemens healthcare; SOMATOM definition or SOMATOM force,

Siemens healthcare. A cortical breakage in the intertrochanteric area was examined carefully on axial, coronal, and sagittal CT images.

Due to the retrospective nature of this study, MRIs were performed using various machines: a 3.0-T (Magnetom Skyra, Siemens Healthcare; Magnetom Verio, Siemens Healthcare) or a 1.5-T (Achieva, Philips Healthcare; Intera, Philips Healthcare; Signa HDx or Signa Excite, GE Healthcare) system. 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 2 orthopedic surgeons, 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 CT images regardless of whether or not the intertrochanteric extension passed the midline on the mid-coronal MR image. All surgeries were performed by two experienced surgeons with compression hip screw (CHS; Zimmer, Warsaw, IN, USA) or proximal femur nailing (Proximal femoral nail antirotation, Synthes, Solothurn, Switzerland ; Gamma3 nail, Stryker, Mahwah, NJ, US; Compression hip nail, TDM, Seoul, South 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), their findings, and the treatment methods are summarized in Figure 1.

In 13 out of 83 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 nailing. It was determined to treat conservatively for the remaining 3 cases. These include a young reliable patient who refused surgery and kept tolerable weight-bearing activities using crutches, a patient who was a poor surgical candidate due to underlying comorbidities, and a patient whose cortical breakage along 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 70 cases, no cortical breakage was detected in the intertrochanteric area on CT images, of which 8 cases were treated surgically, and 62 treated conservatively.

Among the 17 cases evaluated by both MPR CT and MRI, cortical breakage was detected in 3 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 were surgically fixed, and the other 3 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 were treated surgically, and 3 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 treatment, the intertrochanteric extension crossed the midline on the mid-coronal MR image in 1 case, which was treated successfully.

## Discussion

MRI is a highly sensitive tool, superior to MPR CT in detecting occult fractures and intramedullary intertrochanteric extension of IGT fracture (10-12). However, in IGT fracture, a key factor in pursuing the appropriate treatment method is choosing between surgical fixation or conservative treatment. Indications for the 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), though 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 suggested that the sensitivity of MRI is so high that there is a risk of unnecessary surgery due to the overestimation of the fracture, which should be avoided (6). In our study, among the 17 cases evaluated by both MPR CT and MRI, MR images showed intertrochanteric extension crossing the midline, though CT images showed no cortical breakage in 5 cases. Of these 5 cases, 3 were treated successfully without surgery (Pt #7, #9, #11). Besides, of the 3 cases evaluated only by MRI and treated conservatively, 1 case showed intertrochanteric extension crossing the midline, which was treated successfully. 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 only with 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 MR image (Pt #2, #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 reported successful results of conservative treatment for 20 cases of CT diagnosed IGT or IIT fracture without further evaluation of the degree of intertrochanteric extension on MRI (6). In our study, MPR CT was performed on 83 patients, and in 70 of these cases, no cortical breakage was detected. Eight out of 70 cases were treated with surgical fixation considering MRI findings or simply because of anxiety or possible uncertainty. The remaining 62 cases were treated conservatively with successful results. Ingari et al reported that the low signal band of the proximal femoral fracture observed in MRI was not edema or hemorrhage, but trabecular impaction (16). For mechanical strength, however, cortical bone integrity is more important than that of intramedullary cancellous trabeculae. In other words, while MRI has an advantage in detecting occult fracture and viewing intramedullary extension, MPR CT is

valuable in detecting cortical bone integrity, which may be more critical for fracture stability. Even if it is difficult to conclude simply because there are no cortical breakage cases treated conservatively, our result recommends 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 MRI, supported by the results of a small number of cases by Kim et al (17). In the future, a well-designed prospective study will be needed to verify this.

According to the clinical protocol of our institution, MPR CT was routinely performed in the IGT fractures detected by plain radiographs, and MRI was additionally considered when CT findings and clinical symptoms were not correlated. In 70 cases, only evaluated by MPR CT, All cases were treated successfully without further MRI evaluation. When the diagnosis was unclear by MPR CT alone, MRI was additionally performed to determine the treatment method considering the extent of extension and clinical symptoms. However, this is a retrospective study, and there have been some exceptions. In 9 cases of our study, fractures were initially not detected on plain radiographs. Nevertheless, clinically, the occult fracture was suspected, and MPR CT or MRI was performed, and IGT was detected. This finding agrees with recommendations by other studies and supports the necessity of further evaluation using CT or MRI when a fracture is suspected (10,18-20). On the other hand, in 12 cases, only plain radiographs were performed without

further imaging. Some of them visited our institution due to continued pain 4 to 12 weeks after the trauma, and conservatively successful treatment was performed without further examination. Besides, in the patients having only mild focal tenderness on the greater trochanter area without other physical examination abnormalities or refusing further evaluation, plain radiographs were only performed. All of them were treated successfully without surgery. Alam et al reported that before the introduction of MRI, patients with hip pain after the trauma but normal on plain radiographs would have been treated conservatively, and there are no reports of missed intertrochanteric fractures in cases that were normal on the initial plain radiographs, which suggests that incomplete, undiagnosed intertrochanteric fractures are stable and healed well without complications (7). Considering that there was cortical breakage in about 16% of those evaluated by MPR CT in our study, there may be hidden cortical breakage in 12 cases with only plain radiographs. It seems to be necessary to reconsider whether aggressive surgical treatment is reasonable at IGT fractures.

In 5 cases evaluated by only MRI, some of them were consulted after MRI was performed. Among the patients with severe hip pain and unable to gait, surgery was performed without MPR CT evaluation.

This study has some limitations. Firstly, this is a retrospective study performed in a single institution. According to our clinical protocol,

after CT evaluation, additional MRI was considered. There were 5 cases in which surgical treatment was decided after MRI evaluation, which is a limitation of the retrospective study design. Secondly, the number of patients who had both MPR CT and MRI is relatively small. Finally, most cases without cortical breakage on MPR CT were treated conservatively, though some were treated by surgical fixation. Nevertheless, the number of cases of our study is large enough to suggest the advantage of MPR CT and the limitation of MRI in deciding on an appropriate treatment strategy.

## Conclusion

It is essential to perform further imaging in patients with suspected IGT fractures. MRI has an advantage for detecting occult fractures or viewing intramedullary extension but does not accurately reflect cortical bone integrity which is more critical for fracture stability. The result of our study suggests that MPR CT is a useful imaging modality for further evaluation of suspected IGT fractures. It was especially valuable in evaluating cortical bone integrity, which may be more critical for fracture stability.

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## 국 문 초 록

# 대전자 단독골절의 진단과 치료 : 다면상 재구성 전산화단층촬영 또는 자기공명영상

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### 목적

과거 대다수의 대전자 단독골절은 보존적으로 치료했었다. 하지만 아직 명확한 적응증이 없음에도, 그들 중 일부는 수술적 고정을 필요로 한다. 상당수의 정형외과 의사들은 MRI 상에서 골절선의 확장 범위가 전자간 부위의 50% 이상을 넘어갈 경우, 수술적 치료를 한다. 하지만 골절의 안정성은 골수강 내의 해면골 상태가 아닌 피질골의 손상 정도가 더 중요하다. 또한, 대전자 단독골절에서 언제 CT 혹은 MRI를 고려해야 하는지에 대해서도 명확한 기준이 없다.

본 연구에서 우리는 4가지 의문점을 제시하고 그 해답을 얻고자 한다  
: (1) MRI 상에서 골절선의 확장범위가 대전자 단독골절의 수술적

치료여부를 결정하는 합리적인 적응증이 될 수 있는가?, (2) MRI 상에서 골절선의 확장범위 정도가 실제 피질골의 상태를 반영할 수 있는가?, (3) MRI 와 비교하여, 대전자 단독골절에서 다면상 재구성 전산화 단층촬영의 역할은 무엇인가? (4) 본 기관의 치료 가이드라인에서처럼, 다면상 재구성 전산화 단층촬영을 우선 시행한 뒤 그 결과에 따라 MRI를 고려하는 것은 합리적인가?

## 대상 및 방법

2004년 10월부터 2019년 12월까지 본원에서 대전자 단독골절로 진단받은 108명중 중도탈락한 8명을 제외한 100명을 대상으로 연구를 수행하였다. 그들은 67명의 여성, 33명의 남성으로 이뤄졌으며, 평균 나이는 77세였다. 평균 추적관찰 기간은 34개월이었다. 단순방사선 촬영에 더하여 66명의 환자에서 전산화단층촬영, 5명의 환자에서 자기공명영상, 17명의 환자에서 전산화단층촬영 및 자기공명영상을 동시에 시행하였으며 12명의 환자에서는 추가검사를 시행하지 않았다. 자기공명영상 소견과 관계없이 전산화단층촬영에서 골절선의 유무에 따라 수술적 치료여부를 결정하였다.

## 결과

전산화단층촬영을 시행한 83명중 13명에서 전자간 부위 피질골의 불완전 골절선이 관찰되었고 그들 중 10명에서 수술적 치료를 시행하였다. 남은 3명은 각각 환자의 수술치료 거부, 수술이 어려운 내과적 질환, 초기 평가에서 골절선 발견의 실패를 이유로 보존적 치료를 하였다. 골절선이

발견되지 않은 70명 중 62명에서 보존적 치료로 성공적인 결과를 얻었다. 전산화단층촬영과 자기공명영상을 동시에 시행한 17명중 전산화단층촬영에서 골절선이 발견된 경우는 3명이었으며 그들 중 1례에서만 자기공명영상에서 골절선의 확장 범위가 전자간 50%를 넘어갔다. 단층촬영에서 골절선이 발견되지 않은 14명 중 5명에서 자기공명영상의 골절선 확장 범위가 전자간 50%를 넘었고 그들 중 3명에서 보존적 치료를 시도하였고 모두 성공하였다.

#### 결론

전산화단층촬영은 대전자 단독골절에서 추가평가를 위한 유용한 방법이다. 특히, 골절의 안정성에 중요한 피질골의 상태를 평가하는데 있어 그 가치가 있다.

**주요어:** 대전자 단독골절, 전자간 골절, 전산화단층촬영, 자기공명영상

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**Table 1. Demographics of patients with both CT and MRI.**

No.	Sex	Age	Plain radiograph	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

ACB, anterior cortical breakage; CHS, compression hip screw; F, female; IGT, isolated greater trochanter; M, male; OM, extension line over the midline; PFNA, proximal femoral nail antirotation; TM, extension line to the midline

Figure 1. Treatment summary

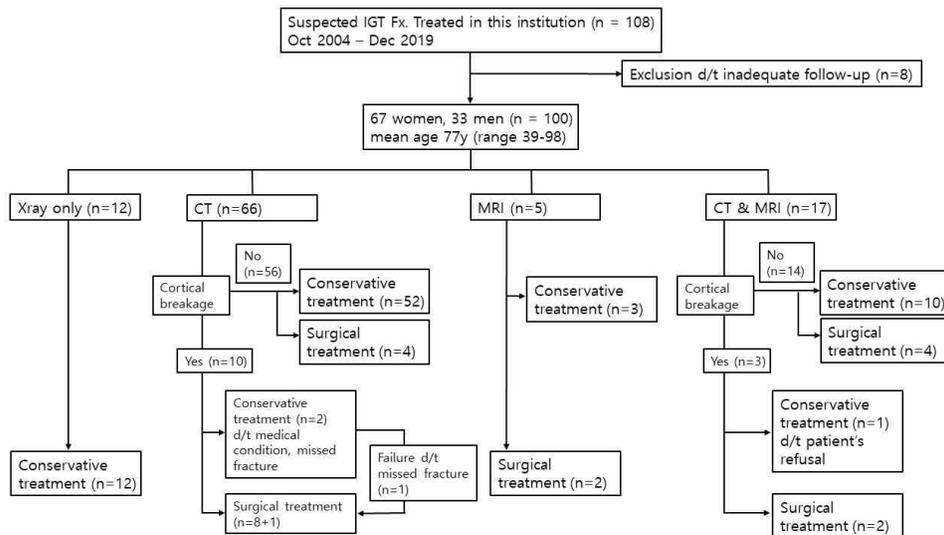


Figure 2. a) Anteroposterior and translateral radiographs of a 91-year-old man showing isolated greater trochanter (IGT) fracture. b) CT images showing a cortical breakage in the anterior portion of the intertrochanteric area (arrows). The posterior portion remained intact.

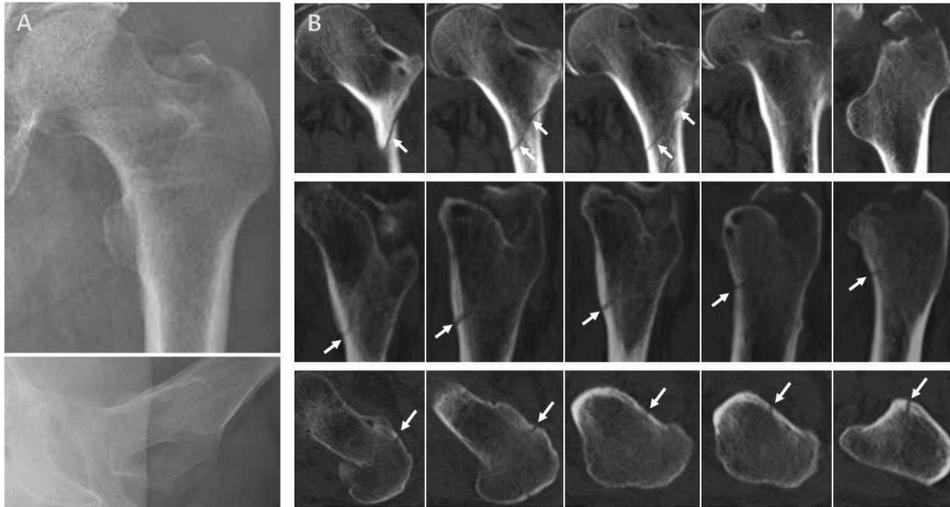


Figure 3. a) Anteroposterior and translateral radiographs of a 90-year-old woman. No cortical breakage was identified in the intertrochanteric area on CT images except isolated greater trochanter (IGT) fracture, therefore conservative treatment was used initially. Two weeks after conservative treatment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

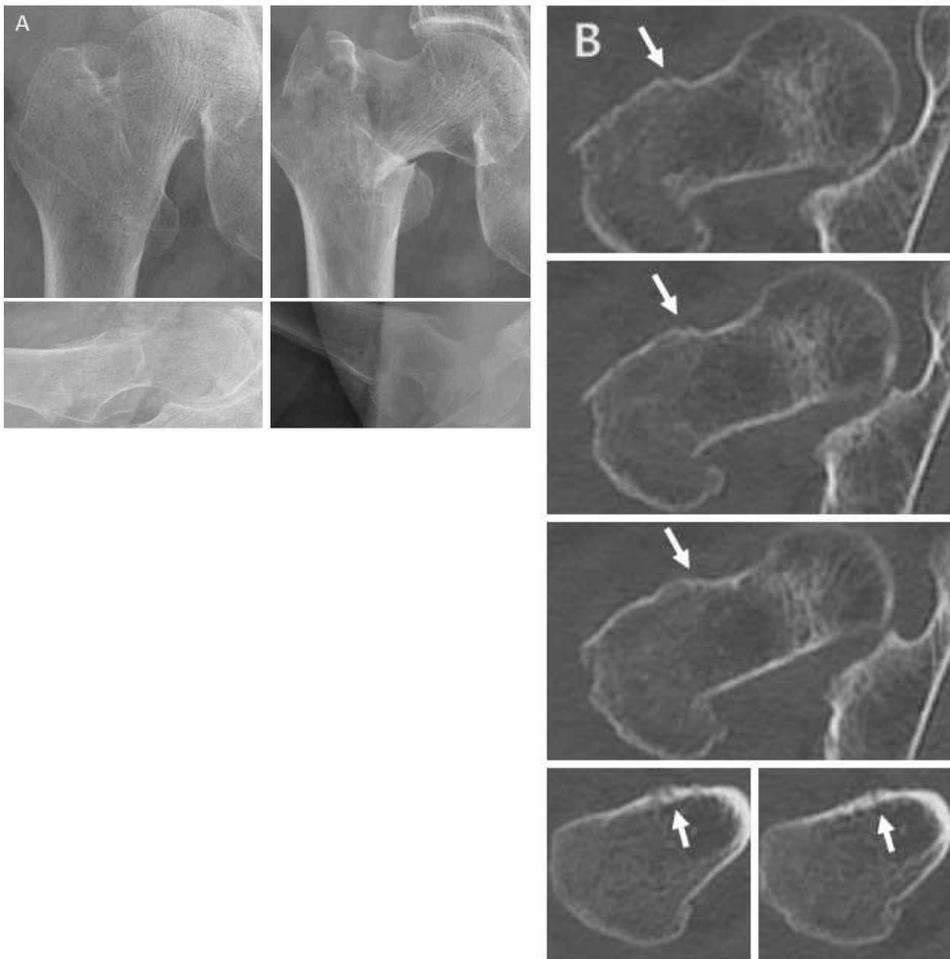


Figure 4. a) Anteroposterior and translateral radiographs of a 71-year-old man showing isolated greater trochanter (IGT) fracture. b) CT images showing an anterior cortical breakage (arrows), and MR images showing that the intertrochanteric extension did not cross the midline (arrowheads). It was fixed with a compression hip screw.

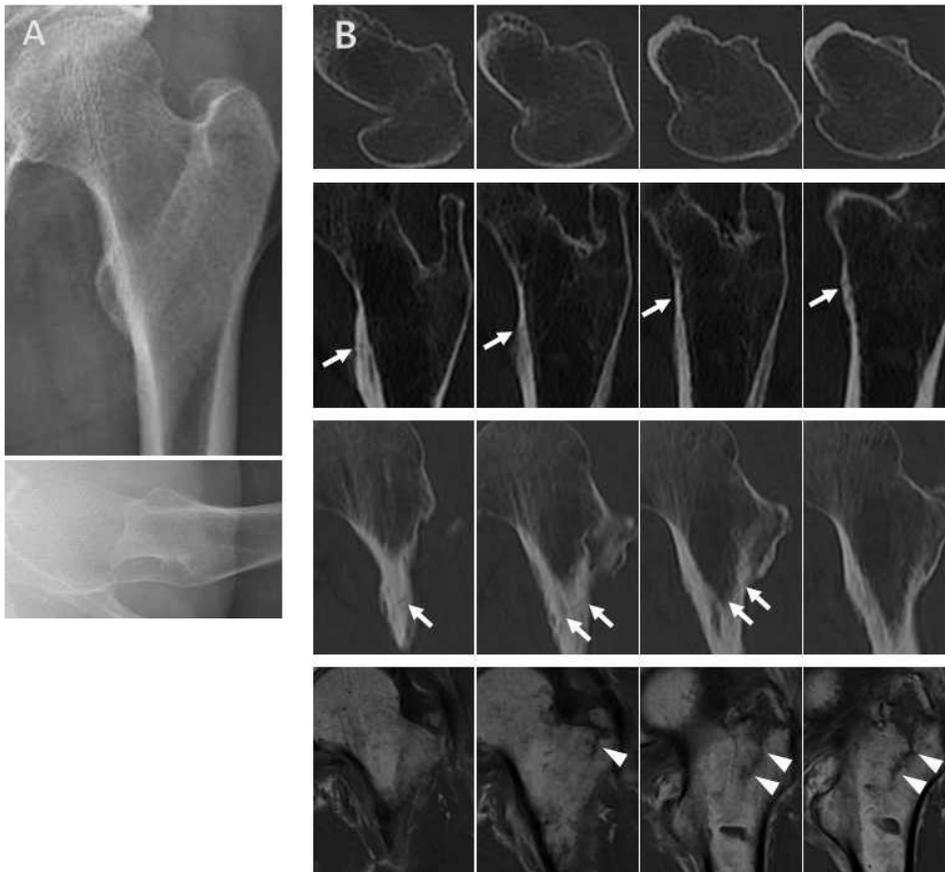


Figure 5. a) Anteroposterior and translateral radiographs of an 89-year-old man showing isolated greater trochanter (IGT) fracture. b) CT images showing intact cortical bone, and MR images showing intertrochanteric extension crossing the midline. c) Anteroposterior and translateral radiographs showing that the intertrochanteric area remained intact following full weight-bearing activity after two months of conservative treatment.

